STRENGTHENING BLUE-GREEN INFRASTRUCTURE IN OUR CITIES

ENHANCING BLUE-GREEN INFRASTRUCTURE & SOCIAL PERFORMANCE IN HIGH DENSITY URBAN ENVIRONMENTS

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ENHANCING BLUE-GREEN INFRASTRUCTURE & SOCIAL PERFORMANCE IN HIGH DENSITY URBAN ENVIRONMENTS

Usually we think of a city as buildings, roads, concrete, asphalt and all the other hard, grey elements. But what if the city has more than one layer? What if we define a city by looking at water and vegetation as well? Elements that shape and improve human life. We call this BGI = Blue-Green Infrastructure – the essential layer in a liveable city.

For too long, we have pushed water underground – out of sight, out of mind – and disregarded the green. Though essential to our lives, it has lacked a strong advocate. But times change and suddenly we have become aware that grey cannot cope with the challenges of climate change.

Blue-Green Infrastructure
The traditional grey approach to urban infrastructure, which is to discharge rainwater into pipes, is not an adequate solution for hydroclimatic problems induced by urbanisation, urban density, and impervious land cover. Nor is it a way to mobilize the many socioeconomic benefits of water as an element in people's living environments.

Blue-Green infrastructure (BGI) offers a feasible and valuable solution for urban areas facing the challenges of climate change. It complements and in some cases replaces the need for grey infrastructure. BGI connects urban hydrological functions (blue infrastructure) with vegetation systems (green infrastructure) in urban landscape design. It provides overall socioeconomic benefits that are greater than the sum of its individual components.

Taken together as a comprehensive system, these components of BGI projects strengthen urban ecosystems by employing natural processes in man-made environments. They combine the demand for sustainable water and stormwater management with the demands of adaptive urban life and planning. ■

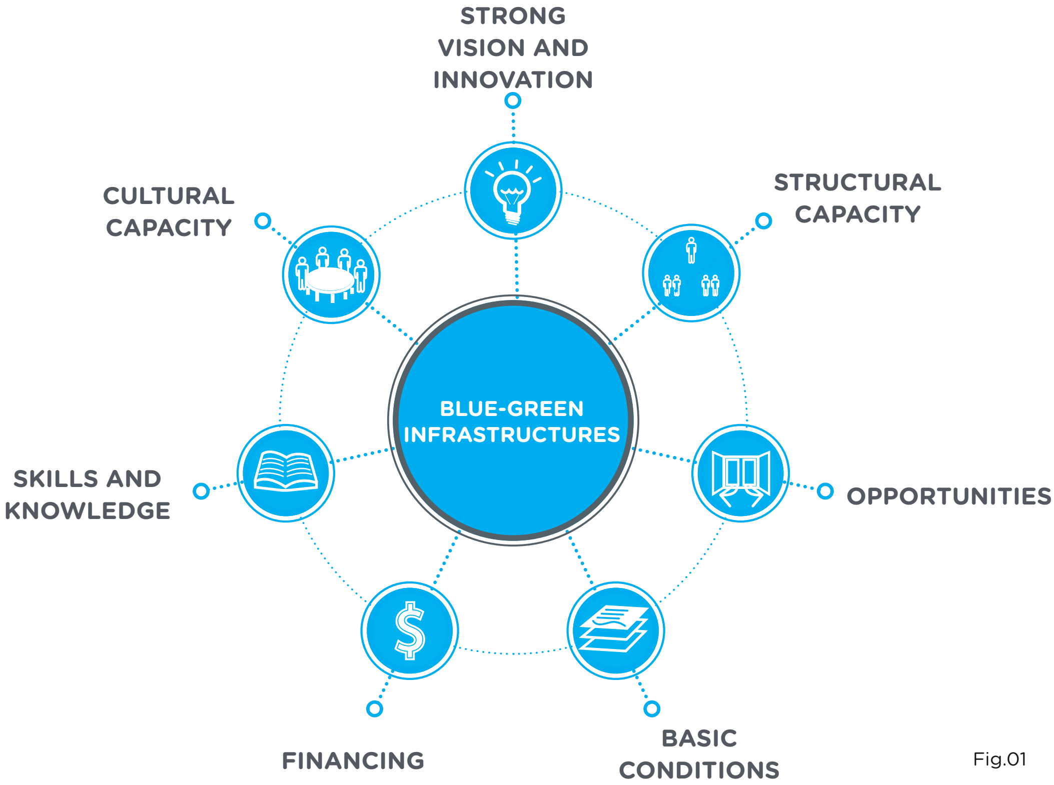
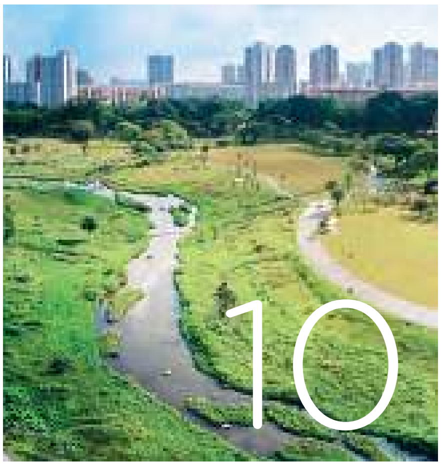
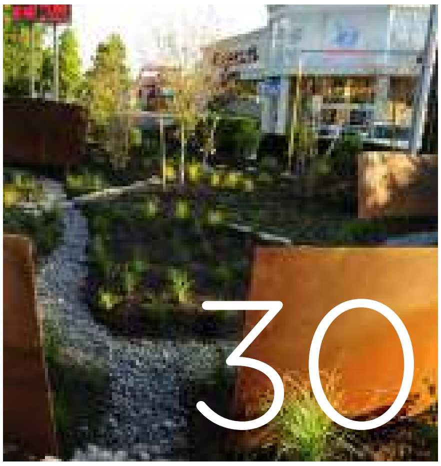


Fig.01





STRENGTHENING BLUE-GREEN INFRASTRUCTURE IN OUR CITIES

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CHAPTER 1

PREFACE AND INTRODUCTION

BLUE AND GREEN INFRASTRUCTURE FOR LIVEABLE CITIES

What makes a city? Often we think about buildings, roads, concrete, asphalt and all the other hard grey elements. But what if the city has more than one layer? What if we define a city by looking at water and vegetation as well? Elements, that more than others shape and improve human life.

We call this BGI, the Blue and Green Infrastructure – the essential layer in a liveable city.

Rather than viewing the city as a single, discrete entity, it might be more useful to think of it as interacting layers of different kinds of activities and physical features. There is one element in particular that, perhaps more than all of the others, shapes a city and supports urban activity and human life – that element is water. Water is necessary for human life and a variety of economic activities.

However, for too long we have pushed water – one of the most essential resources for a functioning city – underground, and therefore out of sight and out of mind. There is growing awareness that securing clean and sufficient freshwater will be a defining challenge for cities in the 21st century.

The conventional approach to urban water infrastructure has been to use simple quantitative models to predict future water demand and then to construct additional infrastructure to meet this demand. That approach prioritizes technology and large physical interventions which attempt to manipulate natural processes to suit the needs of humankind. However, that focus on "grey" infrastructure – so-called because of the massive amounts of concrete and metal typically involved – is proving to be no longer adequate in meeting the additional stresses to urban water supply induced by rapid urbanization, impervious land cover, and climate change.

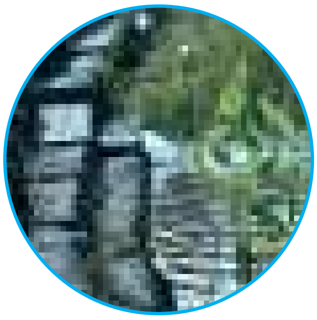
In some cases, the reliance on grey infrastructure can actually contribute to these stresses. For instance, the conventional approach to urban stormwater runoff has been to collect precipitation in a connected sewer system and to transport it out of the city as quickly as possible. As cities have grown, impervious land cover has increased which generates a larger volume of stormwater runoff in a shorter period of time, overwhelming existing sewers and increasing flooding.

Nor does grey infrastructure mobilize the many potential socioeconomic benefits of water in enhancing the aesthetics of the urban fabric and the quality of life.

In response to these changing times, decision-makers are starting to look beyond the grey and experimenting with less conventional approaches to infrastructure.

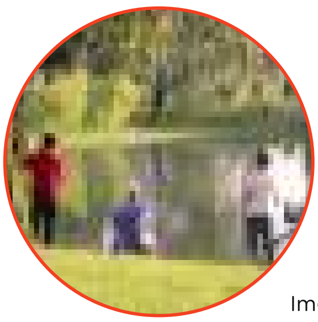
Blue-Green Infrastructure offers a feasible, economical and valuable option for urban regions facing challenges of climate change. It complements and in some cases mitigates the need for grey infrastructure. Blue-Green Infrastructure (BGI) represents a paradigm shift that recognizes the importance of and value in including the role of urban hydrology within urban water management. The "Blue" recognizes the importance of the physicality of water itself, while the "Green" connects urban hydrological functions with vegetation systems in urban landscape design. The resulting BGI has overall socioeconomic benefits that are greater than the sum of the individual components.

BLUE
WATER RESOURCES



GREEN
NATURAL HABITAT

RED
PEOPLE'S WELL-BEING



Img.01

If BGI has so many benefits and is so economical, then why are examples of successfully implemented BGI projects still so rare?

BGI systems are not unknown and are gaining recognition in many cities and countries worldwide. Already there exist a number of programs and organizations[1] that raise awareness of BGI and support implementation of BGI projects. While it is true that the number of projects that have been successfully built and are in operation is still relatively small, this number is increasing daily.

Several challenges still exist, however, in increasing awareness, adoption, and implementation of BGI. One challenge is that many BGI projects are implemented on a small scale – on the scale of a building or a block. Another challenge is that the number of BGI projects is small, especially when compared with the growing interest in and demand for BGI. An additional challenge is that in spite of the multitude of diverse societal, ecological and economic benefits enhanced by BGI projects, many of these benefits are difficult to quantify. Where they are quantifiable, BGI projects may lack the resources to carry out data collection. It is especially difficult to do before and after studies, which require data to be collected before the project is implemented.

We do recognize that many obstacles surrounding BGI projects need to be resolved in order to be more influential and successful. We have studied both the obstacles to and the opportunities for BGI and present this knowledge here to increase awareness and support implementation for projects around the world. While we identified many obstacles and barriers in each of the cases studied in this report, we emphasize that these cases also provide examples for confronting these challenges and have found convincing and inspiring cases of success.

Very often implementation appears to be constrained by factors such as lack of the foresight to include a BGI project in all planning efforts; scarcity of experts and decision-makers familiar with the BGI approach; priorities given to other, more familiar technological solutions or more urgent responsibilities; a lack of financial resources; and a prioritization of the maintenance of existing infrastructure, although it is failing. The obstacles and barriers associated with BGI projects are similar to the risks associated with any infrastructure project. However, since BGI is still a relatively new paradigm in most parts of the world, the association with a successful project is often unfamiliar to many individuals – politicians, engineers, designers, urban planners, and financiers, among others. As we discuss in our analysis and recommendations, particular attention and care must therefore be paid to aligning the BGI project design with the social, political, and institutional capacities of local decision-makers.

The impacts of BGI on the water resources, the natural habitat and people´s well-being will be further explored in Chapter 3.

1 The ABC-Waters Program of the Public Utilities Agency aims to integrate urban green and Singaporean water bodies, that is break up the dominant grey and concrete approach for storm water infrastructure and use bio-engineering techniques. It is a big scale policy program with three certain foci: Identify opportunities for BGI in a ABC-Masterplan and start implementing BGI in 100 single projects from 2006 – 2031; Building up engineering capability and engineering culture by ABC Water Guidelines; education for water awareness.

THE INTENTION OF THIS HANDBOOK

Cities and their decision-makers today face many complex challenges that are associated with balancing urban development and its impact on the environment. The trend towards urbanization continues at a break-neck pace worldwide – with a majority of the world's population now living in cities, and an expected increase to 66% by 2050.[1] Consequently, the demand for new infrastructure construction is expected to increase commensurately. These infrastructure expansions are aligned with enormous costs.

Enormous investments are required for the upgrade and maintenance of aging infrastructure stocks as well as the construction of new built infrastructure to accommodate population growth. One of the many challenges cities face is in securing clean and sufficient water supply while mitigating environmental stress and pollution. There is growing recognition that the traditional, so-called "grey" approach to infrastructure will be insufficient to meet the growing pressures from urbanization and additional stresses associated with climate change and energy scarcity.

In such demanding times, we need solutions that help to solve more than one challenge at the same time. A paradigm shift is required – one that recognizes that we can no longer focus only on temporary technological fixes. Instead, we must integrate planning of built infrastructures with an understanding of how these technical systems perform in society and the environment.

In this handbook we present the results of the research project "Enhancing Blue-Green and Social Performance in High Density Urban Environments". The goal of this research was to move towards a more comprehensive understanding of underlying concepts contributing to the effective implementation of BGI. Towards this end, we examined the challenges, obstacles, and successes of selected BGI case studies.

The lessons learned are described for each specific project and are then compared and summarized, and general lessons presented. These lessons are intended to assist in setting priorities and agendas for BGI projects and to facilitate a strategic approach for the implementation of BGI throughout the project life cycle, from developing a vision through effective construction and operation. Since many local factors, different disciplines and responsibilities need to be considered when planning, financing, constructing and maintaining BGIs, a range of relevant target groups and key audiences were identified. We present a set of customized recommendations tailored to each of these specific interests.

This report demonstrates the many benefits of BGI projects and how they enhance the value of a variety of urban ecological, economic and social functions: including prosperity, urban sustainability and liveability. We believe that the cases presented here provide strong arguments for the many benefits of BGIs and hope that the specific projects and general principles will convince key actors like government authorities, public administration, urban planners and designers, academic groups, public-at-large, NGOs, construction builders and developers that BGI is achievable and economical.

We hope this work will positively influence the adoption and success of blue-green infrastructures worldwide.

1 United Nations Department of Economic and Social Affairs/Population Division (2014): World Urbanization Prospects: The 2014 Revision. http://esa.un.org/unpd/wup/Publications/Files/WUP2014-Report.pdf

Img.02

We hope this work will positively influence the adoption and success of blue-green infrastructures worldwide.

A MANDATE FOR BLUE-GREEN INFRASTRUCTURE IN CITIES

As the global trend of urbanization continues steadily, cities are increasingly an important facet of our future. Whether for the good or bad, principles of urban design can and will affect the quality of life for many people.

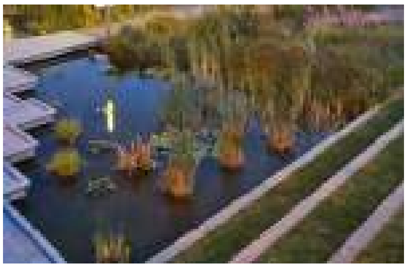
As the global trend of urbanization continues steadily, cities are increasingly an important facet of our future. Whether for the good or bad, principles of urban design can and will affect the quality of life for many people. This urbanization brings both advantages and challenges. While cities often enhance prosperity, quality of life, and even resource efficiency in the long-term, in the short term growing cities face the joint challenges of constructing built infrastructure to meet the rising demand for urban services and for providing access to these resources in a sufficient and socially equitable manner. Paradoxically, urbanization presents environmental dilemmas such as changes to local hydrology and unprecedented biodiversity loss that negatively impact the quality and availability of local water resources. Compounding these challenges, cities must now factor in an increasing frequency of extreme climatic events that exacerbate the intensity of flash flooding, drought and heat waves. These extreme events overwhelm existing infrastructure and increasingly disrupting economic activities and threaten quality of life and in some cases life itself.

The growth and densification of social settlements that are associated with urbanization are accompanied with a range of complex and systemic challenges. One of the most pervasive challenges is the alteration of the local water cycle. Urbanization is associated with reduced surface perviousness within the boundary of the city. This reduces infiltration and therefore reduces local groundwater availability, and increases the risk and intensity of flooding and also increases pollution of surface water. Larger populations and affluence increase water demand, which intensifies the need for freshwater supply as well as increasing the by-products of water use – i.e. sewage. Cities throughout history have depended heavily on technology and infrastructure especially for urban water management. Conventional urban water interventions are mostly based on singular functions with the objective of water supply or disposal of wastewater and rainwater as fast as possible through channelized rivers and drainage systems. In the last century, water in the city has been seen more as a problem to be managed efficiently, and greenery was more an option that is nice to have but has rarely been top of the agenda of urban developers.

Today we know that conventional grey water infrastructure may address water demands in the short-term but often generate additional problems to be solved in the long-term. These unintended consequences include reduced surface water quality, altered or reduced groundwater recharge, and increased flooding. Grey water infrastructure, by itself, lacks resilience to weather extremes, rapid urbanization, and climate change.

Blue-green infrastructure has shown promise in enhancing resiliency in urban environments. BGI complements and can also reduce the need for grey infrastructure. It also helps to offset some of the negative impacts of urbanization on local hydrology and can be especially effective in mitigating risks associated with climate change.

TANNER SPRINGS PARK, PORTLAND
An ecological waterscape park that brings together landscape, water and people



Img.03

SWALE SYSTEM, PORTLAND
Swale conveyance elements located throughout cities, can enhance neighbourhoods and other urban spaces.

Img.04

PLAY AREAS NEXT TO WATER
Visitors can experience recreation and other events, as people, culture and ecological waterscapes meet

Img.05

WHAT IS BLUE-GREEN INFRASTRUCTURE?

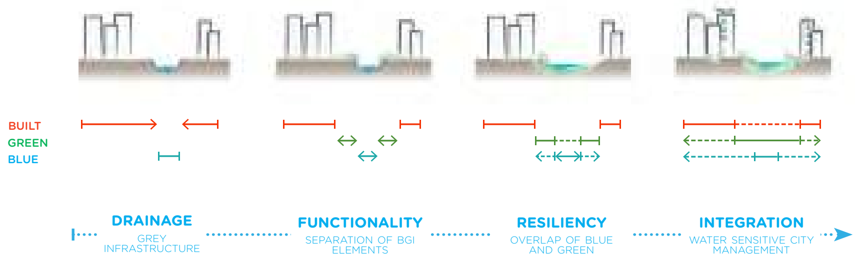


Fig. 1a **THE PROCESS OF INTEGRATION**
Urban infrastructures need to be retrofitted from conventional drainage systems to more functional and resilient systems that bring together built areas, green (landscape systems) and water.

This research project focused on environmental urban infrastructures that include vegetation (the "green") as well as hydrological features ("blue") within urban design interventions. We refer to this type of infrastructure as Blue-Green Infrastructure, or by the acronym BGI. We will present a more detailed definition of what we considered BGI in Chapter 2.

The use of the term "infrastructure" in BGI is a recognition that the natural processes associated with vegetation and hydrology contribute valuable and functional services to human societies. There has been growing awareness of the value of so-called "green" infrastructure (e.g. open space and tree canopy). Including "blue" in BGI is a natural extension of the green infrastructure concept, since green features depend on water and also affect local hydrology.

BGI integrates hydrological and ecological water treatment within designs, where green features are seamlessly integrated with blue features. In re-introducing natural processes within the built environment, BGI strengthens urban ecosystems, improves quality of life, and promotes sustainable water and stormwater management.

Design principles of BGI draw from principles of hydrology and ecology to design urban features that combine blue and green elements for the creation of interactive and multifunctional systems. The functional requirements of these systems are to capture, filter, slow down, and where possible infiltrate and store rain and stormwater. BGI alters the local water cycle in a systemic way that benefits health and biodiversity for both flora and fauna, while improving local water security and water supply.

BGIs are adaptable systems and can be efficient on a variety of different scales, depending on attributes of the local urban context, such as available space, topography, and climate.

Typical BGI consists of elements like green roofs, bioswales, cleansing biotopes/raingardens, retention and detention swales and lakes, infiltration systems and others, which may be connected to other BGI elements in a water catchment area. Each element fulfills and contributes to rainwater and stormwater treatment but can also be considered as an ecological stepping stone by itself, enhancing connectivity, which is fundamental to the ecological management and maintenance of floodplains. These connected modules are often called "treatment trains". The integration of such blue and green infrastructure services results in a multi-functional design with myriad socio-economic and socio-ecological benefits. These socio-economic and socio-ecological benefits are described further in Chapter 5.

WHY IMPLEMENTATION OFTEN FAILS

A wide implementation of BGI elements and techniques to achieve multifunctional urban landscapes on a holistic catchment scale has yet to be realized. Blue-green infrastructure often is not seen as valuable opportunity for creating multifunctional landscapes with an ecological approach to sustainable urban stormwater practice.

The underlying hypothesis of this work is that the main obstacles for the implementation of sustainable stormwater management go beyond the technical. We believe that a paradigm shift is needed and that urban water management must move beyond the conventional engineering mindset to a more holistic approach that includes knowledge about societal values and ecosystem services. Such a paradigm shift has begun to be appreciated, but many decision-makers still remain unaware of the value of such an approach or how to operationalize it.

The transition of urban water management from standard grey to blue-green is more than a technical innovation. It implies a change in the social and political setting of a city and therefore it relies on the capabilities in a city to negotiate forms and outcomes of this change with all different civic stakeholders as well as to be aware of unintended consequences in the wider (spatial, social, temporal) context.

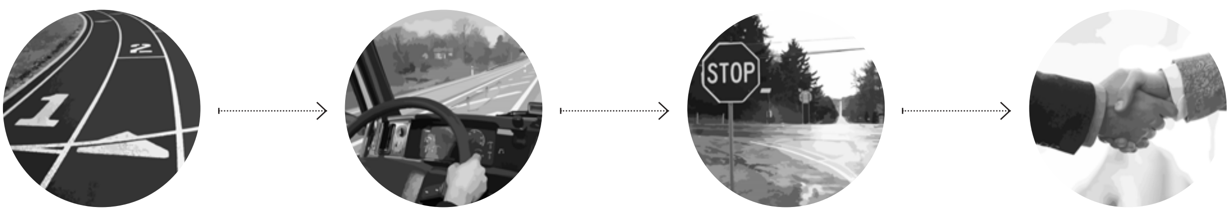
Moving forward, we believe in (and the case studies demonstrate) the importance of effective communication, knowledge-sharing, and cooperative agenda-setting in promoting BGI. There is a need for improved argumentation and for increased efforts in data-driven analysis to support and refine the ecologic, economic and social arguments for BGI. In particular, further research is needed on what we call "The Expanded Process Model" to identify, analyse, and enhance:

- The challenges, drivers and enabling conditions of successful BGI-implementation, and
- The benefits and added values stemming from this combination of blue-green infrastructure, especially its impact on improving social life and human-environmental relations.

THE EXPANDED PROCESS MODEL

Fig.02

INITIAL CONDITIONS | **DRIVERS OF CHANGE** | **CONSTRAINING CONDITIONS** | **ENABLING CONDITIONS**



Initial conditions: Problems and opportunities that gave rise to the BGI inquiry (e.g. crisis, hazards, pollution) to understand motives, targets and resources for BGI-Implementation

Drivers of change: Agents who take initiative for BGI-Implementation: persons/leaders, institutions and or social movements

Constraining conditions: Anti-BGI agents/institutions, design standards or policy programs that work against BGI

Enabling conditions: Technical tools, legal regulations, political and social awareness, financial support that had a secondary effect as lever for BGI-Implementation

WHY TALK ABOUT ADDED VALUES OF BGI?

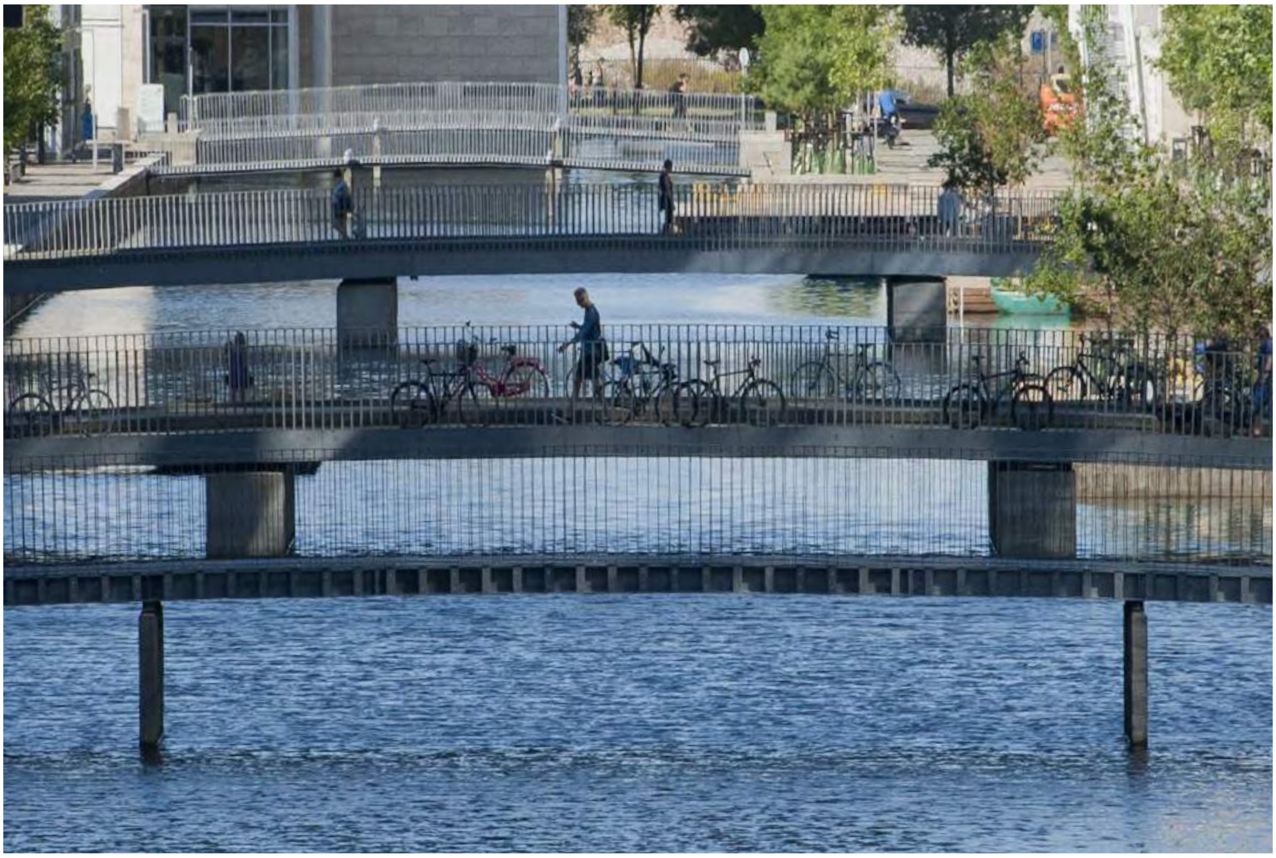
The increasingly well-documented consequences of global climate change and the associated increase in frequency of extreme weather events have pushed water resources to the forefront of urban planning and infrastructure development concerns. BGI is highly relevant in urban areas for mitigating the negative effects of climate change, and for its enhancements to quality of life and health and well-being. Recent studies have shown that exposure of humans to nature, such as that included in BGI, can have benefits for biophilia and place attachment (see Chapter 5). Biophilia – referring to people´s personal affiliation with nature and natural environment – has a positive influence on people's physical and mental health; however, this fact is only slowly beginning to be understood and accepted.

BGI is associated with a variety of benefits. Effective BGI design provides many important water-related ecosystem services like recharge of groundwater, reduced peak discharge of stormwater runoff, increased base streamflow, reduced soil erosion and nutrient loss, reduced riparian ecological disturbances, and improved quality of stormwater runoff.

With these hydrological functions, BGI enhances not only the adaptability and resilience of urban infrastructure by managing and modulating hydroclimatic variability and weather extremes. BGI also modulates urban climates by reducing urban heat island effects, reducing variation in diurnal temperature fluctuation, and supporting natural air ventilation. It also reduces negative bioclimatic impacts of land cover changes, e.g. desiccation of urban soils and associated windborne air pollution and dust hazards.

To account for the many diverse types of added values, the Polychrome Sustainability framework of Manfred Moldaschl is used to analyze the modes of consumption, reproduction, and creation of collective resources defined as different forms of societal capital. This framework describes and assesses the added values of BGI in terms of natural, built, human, social, symbolic and financial capital (see Chapter 5). These different types of capital are used to evaluate the change in societies' capital stocks resulting from the implementation of BGI in dense urban areas like human health, public well-being, financial assets, other long-term economic resources and other human values.

Img.06



CASE STUDIES

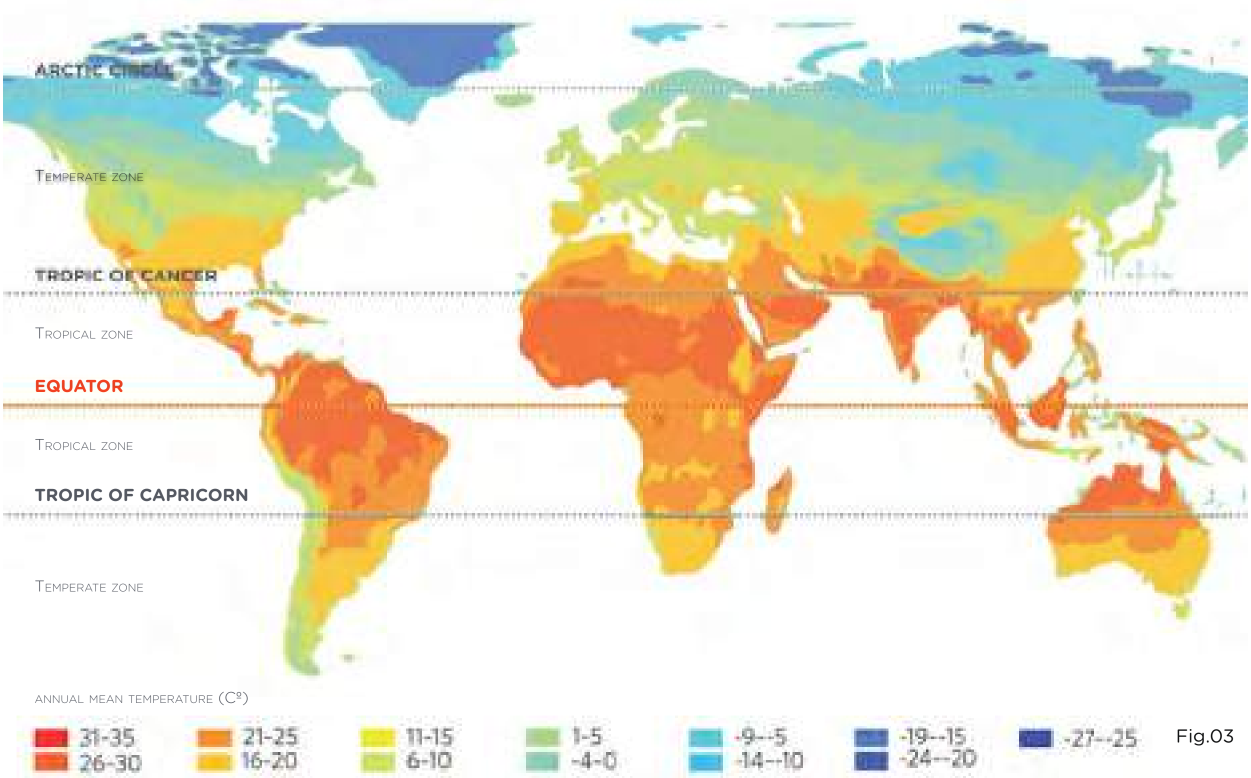


Fig.03

The research work, which is the foundation of this handbook, is based upon case studies, namely individual projects and cities. The case studies included an extended literature review as well as numerous interviews with different stakeholders such as governmental officials, developers, planners, and construction companies. These case studies are summarized in the Annex.

To provide a more balanced picture of BGI challenges relevant around the world and in a variety of contexts, the selection criteria for case studies included climate, governance systems, and variations in the history of BGI-development types as well as the designed functionality within the BGI. The cases chosen for the study represent several continents (America, Europe, and Asia) and a range of climate types including the tropical rainforest climate (Singapore), the tropical wet and dry climate (Mumbai), and the humid continental climate (Germany, Denmark, etc.).

In addition to assessing individual BGI at the project scale, we also compared opportunities and challenges for BGI successes at the city scale to gain insight into relevant citywide agendas and policies.

For each case study, positive and negative lessons were identified and an attempt made to generalize these lessons as good practices important for current and future BGI planning and implementation in cities.

The results of studying BGI projects and programs of cities are comprised in Chapter 4 "Lessons learned", and build the substance for the analysis of added values (Chapter 5), and finally the recommendations for successful implementation of blue-green infrastructure (Chapter 6).

THE CASE STUDY APPROACH

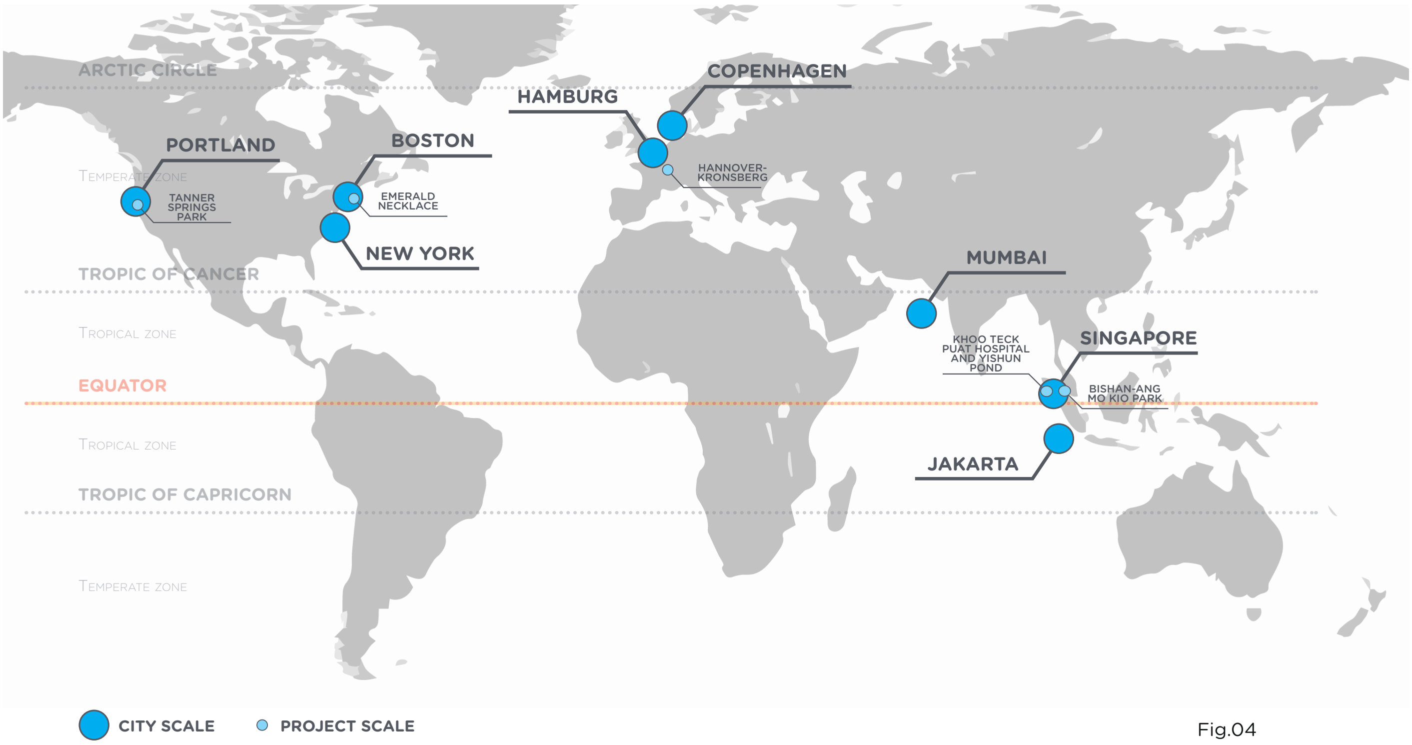


Fig.04

CASE STUDIES ON PROJECT LEVEL

Emerald Necklace, Boston, US

Hannover-Kronsberg, Germany

Bishan-Ang Mo Kio Park, Singapore

Khoo Teck Puat Hospital and Yishun Pond, Singapore

Ulu Pandan Park Connector (UPPC), Singapore

CASE STUDIES ON CITY LEVEL

Hamburg, Germany

Portland, Oregon, US

Copenhagen, Denmark

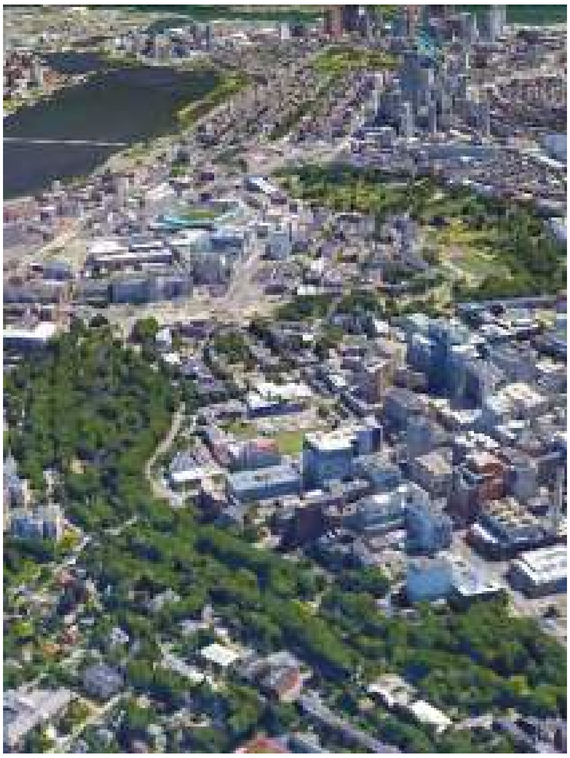
New York City, US

Jakarta, Indonesia

Mumbai, India

EMERALD NECKLACE, BOSTON, US

The park system "Emerald Necklace" has been a continuously evolving example of blue-green infrastructure over the past 130+ years. Designed by landscape architect Frederick Law Olmsted toward the end of his career in the 1880s, the Emerald Necklace was a breakthrough project in urban environmental design. It stands as an early model for addressing functional issues of urban stormwater management on tidal rivers, and it has been emulated in other cities in the U.S. and internationally. Seven major blue-green components comprise the Emerald Necklace, linking sanitary and stormwater sewerage improvements with river corridor parks, urban ponds, an arboretum and subwatershed, and Boston's largest public park. This early design precedent underwent major changes in its underlying assumptions since the 1910s when its tidal outlet was dammed, at which point it became a freshwater reservoir. The long history of the Emerald Necklace and changes to its program allowed a long-term evaluation of its performance as a BGI both in social and environmental terms and thus offers guidance and important lessons for designing contemporary urban BGI initiatives that will withstand the test of time and changing political, financial, and cultural circumstances. Therefore it is an especially useful precedent for assessing future BGI development opportunities in cities.



Img.07

Img.08

Fig.05

Enhancing Blue-Green and Social Performance in High Density Urban Environments - Case Studies - Project Profile

Emerald Necklace

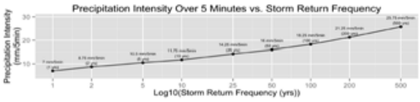
General Information

Geography

Country/ City: United States of America/ Boston, MA
Geographic coordinates: 42°21′N, 71°0451′W [1]

Total Area of Boston (City)[2]: 232 km²

Climate Zone (Koeppen) [3]: Dfa, humid continental (*hot summer subtype*)
Rainfall
Annual: 1 039 mm [4]
Number of heavy rains p.a. [14]: 16 *(Mean number of heavy rains per year (1948-2012), st. dev. = 7)*
Intensity in mm/ 5 min [15]:



Net annual water budget [8]: 540 mm/year

Location Boston

Climate Charts Boston

Demography

GDP (nominal) per Capita (2013): US$ 370, 769 [5]
Human Development Index: 0.914 · Increase · very high · 5th [6]

Population/Population Density [1]: 645 966
Population Density (*calculated*): 2 780 / km²

Percentage of Blue in the city [1]: 46 %
Percentage of Green in the city [7]: 9.5 %
Per Capita Coverage of Blue: 170 m²
Per Capita Coverage of Green [16]: 34 m²

1 Emerald Necklace (EN)
- **BB** - Back Bay Fens
- **RW** - The Riverway
- **OP** - Olmsted Park
- **JP** - Jamaica Pond Park
- **AA** - Arnold Arboretum
- **FP** - Franklin Park
- **CM** - Commonwealth Ave. Mall

2 EN-Connected
- **CR** - Charles River Esplanade
- **PG** - Public Gardens
- **BC** - Boston Common

3 Other BGI
- **PS** - Peabody Square
- **PG** - Green Alley
- **PA** - Porous Alley

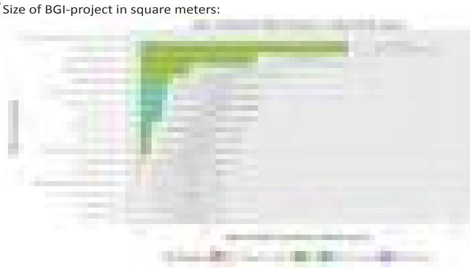
4 2012 Consent Decree
- **CS** - Central Square (E. Boston)
- **AC** - Audubon Circle
- **CHP** - City Hall Plaza

Boston & BGI Projects [8]

Specific BGI Information

Blue-Green Infrastructure

3 Size of BGI-project in square meters:



Map of the Emerald Necklace in Boston [18].

Olmstead's original plan for a greener Boston [19].

Dredging of the Back Bay Fens (1882) [22].

View of the Back Bay Fens today [21]

Table 1: Specific Blue-Green Infrastructure Characteristics for the Emerald Necklace Components

	Emerald Necklace (EN) BGI Components							Necklace-Connected BGI			Other BGI Demo Projects			2012 Consent Decree-BGI		
Motivation/Targets	**BB**	**RW**	**OP**	**JP**	**AA**	**FP**	**CM**	**CR**	**PG**	**BC**	**PS**	**GA**	**PA**	**CS**	**AC**	**CHP**
Climate change mitigation																X
Air pollution mitigation																
Urban heat island mitigation									X			X				X
Rainwater management, flood prevention, groundwater level, quality improvement *Question: Do we want to know Y/N/Other? Level of Import? Intentional/Incidental?*	X	X	X					X			X	X	X	X	X	X
Restoration		X	X	X					X	X	X			X	X	X
Increasing permeability											X	X	X	X	X	X
Recreation in dense settlements	X	X	X	X	X	X	X	X	X	X	X	X	X	X X	X	
Renaturation		X	X	X				X	X	X		X	X	X	X	X
Water pollution mitigation	X	X	X	X				X			X	X	X	X	X	X
Water recycling									X			X		X	X	X
Conservation of natural & cultural heritage	X	X	X	X				X	X	X						
BGI Functionality	**BB**	**RW**	**OP**	**JP**	**AA**	**FP**	**CM**	**CR**	**PG**	**BC**	**PS**	**GA**	**PA**	**CS**	**AC**	**CHP**
Recreation	X	X	X	X	X	X	X	X	X	x				X		
Floodplain management	X	X	X	X				X	X	X				X		X
Public Square							X			X	X			X	X	
Street Greening							X				X					
Urban Gardening & Farming	X															
Greenroof												X				X
Retention System, Water Drainage, Open Water System, Closed Water Loop, Climate Change Adaptation, etc.	X	X	X	X				X X X			X	X	X	X X X		
Physical Facilities	**BB**	**RW**	**OP**	**JP**	**AA**	**FP**	**CM**	**CR**	**PG**	**BC**	**PS**	**GA**	**PA**	**CS**	**AC**	**CHP**
Playground	X					X										
Open space	X	X	X	X	X	X	X	X			X			X		X
Community space	X		X	X		X	X	X			X			X		X
Pet area	X			X		X	X							X		
Wetland biotope	X	X	X	X												
Cycle path	X	X	X	X		X	X							X	X	
Sunbathing lawns			X			X								X		
Cafes						X										
Day care																
Site Conditions	**BB**	**RW**	**OP**	**JP**	**AA**	**FP**	**CM**	**CR**	**PG**	**BC**	**PS**	**GA**	**PA**	**CS**	**AC**	**CHP**
Surface texture *I: Hard scape II: Soft scape III: Sealed area IV: Green area*	*IV*	*IV*	*IV*	*IV*	*IV*	*IV*	*IV*	*IV*	*I*	*I*	*IV*	*I*	*I*	*V*	*V*	*V*
Principal bedrock *a: Cambridge & Braintree Argillite b: Roxbury Conglomerate*	*a*	*b*	*b*	*b*	*b*	*b*	*a*	*b*	*a*	*a*	*b*	*a*	*a*	*a*	*a*	*a*
Surficial geology *i: Flood plain alluvium ii: Fine-grained deposit iii: Till or bedrock*	*i*	*i*	*ii*	*ii*	*iii*	*iii*	*i*	*iii*	*i*	*i*	*iii*	*i*	*i*	*iii*	*i*	*iii*
Soil classification *X: Udorthent (Urban)*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*
Infiltration rate (L/sec*ha)	*4.2– 14*	*4.2– 14*	*4.2– 14*	*4.2– 14*	*4.2– 14*	*4.2– 14*	*4.2– 14*	*4.2– 14*	*4.2– 14*	*4.2– 14*	*4.2– 14*	*4.2– 14*	*4.2– 14*	*4.2– 14*	*4.2– 14*	*4.2– 14*
Facility Management	**BB**	**RW**	**OP**	**JP**	**AA**	**FP**	**CM**	**CR**	**PG**	**BC**	**PS**	**GA**	**PA**	**CS**	**AC**	**CHP**
Management authority *BAC: Boston Architectural College BPW: Boston Public Works BWSC: Boston Water & Sewer DCR: Department of Conservation & Recreation HU: Harvard University PR: Parks & Recreation TD: Transportation Department*	*PR*	*PR*	*PR*	*PR*	*PR*	*PR*	*PR, TD*	*DCR*	*BPW*	*BPW*	*BPW, PR*	*BAC*	*BPW, PR*	*BWSC, BPW, PR*	*BWSC, BPW, PR*	*BWSC, BPW, PR*
Maintenance costs (USD/m^2) *(2012)*	$3.06	$3.06	$3.06	$3.06	$3.06	$3.06	$3.06	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD

Data from [10], [11], and others.

Planning policy information

BGI Strategy

Is the project embedded in a city-wide BGI strategy?

Olmsted's Emerald Necklace was designed and constructed as a series of interconnected BGI components that addressed city-wide needs for improved air and water quality, increased biodiversity and convenient access to plentiful and high quality open space within the city. Current day efforts to improve the Necklace, such as daylighting streams, improved flood management and increasing permeability appear consistent with Boston's city-wide BGI strategies[10].

Was the project supported or regulated by guidelines, building regulations etc.?

The late 19th century construction of the Emerald Necklace happened when city-based regulations and guidelines were scant. However, Olmsted imposed his own set of design guidelines that were inspired by commonly understood best practices of BGI and were ultimately adopted by the city [10].

Was the project supported by financial government support programs or any tax systems?

Annual appropriations to support the construction of the necklace came mostly from city property tax assessments, property contributions and perhaps a lesser portion from the state budget [10].

Was there any involvement of public or private stakeholders?

Public stakeholders apart from the city were few, and the private stakeholders came in the form of philanthropic land owners close by the park system. The exception I guess is the arboretum, with Harvard as a key stakeholder [10].

Rendering of a future project, the Muddy River Restoration, connecting the contemporary Back Bay and Emerald Necklace with the river [20].

City Hall Plaza Green Infrastructure Renovation [17]

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HANNOVER-KRONSBERG, GERMANY

Hannover-Kronsberg (Germany) is a residential area with 3000 dwellings built 1992-2000 as an exhibit for the World Exposition 2000 titled "Mensch-Natur-Technik" (Human – Nature – Technology). Referring to Agenda 21, the Habitat II Modell and the standards for sustainability included in the local Agenda 21 of the Deutsche Städtetag (German Association of Cities), Kronsberg was set out as an innovation project that would combine urban life and sustainable housing. The expo-concept clearly focused on energy efficiency optimization, soil management, rainwater management, waste concepts and environmental communication. Originally a topic of medium importance, rainwater management became one of the central issues as hydrological and technical studies showed that a residential district with standard drainage system in this area would have major impacts on the regional water flows. In order to make construction and development environmentally sound despite this difficult situation, a semi-natural drainage concept was developed to minimize the effects of development on the natural water balance and to safe-guard infiltration and groundwater refill.

Img.09

Img.10

Fig.06 Enhancing Blue-Green and Social Performance in High Density Urban Environments - Case Studies - Project Profile

Hannover Kronsberg

General Information

Geography

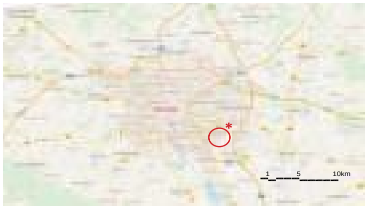
Country/ City:	Germany, Hannover
Geographic coordinates:	52° 22’ 33.21’’ N (DMS Lat), 9° 43’55.24’’ E (DMS Long)
Total Area of the City:	204.13 sq km (Stadt Hannover)
Climate Zone (Koeppen):	Cfb (oceanic)
Rainfall	
Annual:	666 mm
Distribution:	27-76 mm/m in 2014
Number of heavy rains p.a.:	4 events of heavy rain in the last 10 years (<50 L/sqm in 6 h)
Intensity in mm/ 5 min:	n.a.
Net annual water budget:	n.a.
Temperature:	Means Daily Maximum 13,3 °C Daily Minimum 5,2 °C

Location Hannover, Germany

Climate Chart Hannover

Demography

Gross National Product (GNP):	n.a.
GDP per capita:	45,008 € (Region Hannover in 2006)
Human Development Index:	0.916
Population:	515,232 (Stadt Hannover)
Population Density:	1209 p/sq km
Percentage of Green in the city:	Projects: reforestation of 70 hectares of woodland; two green residential parks a 1 ha, 11 km Mulden-Rigolen; two slope boulevards as surface water drains
Percentage of Blue in the city:	n.a


Hannover

* Case Study Hannover Kronsberg

Specific BGI Information

Blue-Green Infrastructure

Size of BGI-project in square meters:	**A residential area of 150 ha with 3000 dwellings for about 7.ooo people**
Owner / investor of the project:	**City of Hannover and Immobilien Development und Beteiligungsgesellschaft Niedersachsen GmbH IDB & Co -Objekt Kronsberg-KG**
Years of construction / completion of the project:	**1999**

What was the motivation for the BGI-project? What were the drivers and what were the arguments? (Please select and describe by using the following topics):

- o Rainwater management — **Balancing of conventional stormwater drainage and semi-natural retention and sewage to stabilize groundwater table on area and in nearby woodland under conditions of poor permeability and hillside situation.**
- o Increasing permeability — **Upgrading of green by provision of trees and plants**
- o Recreation in dense settlements — **New urban settlement in green, semi-central landscape**
- o Renaturation

What are the functionalities of the BGI-project?

- o Retention System, Water Drainage, Open Water System, Closed Water Loop, Climate Change Adaptation — **Limited flow shaft, decentral water retention**
- o Recreation zone — **BGI as part of public and semi-public recreation space**
- o Open space
- o Street greening, green roof — **Mulden-Rigolen-System (Swales/ Underground storage system)**

Which are the main facilities?

- o Playground
- o Community space
- o Cycle path

Site conditions:

- o Surface hard scape/soft scape — **Meager, Unsealed, agricultural area of low-medium quality**
- o Percentage of sealed area/green area — **n.a.**
- o Soil classification: clay, silt, sand, gravel, peat, loam, loess — **limestone marl and chalk**
- o Coefficient of permeability, rain water infiltration rate in l/(s*ha) **3 (-7) l/s+ha)**

Studies made about the BGI-project

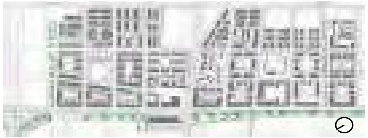
- o Focus of major assessments (e.g., visitor use, biodiversity) — **Well researched as part of World Exposition 2000 – list of studies and literature on request**
- o Major gaps in previous studies
  - **Function of BGI for quality of residents life**
  - **Learning effects in city planning**

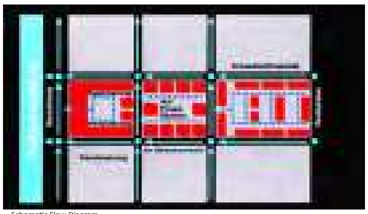
Facility management

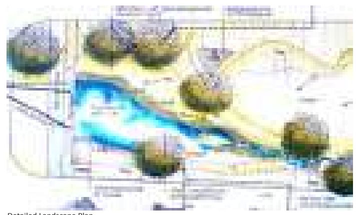
- o Authority or company in charge of maintenance — **Amt für Wasserwirtschaft, City of Hannover**
- o Maintenance costs — **Mulden-Rigolen + residential parks: Ca. 70 T€ p.a.**

Finances:

- o Investment costs for the BGI project — **5.9 mio € for the rainwater system (cheaper than conventional draining)**


Plan View Hannover Kronsberg


Schematic Flow Diagram


Detailed Landscape Plan


Green corridor

Planning policy information

BGI Strategy

Hannover Kronsberg is a pilot-project for ecological construction of new urban settlements as part of World Exposition 2000 in Hannover. The Water concept was ambitious and had great impact on water regulation in Hannover. After Kronsberg construction on-site seepage became the standard technology in new settlements in Hannover. Kronsberg is an important reference project for new technologies for rain water management - Mulden-Rigolen-System and limited flow shaft, decentral water retention – in Germany and in international context.
The water concept was governed by the building plan, the Drainage Regulations for the Regional Capital Hanover (of 16.05.1991) and the Lower Saxony Water regulations (of 25.03.1999). As a consequence rainwater from sealed surfaces had to be channeled into a gulley-and-trench system, there to soak away or be fed at a controlled rate into the public drainage system. The system brings together decentralised retention, as high a level of seepage as possible and strictly-controlled outfall into the public drains.
The Kronsberg settlement was financed by public and private investors. Development costs (c.a. 50 mio €) were covered by return on sales of land hold by City of Hannover to private investors. The was a budget for public communication of ecological issues including construction consultancy for water infrastructure provided by European Union (1,5 mio €). Rain water system was financed by the citywide charge for waste water connection. Maintenance costs for Mulden-Rigolen are covered by the Division for Waste Water Treatment of City of Hannover.
The IDB Niedersachsen mbH -Object Kronsberg (IDB) - a consortium of the Sparkasse Hannover and two local construction companies – was the main private partner of City of Hannover. The IDB owned 30% of Kronsberg Area. The IDB developed its part of Kronsberg according to the building plan and sold smaller blocks to local construction companies. Thereby IDB worked as an important mediator between city planning office and private investors e.g. in negotiation of building requirements in sales contracts.


Inner courtyard pond

Logo Urban Drainage Hannover

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Plan View Hannover Kronsberg: ©Atelier Dreiseitl (2000) [Graphic]
Schematic Flow Diagram: ©Atelier Dreiseitl (2000) [Graphic]
Detailed Landscape Plan: ©Atelier Dreiseitl (2000) [Graphic]
Green corridor:
Inner courtyard pond:
Logo Stadtentwässerung Hannover: [Online]

BISHAN-ANG MO KIO PARK, SINGAPORE

Bishan-Ang Mo Kio Park, Singapore, is a large regional park connecting two residential areas Bishan and Ang Mo Kio (BAMK) that were constructed in the 1970s. In the early 1980s, a concrete canal, which bisected the park, was built for flood mitigation. The canal collected water from the surrounding neighborhoods into the Kallang River basin, a catchment area now used in within Singapore's water reuse system. When Bishan Park was chosen to be one of the first of 20 pilot projects as part of Singapore's national ABC Waters Program[1] in 2006, both the park and the canal had strong need for restoration. The Public Utility Board (PUB), which overseas municipal water management for Singapore, decided that Bishan Park should be a demonstration project that retained the existing functionality of the existing canal while enhancing water quality and mitigating stormwater runoff using additional green design elements. An opportunity was also seen to combine water management functionality while enhancing community activities and recreation. PUB cooperated with the [Singapore's Parks board], and the budgets from each agency were merged. The resulting, [award-winning] design removed the concrete canal, re-using the concrete waste within different features in the landscape. In place of the canal, the landscape was designed to mimic a small, meandering stream, which provides natural cleansing of runoff through bioretention and filtration. During periods of intense rainfall, the height of the stream increases and floods up the banks of the adjacent green space, demonstrating the adaptability of BGI to extreme climate events.

Today the park serves not only as a recreational space for the local residents but as a unique opportunity to revalue nature, animal life and water in Singapore as it transcends boundaries between the park as open public space and the semi-natural canal.

1 The ABC-Waters Program of the Public Utilities Agency aims to integrate urban green and Singaporean water bodies, that is break up the dominant grey and concrete approach for storm water infrastructure and use bio-engineering techniques. It is a big scale policy program with three certain foci: Identify opportunities for BGI in a ABC-Masterplan and start implementing BGI in 100 single projects from 2006 – 2031; Building up engineering capability and engineering culture by ABC Water Guidelines; education for water awareness.

Img.11

Img.12

Fig.07 Enhancing Blue-Green and Social Performance in High Density Urban Environments - Case Studies - Project Profile

Bishan-Ang Mo Kio Park

General Information

Geography

Country/ City: Singapore/ Singapore
Geographic coordinates: 1° 21’ 43.71’’ N (DMS Lat), 103° 50’51.9’’ E (DMS Long)

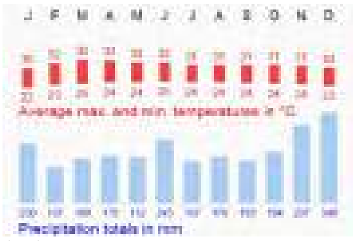
Total Area of the City: 718.3 Sq km (2014, SingStat)

Location Singapore

Climate Zone (Koeppen): Af, tropical rainforest
Rainfall
- Annual: 2357.8 mm (Meteorological Service Singapore)
- Distribution: n.a.
- Number of heavy rains p.a.: 4 in 2013
- Intensity in mm/ 5 min: The maximum hourly rain intensity reached 85 mm/hr (Annual Weather Review 2012 - National Environment Agency)

Net annual water budget: n.a.

Temperature: Means
Daily Maximum 31,6 °C
Daily Minimum 25,3 °C (2014 SingStat)



Climate Chart Singapore

Demography

Gross National Product (GNP): 363827 SGD Million (≈229417 Euro Million) (Tradingeconomics)
GDP per capita: 69,050 SGD (2013, SingStat)
Human Development Index: 0.901 (UNEP)
Population: 5,469,700 (2014, SingStat)
Population Density: 7,615 p/Sq km (2014, SingStat)

Percentage of Blue in the city: 959 ha (amount of water-bodies open for recreational activities) (Sustainable Singapore Blueprint)
Percentage of Green in the city: 2850 ha

Percentage of coverage per Capita of Blue and Green: 6,96 sq m

Map of Singapore * Case Study Bishan-Ang Mo Kio Park

Specific BGI Information

Blue-Green Infrastructure

Size of BGI-project in square meters: 62,000 sq m

Owner / investor of the project: Municipal; NParks + PUB

Years of construction: 2009

completion of the project: 2012

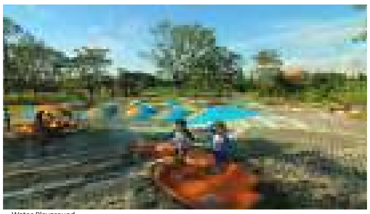
Plan View Bishan-Ang Mo Kio Park

What was the motivation for the BGI-project? What were the drivers and what were the arguments?

- o Adaptation to climate change, urban heat island, etc.
- o Restoration, renaturation of infrastructure
- o Rainwater management (flood prevention, groundwater level, quality improvement)
- o Water pollution, water recycling
- o Recreation in dense settlements
- o Increasing Biodiversity
- o Increasing Permaebility

What are the functionalities of the BGI-project?

- o Rainwater Management (Flood Prevention, Groundwater Level, Quality improvement, etc.)
- o Retention System, Water Drainage, Open Water System, Closed Water Loop, etc.
- o Climate Change Adaptation etc.
- o Recreation zone
- o Open space
- o Urban gardening and farming



Water Playground

Which are the main facilities?
- o Playground, water playground
- o Community space
- o Pet area
- o Wetland biotope/ cleansing biotope
- o Cycle path
- o Sunbathing lawns
- o Cafes

Finances:
- o Investment costs for the BGI project: 68 M

Bioengineered River

Planning policy information

BGI Strategy

Is the project embedded in a citywide BGI-strategy?
Yes, it is part of the Active, Beautiful, Clean Waters (ABC Waters) programme.

Was the project supported or regulated by guidelines, building regulations etc.?
Partly, but it did also function as a pilot project.

Was the project supported by financial government support programs or any tax systems? *It was completely funded by the government.*

Was there any involvement of public or private stakeholders?
Yes, engagement was made with various schools. (Herbert Dreiseitl)

Logo PUB

Logo NParks

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Aerial view Bishan-Ang Mo Kio Park: ©Atelier Dreiseitl (2011) [Photograph]
Water Playground: ©Atelier Dreiseitl (2012) [Photograph]
Bioengineered River: ©Atelier Dreiseitl (2012) [Photograph]
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KHOO TECK PUAT HOSPITAL & YISHUN POND, SINGAPORE

Khoo Teck Puat Hospital (KTPH) and Yishun Pond, Singapore: KTPH is the most recent of seven public hospitals in Singapore. It is set out to widen the perspective on healthcare in Singapore to include healing spaces in which the design of the physical environment actively contributes to wellness. This translated into the integration of biophilic elements. The KTPH design brief spoke explicitly of a patient-centric approach, predicated on access to daylight, ventilation, views, the presence of gardens and nature. Patient and visitor areas are placed around a landscaped central garden. This garden opens up to an adjacent stormwater pond (Yishun Pond) from which it taps vistas and breezes. Visitors from nearby housing estates now use the hospital's public spaces alongside patients and other official visitors. In 2005, KTPH team expanded its blue-green footprint by adopting the adjacent Yishun Pond, linking its central garden to a waterfront promenade overlooking the pond and a walking track around it. The former grey pond now gives a picturesque view as its concrete edge was softened with planting, and artificial floating wetlands were added to the pond.

Img.13

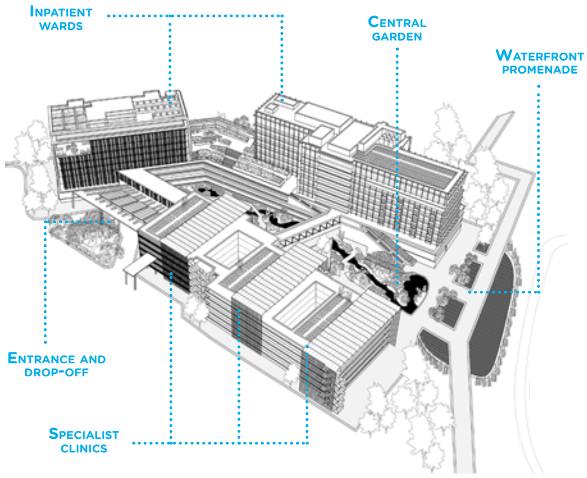


Fig.08

Img.14

Fig.09

Enhancing Blue-Green and Social Performance in High Density Urban Environments - Case Studies - Project Profile

Khoo Teck Puat Hospital

General Information

Geography

Country/ City: Singapore/ Singapore
Geographic coordinates: 1° 21’ 43.71’’ N (DMS Lat), 103° 50’51.9’’ E (DMS Long)

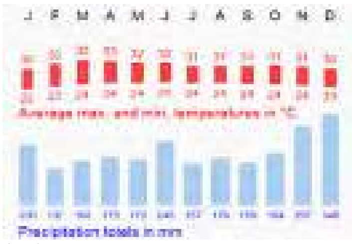
Total Area of the City: 718.3 Sq km (2014, SingStat)

Climate Zone (Koeppen): Af, tropical rainforest
Rainfall
- Annual: 2357.8 mm (Meteorological Service Singapore)
- Distribution: n.a.
- Number of heavy rains p.a.: 4 in 2013
- Intensity in mm/ 5 min: The maximum hourly rain intensity reached 85 mm/hr (Annual Weather Review 2012 - National Environment Agency)

Net annual water budget: n.a.

Temperature: Means
Daily Maximum 31,6 °C
Daily Minimum 25,3 °C (2014 SingStat)

Location Singapore



Climate Chart Singapore

Demography

Gross National Product (GNP): 363827 SGD Million (≈229417 Euro Million) (Tradingeconomics)
GDP per capita: 69,050 SGD (2013, SingStat)
Human Development Index: 0.901 (UNEP)
Population: 5,469,700 (2014, SingStat)
Population Density: 7,615 p/Sq km (2014, SingStat)

Percentage of Blue in the city: 959 ha (amount of waterbodies open for recreational activities) (Sustainable Singapore Blueprint)
Regional Parks Managed by NParks (2012): 2,847.51 ha
Percentage of coverage per Capita of Blue and Green: 6,96 sq m

Map of Singapore

Specific BGI Information

Blue-Green Infrastructure

Size of project in square meters: GFA (Gross Floor Area) - 108,600 m²

Owner / investor of the project (Private, municipal etc.): Fully funded by the Singapore Government

Years of project completion: June 2010
What was the motivation for the BGI-project? What were the drivers and what were the arguments? (Please select and describe by using the following topics):
- o Adaptation to climate change, urban heat island, etc.
- o Reduction of air pollution
- o Restoration, renaturation of infrastructure
- o Rainwater management (flood prevention, groundwater level, quality improvement)
- o Water pollution, water recycling
- o Increasing permeability

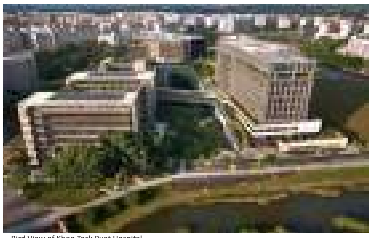
The KTPH brief called for the seven principles of Erik Asmussen healing architecture:
1. The unity of form and function - 2. Polarity - 3. Metamorphosis - 4. Harmony with nature and site - 5. Living wall - 6. Color luminosity and color perspective - 7. Dynamic equilibrium of spatial experience. The hospital was designed to promote natural air movement and use passive elements to reduce heat. The architecture shall be a holistic example of patient-centric approach that speaks to the whole person as a being of body, soul and spirit.

What are the functionalities of the BGI-project?
- o Rainwater Management (Flood Prevention, Groundwater Level, Quality improvement, etc.)
- o Retention System, Water Drainage, Open Water System, Closed Water Loop, etc.
- o Climate Change Adaptation etc.
- o Recreation zone
- o Open space
- o Street greening, green roof
- o Urban gardening and farming

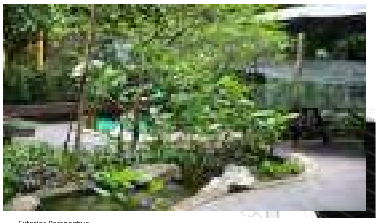
Which are the main facilities?
- o Community space
- o Bicycle Parking stations
- o Cafes
- o Rehab and Geriatric Care Center

Facility management
- o Authority or company in charge of maintenance: KTPH Facilities Management team

Finances:
- o Investment costs for the BGI project : US$ 500,000,000 approximately



Bird View of Khoo Teck Puat Hospital



Exterior Perspective

Exterior View

Planning policy information

BGI Strategy

Is the project embedded in a citywide BGI-strategy?
The project is not embedded in a citywide strategy but targeted at the community-at-large. It is also part of the Active, Beautiful, Clean Waters (ABC Waters) programme

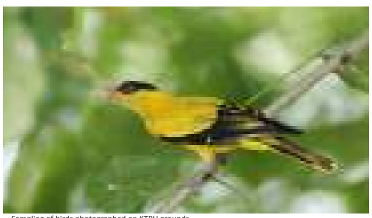
Was the project supported or regulated by guidelines, building regulations etc.?
Yes, the development was regulated by BCA, URA, LTA and other infrastructure planning-related agencies (BCA _ Building & Construction Authority ; URA _ Urban Redevelopment Authority ; LTA _ Land Transport Authority)

Was the project supported by financial government support programs or any tax systems?
Yes, the development was fully funded by the Singapore Government

Was there any involvement of public or private stakeholders?
Yes, engagement was made with various government agencies involved in infrastructure planning and feedback was sought from the community, residents, grassroots and healthcare collaboration partners

KTPH Driving Philosophy
“The driving philosophy behind the transformation of Yishun Pond is the idea of placemaking, which encourages the creation of public spaces to promote active lifestyles and well-being as well as foster a sense of community. It is also part of the Active, Beautiful, Clean Waters (ABC Waters) programme which aims to transform Singapore’s water bodies and create new spaces for recreation and community bonding, turning Singapore into a City of Gardens and Water. With this makeover, Yishun Pond has been transformed into a multi-generational, health-promoting park. Residents in the vicinity and patients at the adjacent Khoo Teck Puat Hospital (KTPH) will be able to use the place for exercise, recreation, interaction and recuperation. The project, focuses on enhancing accessibility, improving water quality, creating new green spaces and encouraging active lifestyles in the community.”

People-friendly spaces within central courtyard



Sampling of birds photographed on KTPH grounds

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Map of Singapore: [Online], Available: https://goo.gl/maps/uoF8j [11.Feb. 2015]
Precipitation Diagram
KTPH Bird View: © Nirmal Kishnani (2012), *Greening Asia,* FuturArc , pp. 166-183 [Photograph]
KTPH Exterior Perspective: © Nirmal Kishnani (2012), *Greening Asia,* FuturArc , pp. 166-183 [Perspective]
KTPH Central courtyard: © Nirmal Kishnani (2012), *Greening Asia,* FuturArc , pp. 166-183 [Photograph]
KTPH Sampling of birds: © Nirmal Kishnani (2012), *Greening Asia,* FuturArc , pp. 166-183 [Photograph]

ULU PANDAN PARK CONNECTOR (UPPC), SINGAPORE

The Ulu Pandan Park Connector (UPPC) in Singapore is a green corridor surrounding the Sungei Ulu Pandan River stretching from Commonwealth Ave West through the Holland Grove estates, crossing Clementi Road and continuing across the Sunset estates and towards Ayer-Rajah Expressway. Two sections were examined: (1) The western section, between Clementi Road and Ayer-Rajah Expressway, is semi-integrated with concrete banks covered in greenery providing a rustic and inviting view. There are also other "Active, Beautiful and Clean Waters"[1] design features, such as vegetated swales and a sedimentations basin. Despite the protective fence, there are at times people walking down to the water to fish. (2) The western section of the UPPC, stretching between Commonwealth Ave West and Clementi Road, consists of a concrete drain without any green cover. The green structure is completely separated and the drain fulfills no other purpose than to transport water during heavy rainfall. No ABC Waters design features have been installed.

Both sections of the UPPC are provided with pathways, benches and exercise stations, enabling social activity and interaction. As Ulu Pandan Park Connector is divided into a semi-integrated part (Ulu Pandan Green) and a part with a pure concrete canal and no green, it (Ulu Pandan Grey) serves as a case to study the effects of blue and green design elements on human use. Areas with no integration and semi-integrated areas were studied separately and compared to Bishan Park (see above), which is an excellent example for full blue-green integration.

1 "ABC Waters", special program to promote blue-green design features in Singapore: http://www.pub.gov.sg/abcwaters/Pages/default.aspx

Img.15

Img.16

Img.17

HAMBURG, GERMANY

Hamburg is situated on the river Elbe and hosts one of the biggest harbors of Europe. Situated only six meters above sea level and increasingly hit by heavy rainfall, severe flooding and associated damages increasingly threaten central Hamburg (e.g. in course of Xaver storm in 2013). The high built density and surface imperviousness increase the risk of flooding. All these factors increased the pressure to adapt the existing rainwater system.
In 2009, Hamburg introduced an initiative to develop a rainwater adaptation plan – RISA – in which all relevant agencies (water, park and urban green, traffic, environment) were required to cooperate and develop comprehensive and holistic guidelines for a satisfactory infrastructure intervention. BGI is expected to have a prominent position in the new design, especially since individual, smaller-scale BGI projects (e.g. Kleine Horst in Hamburg Ohlendorf) have proven to be very successful.[1]

1 Originally we planned to explore the Hamburg case more intensively. The RISA project promised to provide relevant insight. Unfortunately the completion of RISA has been delayed unforeseeably. When RISA results have been published in December 2015 the phase of active research in this research project has already been finished. Therefore we do not discuss RISA in detail. For further information about the RISA please see http://www.risa-hamburg.de/. Nonetheless we provide analysis of the institutional setting of stormwater management in Hamburg and even more extensively in: Schröter, E., Röber, J. (2015): Urban Governance for Livable Cities: Institutional Capacity Building for 'Blue-Green Infrastructure' Planning and Development. Final Report of Ramboll´s Research Project "Enhancing Blue-Green and Social Performance in High Density Urban Environments". Zeppelin University (previously unpublished).

Img.18

Img.19

Fig.10

Enhancing Blue-Green and Social Performance in High Density Urban Environments - Case Studies - Project Profile

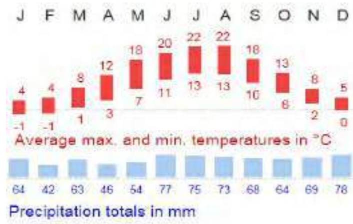
Hamburg RISA

General Information

Geography

Country/ City:	Germany, Hamburg
Geographic coordinates:	53° 33' 2'' N (DMS Lat), 9° 59' 36'' E (DMS Long)
Total Area of the City:	722.22 sq km (2013)
Climate Zone (Koeppen):	Cfb (Marine west coast) [vetmed uni vienna]
Rainfall	
Annual:	681.2 mm (2014) [wetterkontor]
Distribution:	n.a.
Number of heavy rains p.a.:	4 events of heavy rain in 2014 [wzforum]
Intensity in mm/ 5 min:	on June 6th 2011 the max. rainfall intensity in Hamburg City was up to 15.42 mm/5min [Moeller DWD]
Net annual water budget:	n.a.
Temperature:	Means Daily Maximum 12,8 °C Daily Minimum 5,3 °C

Location Hamburg, Germany



Climate Chart Hamburg

Demography

Gross National Product (GNP):	97.731 BIL Euro (2013)
GDP per capita:	55,772 Euro (2013)
Human Development Index:	0.911 (UNEP)
Population:	1,746,342 (2013) [statistik nord]
Population Density:	2,312 p/sq km (2013)
Percentage of Green in the city:	24.6% agricultural area, about 11.34% living/open area without sealed area, 7.8% recreational area, 6.4% forest area, 1% cemetery area and about 0.9% operational area, which is defined as permeable. Adding this up, the total percentage of the permeable area in the city amounts about 52.04%.
Percentage of Blue in the city:	8% [Stadt Hamburg]

Hamburg

* Case Study Hamburg Kleine Horst

Specific BGI Information

Blue-Green Infrastructure

Size of BGI-project in square meters:	**Projects (RISA): RISA is a project carried out by two municipal departments of the city of Hamburg. The project wants to create an official citywide plan for sustainable rain water management. RISA will publish their results in the first half of 2015. This city profile will show you 5 projects, which were followed through by the team of RISA. The area in sum of these 5 BGI projects are in a total about 14.5 ha.**
Owner / investor of the project:	**Behörde für Stadtentwicklung und Umwelt (BSU) and HAMBURG WASSER (HW) (municipal) Examined Projects: RISA (RegenInfraStrukturAnpassung)**
Years of construction / completion of the project:	**The project started in 2009 with a duration planned of 3 years; it was extended and results are expected in the first half of 2015**

What was the motivation for the BGI-project? What were the drivers and what were the arguments?
- Adaptation to climate change
- Rainwater management (flood prevention, groundwater level, quality improvement)
- Recreation in dense settlements
- Renaturation
- Bad infiltration due to sealing

What are the functionalities of the BGI-project?
- Retention System, Water Drainage, Open Water System, Closed Water Loop, etc.
- Climate Change Adaptation etc.
- Recreation
- Green roof
- Floodplain management

Which are the main facilities?
- Playground
- Open space
- Community space
- Pet area
- Wetland biotope
- Cycle path

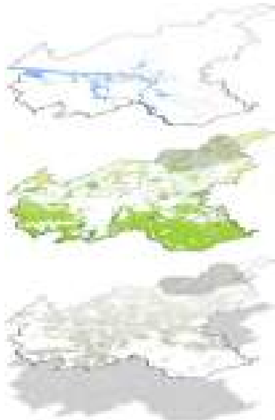
Site conditions:
- Surface hard scape/soft scape/ sealed area/green area

“Kleiner Horst, Ohlsdorf 12”: 9.3ha of a residential complex were planned with sustainable rain water management standards. 12 000m² bodies of water were created, more than 1000m of trough-trench systems were built and 6000m² of retention basins are integrated. “Ohlendorffs Park”: Creation of a new rain water management diverting to prevent the flooding of canalization. Parking of about 0.2ha is being used for retention and infiltration. “Lokstedt 56”: A newly built 4.8ha large residential complex which was also built with rain water management systems to reduce flooding in canalization. For this more than 40 housing complexes in this area have green roofs. “Rainwater playground”: The first rainwater playground in Germany is a future concept for many more playgrounds or other areas that can used for multiple purposes. Rainwater management systems were integrated and the water flows into a nature reserve and is infiltrated for supporting groundwater regeneration. “Elementary school Wegenkamp”: This project should also be a future concept for school yard development. To create a new school yard, Rainwater management systems were installed. This pilot project resulted in a general guideline for sanitation and reconstruction for school grounds.

- Soil classification: clay, silt, sand, gravel, peat, loam, loess **n.a.**
- Water infiltration in meters **“Kleine Horst, Ohlsdorf 12”: 2-5m, “Ohlendorffs Park”: 1-2m, “Lokstedt 56”: 2-5m** Studies made about the BGI-project (topic, observation period, links etc.)
- Focus of major assessments (e.g., visitor use, biodiversity)
- Major gaps in previous studies

Facility management
- Authority or company in charge of maintenance **“Kleine Horst, Ohlsdorf 12”: District and citizens“Ohlendorffs Park”: District “Lokstedt 56”: District and citizens**
- Maintenance costs **n.a.**

Finances:
- Investment costs for the BGI project **“Kleine Horst, Ohlsdorf 12”: ca. 1 000 000€** [Stadt Hamburg]



Water network, landscape, urban planning

Residential development “Kleine Horst” plan view

Surface runoff drainage

Planning policy information

BGI Strategy

Hamburg's RISA Strukturplan – a comprehensive development plan for stormwater infrastructure adaption in the metropolitan region of Hamburg – has led to the establishment of a new foundation for planning and decision-making for sustainable urban design in the city. RISA is a joint project between the municipal water agency, Hamburg Water, and the Hamburg Authority for Urban Development and the Environment.

As a result of this plan, future measures for infrastructural adaption will rely heavily on BGI and decentralized stormwater management and retention. This plan is also guided by the idea of refinancing expenditures for BGI-projects through the costs saved – i.e., the costs that would have been required for enhancement of existing systems, which would have been necessary without BGI.

Rain water collection and infiltration

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Plan View Hannover Kronsberg: ©Atelier Dreiseitl (2000) [Graphic]
Schematic Flow Diagram: ©Atelier Dreiseitl (2000) [Graphic]
Detailed Landscape Plan: ©Atelier Dreiseitl (2000) [Graphic]
Green corridor:
Inner courtyard pond:
Logo Stadtentwässerung Hannover: [Online]

Logo Urban Drainage Hannover

PORTLAND, OREGON, US

Portland is known as one of the most forward-thinking cities in USA in terms of promoting and advocating sustainability. To start, Portland purchased and permanently protected more than 33 km2 of ecologically valuable natural areas from future development and has continued to show a strong support for environmentally conscious land use, including an approach to land conservation and enhancing green areas (Parks Vision 2020). Portland has also emerged as a pioneer in promoting compact city design through municipal policy. In 1996 a Stormwater Policy Advisory Committee (SPAC), with stakeholders from landscape architecture, architecture, engineering, institutional organizations and the stormwater treatment industry was created, that gave important recommendations and guidelines for urban stormwater engineering and design. Meanwhile Portland is also a recognized leader in "green" stormwater management including a number of award-winning BGI projects. These projects include the "Portland Ecoroof Program", the "Green Streets" project and a number of pervious pavement projects. Portland's multi-stakeholder governance structure presents an interesting institutional context in which BGI projects have been successful.

Img.20

Img.21

Img.22

COPENHAGEN, DENMARK

Copenhagen is the capital and most populous city in Denmark. Known internationally as an outstanding example for high livability and future-oriented urban design. Surveys have shown a high degree of public awareness and political support for sustainability- and livability-related issues. Climate adaptation in course of global warming is one of the major topics worthy of special attention in this context as Copenhagen (like several other cities in this study) is a coastal town that is at increased risk from flooding due to the rising sea level combined with increased frequency of extreme precipitation events. Moving to address the increased flooding risks, the Copenhagen Climate Adaptation Plan of October 2011 promoted the incorporation of BGI, especially retention areas, within the urban landscape. Copenhagen is rich in social resources (knowledge, institutional capability, financial capital) that are required in the step-by-step restructuring of the densely populated and built-up inner-city areas, which are also those that have experienced the most frequent and intense flooding. Copenhagen provides an interesting case for examining aspects of political and institutional framing and negotiations of BGI-implementation.

Img.23

Img.24

25

Img.25

NEW YORK CITY, US

New York City has a long tradition of planning and regulation with respect to land use, development and infrastructure. For example, the 1811 Commissioners' Plan for New York laid out Manhattan's infamous rectilinear grid, which facilitated real estate speculation and transaction. In 1916, NYC passed the first local comprehensive zoning ordinance in the United States (City of New York, 2014). Thus, the city's recent BGI planning efforts fit into a long historical context of innovative large-scale land use plans, projects and regulations. New York City has increasingly adopted blue-green infrastructure practices with regards to a broad range of land use types over the last several centuries, with a dramatic increase over the last twenty-five years. NYC provides an excellent example for considering why and how BGI – once an occasional practice - has become increasingly mainstream.

Img.26

Img.27

Fig.11 Blue-Green Infrastructure in NYC: Environmental Governance & Implementation - Case Studies - City Profile

New York

General Information

Geography

Country/ City:	USA/ New York City
Geographic coordinates:	40° 41' 40.07'' N (DMS Lat), 73° 55' 50.76'' W (DMS Long)
Total Area of the City:	783.8 km² (2014, Census)
Climate Zone (Koeppen):	Cfa (Humid Sub-tropical)
Rainfall Annual:	1366.2 mm (2015, NOAA)
Distribution:	
Average days with >=25.4mm (2015, NOAA)	
of rain per anumn:	13.9; max daily accumulation 2014: 127.3mm
of snow per anum:	12; max daily accumulation 2014: 279.4mm
Net annual water budget:	-
Temperature:	See climate table

Demography

GDP per Capita:	68,424 USD (2010, BEA)[a]
Human Development Index:	0.914 (2013, UNDP: USA)[b]
Population:	8,242,624 (2010, Census)
Population Density:	10,516 p/km² (2010, Census)
Percentage of Blue in the city:	--
Percentage of Green in the city:	
Percent tree canopy coverage:	20.9%[c] (2007, USFS)
Percentage of residents within 1/4 mile (402.2m) of a park:	76.6% (2011, PlaNYC)

Location NYC

NOAA[2]: Monthly Climate Normals (1981-2010) - NYC Central Park Area

Specific BGI Information

Blue-Green Infrastructure

Number of BGI-projects: 5 under direct city management

Size of BGI-projects in square meters: incomplete data, minimum estimate: 997,948m²[d]

Description of the different BGI-projects

- o Years of construction: see timeline
- o Main drivers of BGI projects:
  - Rainwater management: CSO, right-of-way bioswales
  - Health concerns, reduction of air pollution, UHI: city greening projects
  - Urban revitalization, community building: productive greenspaces
- o Facility management, functionaries of projects[e]:

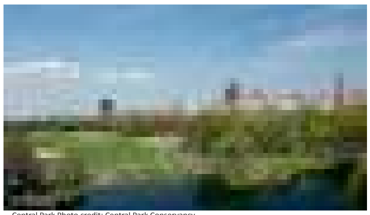
[illegible]

- o Finances[e]:

[illegible] [7,8] [8] [9] [g]

- o Studies made about the BGI-projects
  - MillionTreesNYC: 2007 report by USDA-FS on New York's urban forest: http://www.milliontreesnyc.org/downloads/pdf/nyc_mfra.pdf
  - Gaps
    - breadth of green roofing
    - awaiting long term planning evaluation of Green Infrastructure program


City Map New York City


Central Park Photo credit: Central Park Conservancy


Blue-green roof on Osborne Associates building, Bronx, NY; Photo credit: NYC DEP


Bioswale in Rego Park, Queens, NY; Photo credit: NYC DEP


Greenthumb community garden in Crown Heights, Brooklyn, NY; 1100 Block Bergen Association

Planning policy information

BGI Strategy

Does the city dispose of a citywide-BGI strategy, guidelines or components for BGI?

Specific to green infrastructure, the city has a twenty-year plan managed by the Department of Environmental Protection (DEP). This plan includes aggressive development of stormwater management infrastructure (2014, DEP).

Does the city have any specific regulations and building permissions, which influence the development of BGI projects?

Bioswales controlled are governed by a specific set of possible designs (2014, DEP). There are also standards for cool roofing to be eligible for incentive plans (2010, Buildings).

Are there any tax systems or regulations for BGI?

There was a green roof tax incentive pilot program (2008-2013) that provided a one year tax subsidy of $4.50 per square foot for qualifying green roofs (2010, Buildings). It was meant to end in 2013, but was extended by act of New York State Legislature through 2018 (2013, NY State).

Was there any involvement of public or private stakeholders?

Yes, a number of tax-exempt organizations (public bodies) are involved in funding and maintenance of NY BGI projects, including the City Parks Foundation, NY Restoration Project, and GrowNYC. The MillionTrees campaign (NYRP) is a public-private effort.


Timeline of recent BGI projects; Credit: Evangeline McGlynn

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Notes

[a] Calculated from population of NYC metropolitan area, 19,567,410 from 25 counties
[b] There is a separate US-specific HDI maintained by Measure of America, at which NYC Metro scores 6.12, ranking 5th among US cities
[c] Since the date of study more than 800,000 trees have been planted by the MillionTreesNYC program
[d] Based on reported acrage of greenstreets and Greenthumb gardens, plus DEP's reported number of Bioswales, green roofs, blue roofs, porous pavement and tree pits estimated at the size of the smallest bioswale design, 50 square feet (4.6 square meters).
[e] Draftv021015, do not cite, quote or distribute. Klein Rosenthal, McGlynn, Keesler, 2015
[g] Greening Western Queens was part of the legal settlement following the 2006 blackouts between ConEdison and impacted communities

JAKARTA, INDONESIA

Jakarta is just in the middle of tremendous and rapid growth and densification. While the number of malls and urban plazas has increased, interstitial spaces between buildings and urban infrastructure – which the majority of citizens from Jakarta depend on for social intercourse – dropped from 250 km2 to 51 km2. With this, there has been a substantial loss of green space – from 24% to 9.9% of city area – with a parallel loss of the water footprint from 4% to 2.5%. Green space available to the poor is estimated at 0.19 m2/capita, while the affluent have 6.53. Yet Jakarta was once described as a water city, and the value of water is deeply rooted in local culture and religion. In the recent past, however, the city's rapid development and policy response has altered this relationship generating new anxieties and phobias for water. Factories, buildings and roads have turned rivers into narrow concrete, polluted canals. Access to rivers and green space has decreased. These changes have triggered a change in habits – a new generation of Jakartans pollutes rivers with garbage and sewage without a second thought. The waterways have lost their social value, becoming an open dump. Hydrological problems have worsened: fewer canals and less greenery have resulted in increased flood frequency and intensity. During flood events, water moves rubbish and pollution into the city water-grid which attracts mosquitos that spread bone diseases, affecting mainly children. Unfortunately, Jakarta's recent history demonstrates how quickly water can transition from a culturally important resource into an afterthought. Jakarta presents an important case for understanding the challenges that rapid urbanization present to BGI implementation. It illustrates some of the largest challenges in successful BGI implementation while providing an opportunity for BGI advocates to innovate and adapt existing projects to new contexts.

Img.28

Img.29

Fig.12

Enhancing Blue-Green and Social Performance in High Density Urban Environments - Recent Issue - City Profile

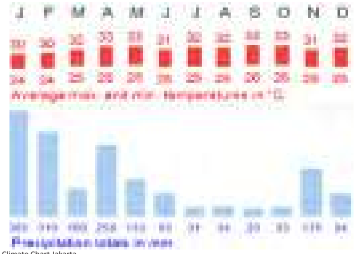
Jakarta

General Information

Geography

Country/ City:	Indonesia / Jakarta
Geographic coordinates:	6°12′S 106°49′E
Total Area of the City:	662.3 sq km (1)
Average Altitude:	7m above sea level
Climate Zone (Koeppen):	Am, Tropical Monsoon Climate
Rainfall	
Annual:	2528 mm(1)
Distribution:	see climate chart
Number of heavy rains p.a.:	n.a.
Intensity in mm/month:	The highest rainfall intensity reached 621,9 mm/month on January and the lowest was 49,5 mm/month on September (1)
Net annual water budget:	n.a.
Temperature:	Daily mean 27,6°C Average High 31,8°C Average Low 25,0 °C (2)

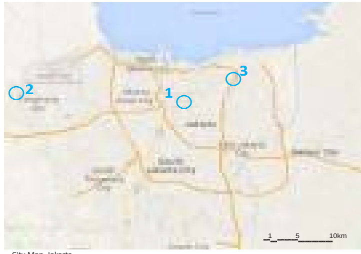
Location Jakarta



Climate Chart Jakarta

Demography

Gross National Product (GNP):	130.8 billion US$ (Tradingeconomics)
GDP per capita:	11,500 US$
Human Development Index:	0.617 (2011)
Population:	10.1 million
Population Density:	average 15,234 p/sq km, peak 48,952 p/sq km
Percentage of Blue in the city:	2,5 %
Percentage of Green in the city:	10 %
Green space per capita per capita:	6,53 sq m



City Map Jakarta

Flood Information

Flooding in 2015

Date Occur:	Rainfall began on February 8th, 2015 Flood began on February 9th, 2015(3)
Rainfall figures:	Soekarno-Hatta Airport 79 mm Observatory 370 mm Tanjung Priok (North Jakarta) 310 mm (4)
Subdistrict Flooded:	97 (out of total 267 in Jakarta)
People Affected by Flood:	Around 15,517 people are affected directly by the flood as their houses are inundated close to 6,000 peolple have been displaced
Total Flood Prone:	49
Depth of flood:	50-80 cm (4)
Damage:	**$235 million**

Flooding Problem

The main caused of flooding problem: (6)

- 40% of Jakarta, particularly the northern areas, is below sea level
- Land Subsidence, during 36 years, land subsidence in north Jakarta has reached 4m (1970-2010).
- Jakarta is the estuary of the 13 rivers which have the catchment area of 850 sq km
- Changes in Land Use (for residential and industrial)
  Vast amount of land up will certainly affect the rate of surface runoff. The rapid growth of development caused by the rapid growth of population.
- Decreasing of the flow capacity of the river due to sediment and informal settlement
  The capacity of the river reduced by sedimentation and also narrowed because of the slum settlement along the river. For example, Ciliwung River have less than 30m width from 50m width.

History of major flooding in Jakarta since 20th century: (5)

- 1918
  Extensive flooding. The Dutch colonial government begins work on the Western Flood Canal
- 1996
  A flood sweeps through the capital. Approximately 10 people died.
- 2002
  The Dartmouth Flood Observatory notes it as the largest flood in Jakarta's history, 25 people died.
- 2007
  the greatest flood in the last three centuries inundated about 40 % of the city, killed 80 people and forced about 340.000 to flee
- 2013
  Starting on 16 Jan 2013, heavy trains triggered extensive flooding in the greater Jakarta area. As of 22 Jan, 29 people had been killed and over 37,000 people had been displaced.

1 A view of a flooded roundabout is seen after heavy overnight rains brought flooding to parts of the city, paralyzing traffic, in Jakarta on Feb. 9. —Zabur Karuru/Antara Foto/Reuters

2 Temporary lake: A car is submerged in floodwater in a housing complex in Periuk, Tangerang, Banten, on Wednesday. Water from the overflowing Sabi River inundated the housing complex, with depths reaching up to 2 meters. (Antara/ Lucky R.)

3 Clogged and blocked: Workers remove trash from the Sunter River in North Jakarta on Wednesday. After floodwaters receded in the Sunter area, a pileup of garbage appeared in the river. (JP/PJ Leo)

Planning policy information

Goverment Strategy

Government Programme: (7)

- Jakarta Urgent Flood Management Programme (JUFMP)
  is a five-year World Bank-funded project aimed at priority areas in Jakarta's flood management systems.
    Removing 2 metres of sediment build-up and rehabilitating inoperable pumps.
    About 67.5 km of 11 key channel sections and 65 hectares of four retention basins will be dredged, to help restore their operating capacities.
    About 42 km of embankments will also be repaired in these sections
  Most of the rehabilitation activities under the project are expected to be completed in the three years between 2012 and 2015.
- The Jakarta Coastal Development Strategy (JCDS)
  The Jakarta Coastal Development Strategy (JCDS) was formulated in 2011, after the Indonesian and Dutch government signed a Memorandum of Understanding in 2007.
    Phase 1 : Sea & River dikes, Retention Ponds, Pumping Station (8)
    Phase 2 : Further Sea & River dikes, Retention Ponds, Pumping Station
    Phase 3 : Construction of giant seawall along Jakarta Bay and includes retention ponds and pumps designed to remove 500 cubic meters of water per second. (The Great Garuda)

Topography Map of Jakarta: http://image.slidesharecdn.com/studentcasestudy-jakartaindonesia-130207080730-phpapp01/95/student-case-study-jakarta-indonesia-5-638.jpg%3Fcb%3D1360246104

Land Subsidence: The flooding city of JAKARTA; May 2013, Pemerintah Provinsi DKI Jakarta Badan Penanggulangan Bencana Daerah

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(2) Wikipedia, [Online], Available: http://en.wikipedia.org/wiki/Jakarta [February 11st,2014]
(3) The Watchers, Jakarta flooded as peak rainy season approaches, Indonesia [Online], Available: http://thewatchers.adorraeli.com/2015/02/09/jakarta-flooded-as-peak-rainy-season-approaches-indonesia/ [February 11st,2014]
(4) Floodlist, Indonesia Floods – Jakarta Under 80cm Flood Water [Online], Available: http://floodlist.com/asia/jakarta-floods-80cm-deep [February 11st,2014]
(5) Jakarta Flood Hazard Mapping Framework : Brinkman, JanJaap (Deltares) and Hartman, Marco (HKV consultants) [Online], Available : http://www.hkv.nl/site/hkv/upload/publication/Jakarta_Flood_Hazard_Mapping_Framework_MH.pdf
(6) The Flooding City of Jakarta: BPBD DKI Jakarta (2013)
(7) Floodlist, Indonesia's Ambitious Plans to Reduce Jakarta Flooding [Online], Available: http://floodlist.com/asia/plans-reduce-jakarta-flooding [February 11st,2014]
(8) Jakarta Coastal Defence Strategy (JCDS) Study, Sinking Cities - Jakarta: JanJaap Brinkman, Deltares (2012)

Figures
(1) World Map: Schernau, Bernd (2014) [Graphic].
(2) Climate Chart Jakarta: [Online], Available: http://www.weather-and-climate.com/average-monthly-Rainfall-Temperature-Sunshine,Jakarta,Indonesia [February 11st,2014]
(3) Map of Jakarta: [Online], Available: https://goo.gl/maps/hfl1x

MUMBAI, INDIA

Mumbai was selected as a case study for several reasons. First, it has a suite of blue-green infrastructure systems that include headwaters that are protected as a National Park, stream corridors that radiate from those headwaters through the city, and a variety of urban coastal areas some of which have mangrove tidal flats. Second, these systems face enormous pressures and are not yet integrated in a metropolitan-scale BGI system. Third, this is one of only two case studies in the Ramboll project involving a megacity in a rapidly developing country.[1] And finally, notwithstanding these distinctive aspects of Mumbai, it also offers valuable comparisons, for example, with Singapore, Boston, Copenhagen, and Jakarta, all of which have long histories of urban environmental planning and coastal land reclamation. Mumbai is thus a model and problematic case study where much is at stake in BGI protection and integration.

1 The second megacity in a rapidly developing country included in the Ramboll project is the aforementioned Jakarta.

Img.30

Img.31

Img.32

CHAPTER 2

DETAILED DEFINITION OF BLUE-GREEN INFRASTRUCTURE

CHARACTER AND FUNCTION OF BLUE-GREEN INFRASTRUCTURE

The main constraints on implementing sustainable urban stormwater and environmental management in a changing climate are not technological. Rather, they involve shifts in vision, policy, design, and the urban planning culture.

LIVEABLE

SUSTAINABLE

RESILIENT

The topic of green infrastructure is now a well-established concept in urban environmental planning, policy, research, and design, while awareness and understanding of its potential benefits for ecology and society have increased. The term green infrastructure often refers to projects that include vegetated design elements such as parks, green roofs, greenbelts, alleys, vertical and horizontal gardens and planters. Such green infrastructures are recognized and intensively discussed with respect to the ecosystem services they provide – services that are especially valuable in densely populated urban areas.

However, "green" infrastructure is a bit of a misnomer, as infrastructures of this type are often closely linked with and even defined by "blue" processes. Blue infrastructure technically refers to infrastructure related to the hydrological functions, including rainwater and urban storm water systems as well as surface water and groundwater aquifers. In urban design blue infrastructure is traditionally discussed as a matter of resilient provision for water supply and water security. Such water infrastructure may be natural, adapted or man-made and provides functions of slowing down, decentralization and spreading, soaking into the underground, evaporating and releasing water into the natural water environment. This includes flow control, detention, retention, filtration, infiltration and different forms of water treatment like reuse and recycling. In general, blue infrastructure provides services for both aspects of quantity and quality control.

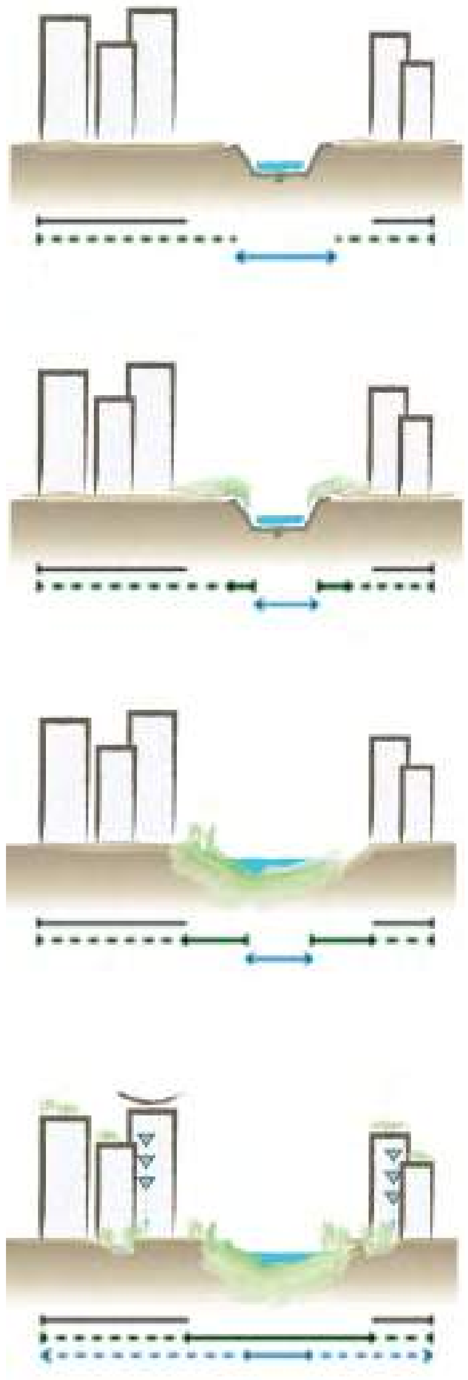
The Blue-Green Infrastructure (BGI)[1] paradigm marries these two types of infrastructures and values together in a union that is greater than the sum of its parts. BGI integrates hydrological and biological water treatment trains into systems where green features are seamlessly overlapping with blue features. Together blue and green infrastructures strengthen urban ecosystems by evoking natural processes in man-made environments and combine the demands of sustainable water and storm water management with the demands of urban planning and urban life. The hypothesis is that such systems have positive impacts on the urban metabolism of natural resources (added green values) and on the experience and behaviour of people using these infrastructures (added social values). (See Fig. 13)

BGI is highly valuable to make cities more liveable, sustainable and resilient.

1 We use "blue-green infrastructure" synonymously with "sustainable urban drainage", "low impact development", "water sensitive urban design", "Water Sensitive Cities", "Modified rainwater management" while acknowledging that some differences may exist in the localized use of these terms, as described by Fletcher, T. D., Shuster, W., Hunt, W. F., Ashley, R., Butler, D., Arthur, S., Trowsdale, S., Barraud, S., Semadeni-Davies, A., Bertrand-Krajewski, J. L., Mikkelsen, P. S., Rivard, G., Uhl, M., Dagenais, D., Viklander, M. (2015): SUDS, LID, BMPs, WSUD and more. The evolution and application of terminology surrounding urban drainage. Urban Water Journal, 12(7), 525-542.

The most defining quality of BGI is the overlapping of blue and green features and processes that provide relevant functions and services.

This graphic illustrates the gradient from the "grey" subset of blue infrastructure through to fully integrated blue-green infrastructure:



→ The "grey" subset of blue infrastructure alone (at the top), to

→ Blue and green infrastructure adjacent but functionally separated from each other (second from top), to

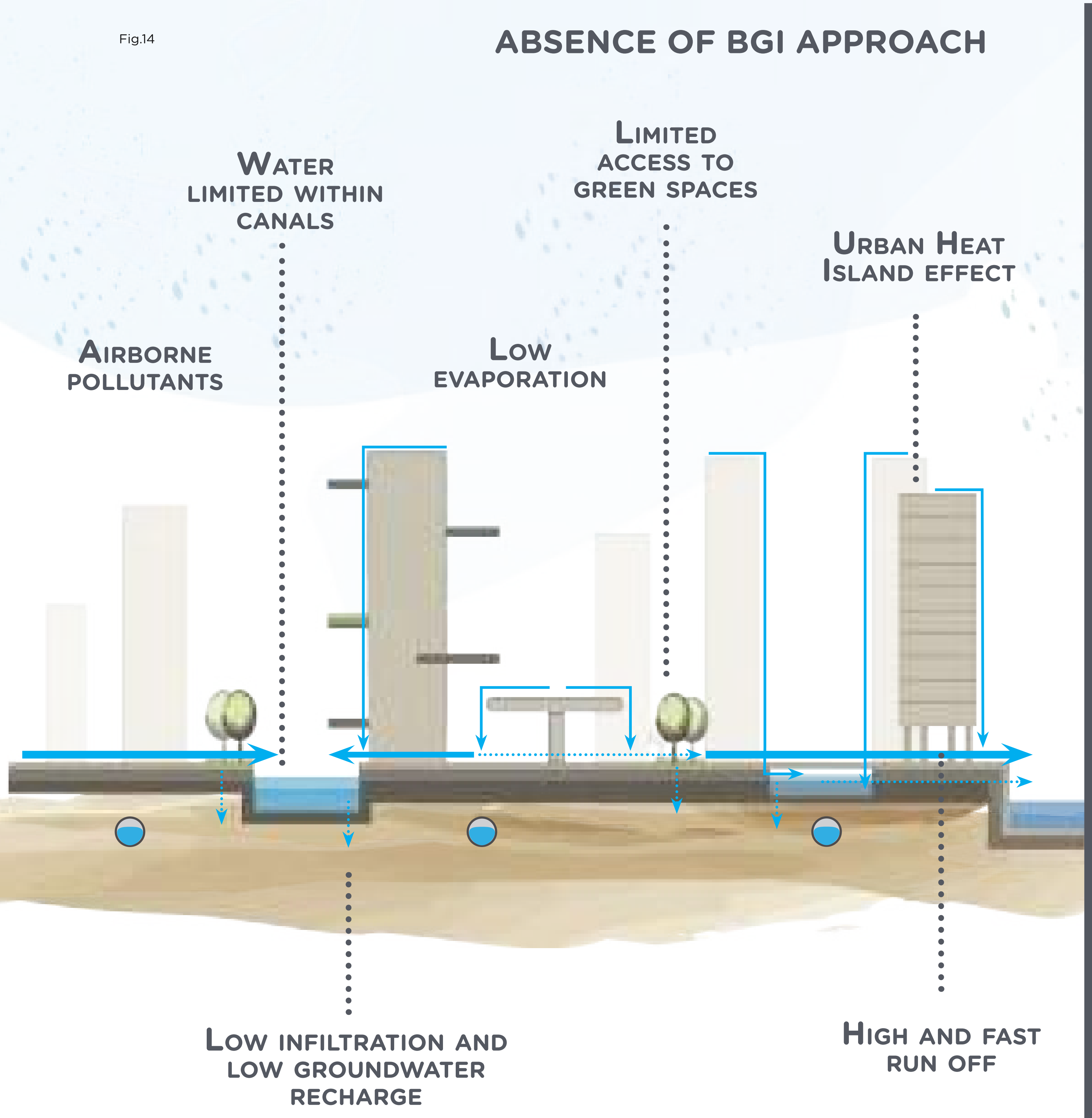
→ Overlapping blue and green infrastructure in a riverbed with green banks (second from bottom), and to

→ Full integration of blue-green stormwater management from rooftops and vertical gardens to drainage systems within the urban structure (bottom).

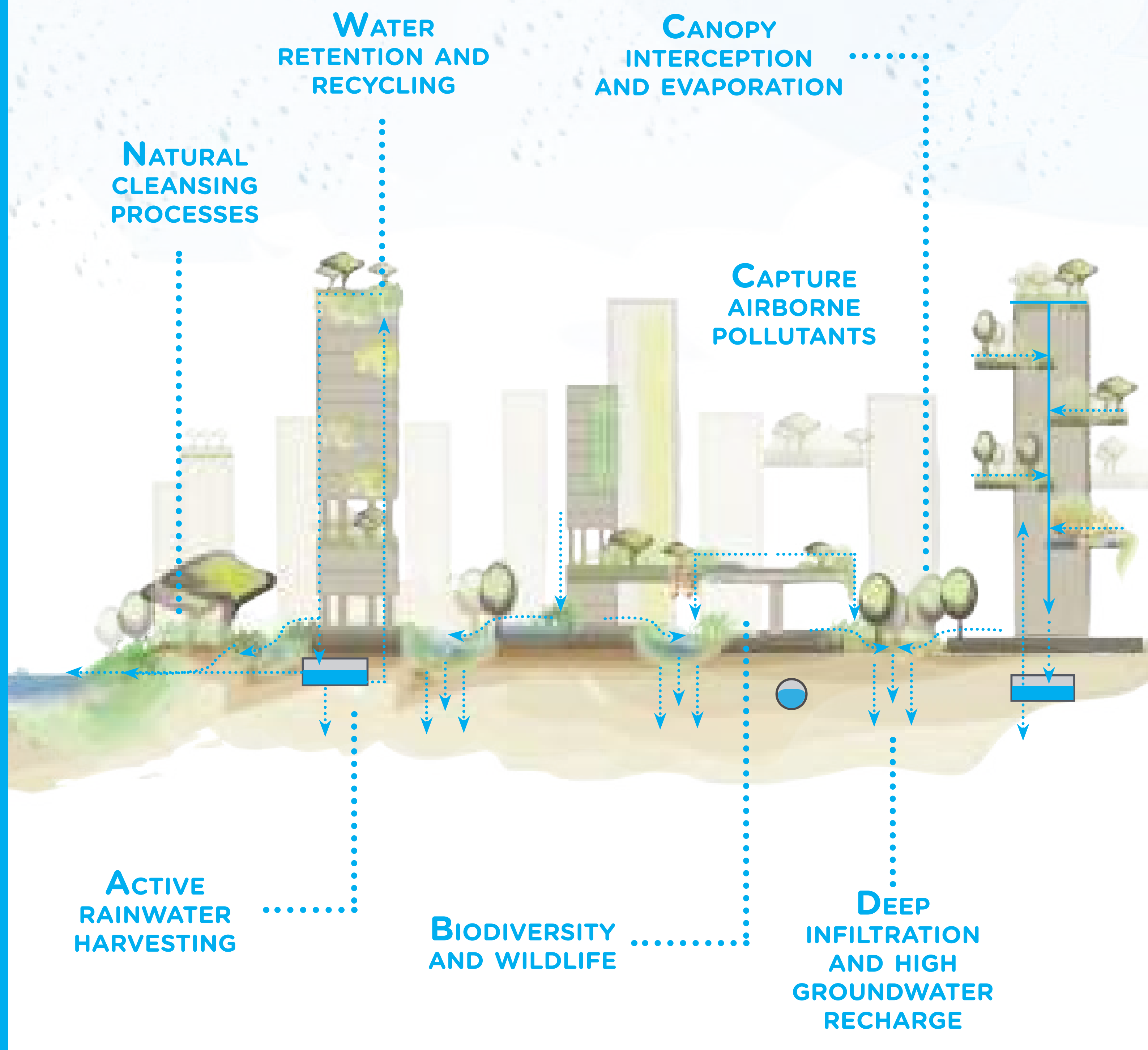
Fig.13 Blue-Green Infrastructure: Gradient from separated to integrated BGI (Herbert Dreiseitl)

HOW THE BGI APPROACH EVOLVED

Fig.14



INTEGRATED BGI APPROACH



BGI BACKGROUND

PRE-INDUSTRIAL | 1850 | 1858 | 1863 | 1890 | 1912

Fig.15

Throughout the evolution of cities, securing sufficient water supply for health, hygiene, and the economy has been a defining challenge (see Fig. 14 and Fig. 15). The era of early industrialization in cities saw a focus on hygiene, with a key environmental concern of creating “sanitary cities”.[1] As the populations of cities like London, Paris and New York burgeoned, the frequency and intensity of epidemics of water-borne diseases such as cholera, typhoid, and dysentery also increased. Throughout most of the 19th century, germ theory was unknown. Instead, the popular theory was that disease was spread through bad vapors or miasmas.. As a consequence municipal authorities promoted public health by putting sewage underground. The goal of that time was to collect as much wastewater into sewerage infrastructures and to convey it away from the city as quickly as possible (typically into an open body of water downstream).

While freshwater features have played a variety of important roles in cities, including for transportation, water supply, or waste conveyance, they are often plagued with all varieties of urban pollution. As such, water features in large, densely populated cities are often not associated with the most positive aesthetics. Only after the know-how for safe water treatments was developed on a larger scale and sewage treatment plants were installed, was it possible to think about water as a valuable and desirable recreational nexus within the urban landscape.

Today we are one step further. The goal of blue-green infrastructure is to mimic and recreate more natural hydrology within the urban context while contributing to additional urban services such as recreation and quality of life. The aim of BGI is to contribute to:

- Conservation of the water balance within urban developments;
- Improvement of water quality by including appropriate treatment methods, such as filtration and/or retention;
- Reduction of rain and stormwater runoff and peak flows by implementing detention and retention measures locally as well as through increasing pervious surfaces;
- Mitigation of the need for drainage infrastructure and associated costs, whilst improving local water reuse; and
- Integration of stormwater management into the urban landscape by designing multiple use infrastructures that enhance the visual aesthetics and recreational amenities of urban areas.

1 Melosi, M. V. (2005): The Sanitary City: Environmental Services in Early America from Colonial Times to the Present. University of Pittsburgh Press: Pittsburgh.

Img.33

BGI IN URBAN DESIGN AND WATER MANAGEMENT

Blue-green infrastructure projects support the transition of the urban water management paradigm from large, centralized[1], technical solutions towards a more integrated approach, exemplified by multi-purpose BGI systems that enhance urban liveability, sustainability and quality of life.

The approach to water in urban management has been paradoxical. On the one hand, water has been regarded as a primary, life-giving resource; on the other, as a source of disease or catastrophic flooding. Conventional water management has primarily focused on designing and constructing infrastructure that subverts the vagaries of nature to the control of the engineer.

1 Yet ironically, these large, "centralized" infrastructures are often isolated.

ROOF ELEMENTS

Roof systems are ideal places to locate water management tools because they help reduce runoff peak flows while also enhancing green areas in dense cities, alleviating heat island

Img.34

Img.35

ROADSIDE BIORETENTION BASINS

Other moments in ground surfaces, like roadsides also provide key opportunities for BGI tools to help reduce peak flows and add value to hardscape dominated zones

LANDSCAPE SURFACE ELEMENTS

Crucial for BGI is the design of the space between buildings on ground surfaces because they should perform as an infrastructure braid between people water and nature

Img.36

Img.37

LANDSCAPE WATER SYSTEMS

Neighborhoods in urban design frameworks should benefit from open spaces that incorporate blue-green features that enhance community life and environmental benefits

Fig.16 **BGI TOOLKIT**

This supply, drainage and sewerage approach to water infrastructure was driven by a narrow focus on getting the water in and out. In focusing only on a few aspects of the water cycle, this conventional approach has not only missed opportunities to enhance urban water quality and reuse, it has also led to the destruction of natural habitat which has unintentionally decreased the resilience of urban water systems.

The premise of BGI supports the ideal of a transition from a technical approach to urban water management focused on inputs and outputs, towards a more holistic approach. The result of a wider adoption and implementation of BGI will be a more resilient urbanwater cycle and water-conscious cities.[1]

BGI – namely, the mimicry of natural hydrology and ecology through engineered systems - is an important manifestation of a larger paradigm shift within integrated water resources management[2] as well as in a larger movement towards sustainable development.

As demonstrated by the principles of *Water Sensitive Urban Design* [3], methods and technologies that were once primarily the domain of the civil engineer are expanding to include a much broader array of disciplines. This adds a level of complexity never-before seen in the stormwater management discourse, particularly with regards to aesthetics and open space planning. And it implies an array of challenges and obstacles to overcome, but with commensurate opportunities for innovation and improvement – in short, an exciting intention.

The next chapters will talk about the challenges but also what enhances and supports the successful implementation of blue and green infrastructure, and recommendations drawn from the case studies research.

1 Brown, R. R., Clarke, J. M. (2007): Transition to water sensitive urban design: The story of Melbourne, Australia (Vol. 7, No. 1). Melbourne: Facility for Advancing Water Biofiltration, Monash University.

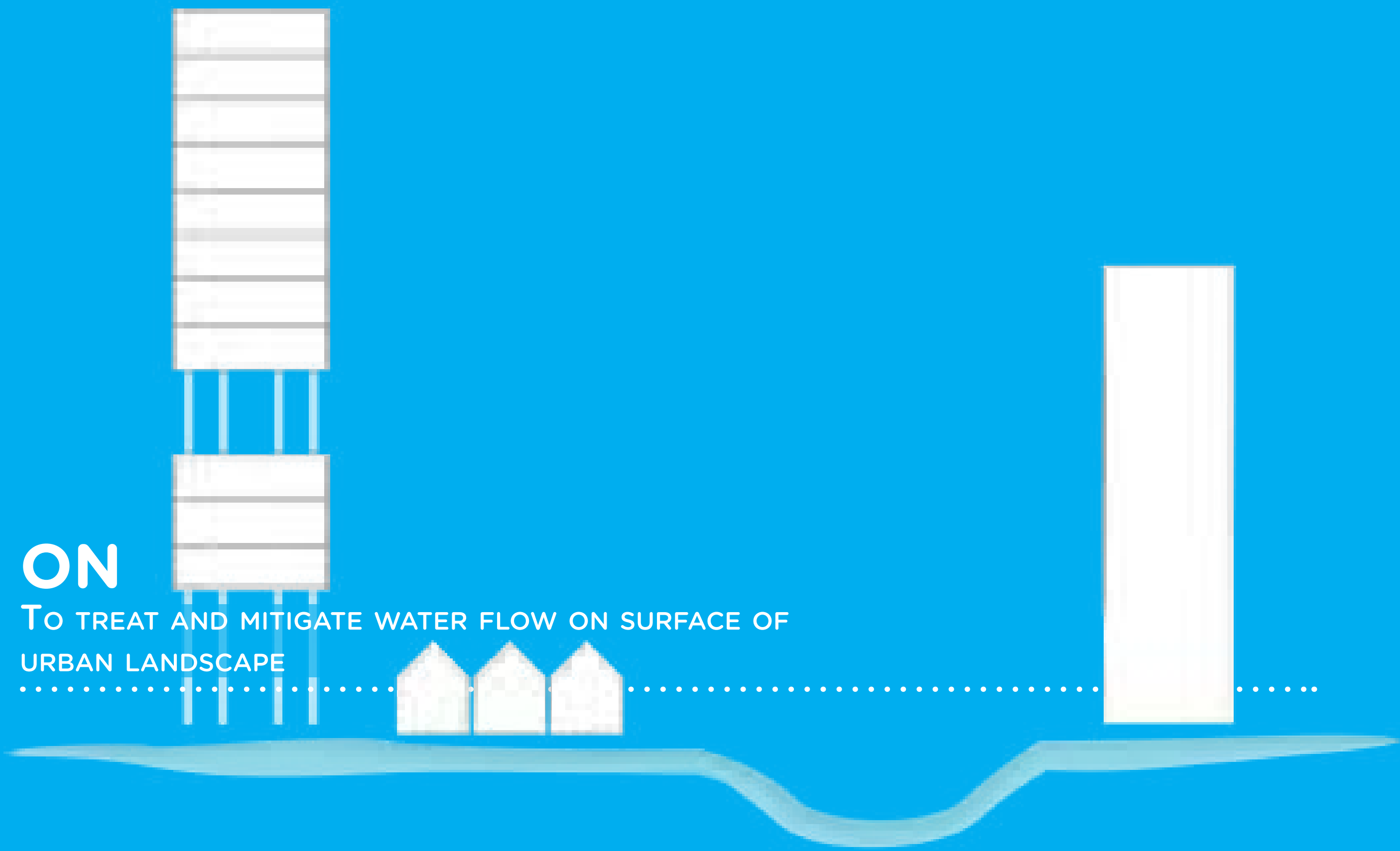
2 E.g. as promoted in the European Water Framework Directive: Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy. http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32000L0060

3 Wong, T. H. (2006): Water sensitive urban design-the journey thus far. Australian Journal of Water Resources, 10(3), 213; and Wong, T. H. F., & Brown, R. R. (2009): The water sensitive city: principles for practice. Water Science and Technology, 60(3), 673.

SCALES OF IMPACT

OVER

RAINWATER, GREYWATER AND BLACKWATER TREATED ON BUILDING SCALE



ON

TO TREAT AND MITIGATE WATER FLOW ON SURFACE OF URBAN LANDSCAPE

UNDER

UNDERGROUND WATER TREATMENT AND STORAGE

Fig.17

Img.38

GREEN ROOF SYSTEM
Tools located at the top of buildings are key elements that help reduce the amount of runoff before it reaches urban systems on the ground level.

Img.39

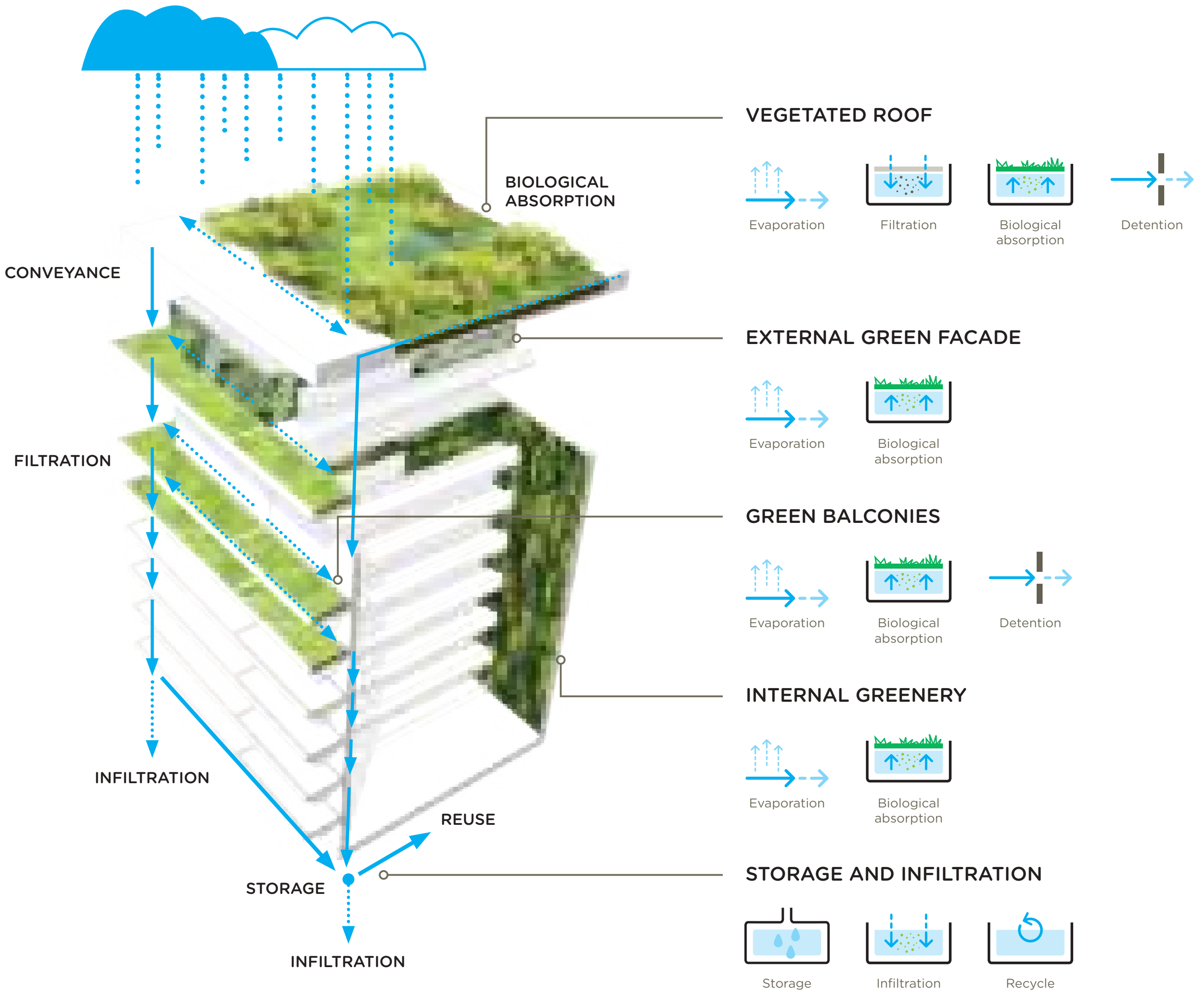
FACADE ELEMENTS
Planter boxes and other facade elements are additional tools that can be accommodated on buildings to reduce peak runoff, cleanse water, improve air quality of cities, reduce urban heat island effect, etc.

Img.40

UNDER AND ON THE LAND
Surface features on the ground and beneath buildings are key landscape moments that integrate buildings with landscape, water systems and other urban infrastructures. They are crucial design moments for BGI and urban landscape design connectivity.

BGI SOLUTIONS ON DIFFERENT SCALES

Fig.18 **BUILDING SCALE**

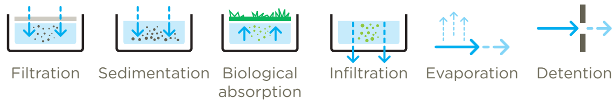


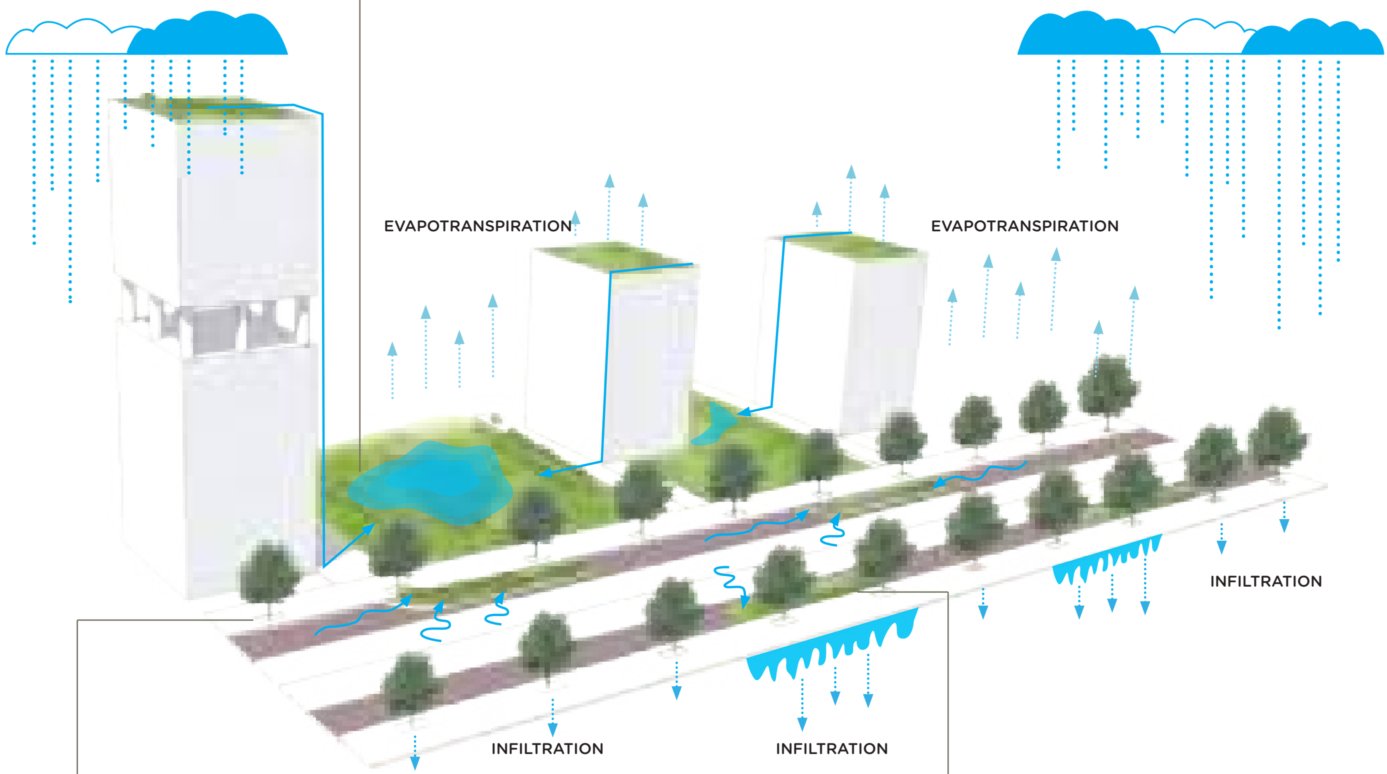
Rainwater can be treated on the building scale by using vegetated roofs, external green facades, having plants on balconies and internal greenery. Within the building, rainwater can be stored, recycled, cleaned and additionally infiltrated into the groundwater.

Img.41 **BOSCO VERTICALE**
Stefano Boeri Architetti, Milan, Italy. Green balconies and external green facade elements are useful examples of BGI tools at the building scale.

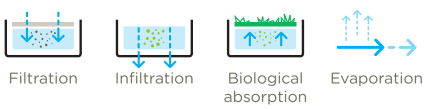
Fig.19 **NEIGHBORHOOD SCALE**

Urban Vegetated Waterbodies
Urban Parks and Vegetated Water-bodies enhance urban beauty, control erosion and regulate water flow and sedimentation.

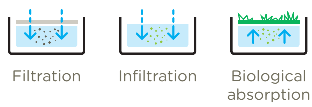




Urban Trees
Tree Boxes control stormwater runoff. They are connected to Rain Gardens and help to filter and lessen runoff.



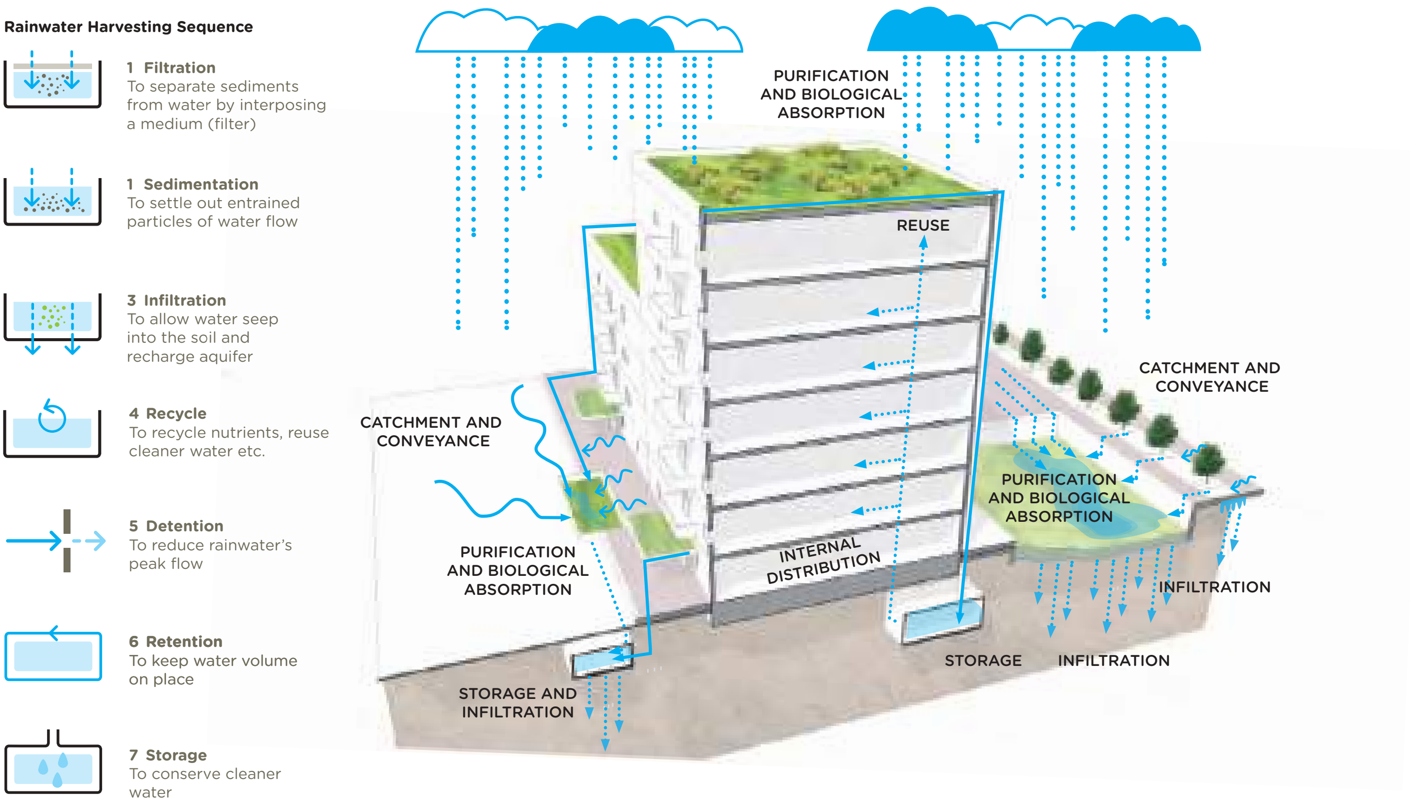
Urban Gardens
Rain Gardens treat stormwater runoff. Impurities are removed through filtration, sedimentation and biological absorption. They reduce flow speed and encourage infiltration while beautifying landscapes.



Within a neighborhood, the space between the buildings shall be used to provide detention and retention services for stormwater by implementing vegetated waterbodies and urban gardens, as well as tree-lined avenues.

Evapotranspiration
The sum of evaporation and plant transpiration from the Earth's land and ocean surface to the atmosphere.

Fig.20 **UNDERGROUND SCALE**



Rainwater harvesting provides an independent water supply through accumulation and deposition of rainwater for reuse on-site. The process consists of catchment, conveyance, filtration and sedimentation, purification (by biological absorption), and finally distribution of the clean rainwater.

With suitable underground conditions such as efficient permeability and no pollution, the purified rainwater is a very good option for refilling the groundwater aquifer.

Img.43

CHAPTER 3

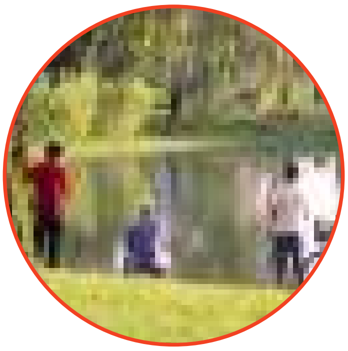
CHALLENGES CITIES ARE FACING TODAY

INTRODUCTION

BLUE
WATER RESOURCES

GREEN
NATURAL HABITAT

RED
PEOPLE'S WELL-BEING



Urbanization increases the density of built infrastructure, which is accompanied by the loss, not only of blue and green spaces, but of social interaction and other changes to the cultural fabric that negatively impact the well-being of city dwellers. These impacts are often disproportionately borne by the poor. It is also widely acknowledged that urbanization exerts immense pressures on ecosystems, natural capital, and global nutrient cycles.[1] These pressures have altered ecosystem functioning, resulting in immense changes to regional and global biodiversity as well as a significant loss of species, which is occurring at a rate not seen since the last mass extinction.

Urbanization also had a tremendous impact on quality of life and lifestyles over the last century. The world´s urban population has dramatically increased from 746 million in 1950 to 3.9 billion in 2014. Asia is home to 53% of the world's urban population, followed by Europe (14%), and Latin America and the Caribbean (13%). Urban growth is not expected to occur uniformly; some regions will grow faster and larger than others. For instance, India, China and Nigeria are expected to host 37% of the projected worldwide population growth by 2050.[2]

Many cities, particularly in Asia, are currently experiencing an unprecedented urbanization speed and the trend is expected to continue as the share of Asia's population living in urban areas is low relative to that in the rest of the world.[3] For example, the population in urban areas in Indonesia increased by 42% between 1950 and 2010[4].

This rapid urbanization has been to the detriment of green spaces, public health and water quality.

While urbanization is associated with a number of negative connotations, it is accompanied by some positive changes, as well. For instance, the use of resources tends to be more efficient as population density increases, as does the efficiency with which the resources are provided. Urban dwellers have access to a higher density of economic opportunities and access to cultural capital than their rural neighbors.

Cities may also represent a new opportunity for re-integrating blue and green spaces into the built environment. However, one of the largest challenges of urban development is the provision of adequate

1 Grimm et al., (2008): "Global Change and the Ecology of Cities", Science, 319 (5864): 756-760.
2 United Nations "World Urbanization Prospects: The 2014 Revision, Highlights. Department of Economic and Social Affairs." Population Division, United Nations. 2014.
3 Asian Development Bank. "Green Urbanization in Asia - Key Indicators for Asia and the Pacific" 2012 http://www.adb.org/sites/default/files/publication/29940/ki2012.pdf
4 Human spaces report (2015): "The Global Impact of Biophilic Design in the Workplace". See http://humanspaces.com/report/

Fig.21

and secure accommodation for all urban dwellers, and to promote a healthy environment. This includes the provision of safe and resilient climate-adapted structures, as well as accessibility to public blue-green spaces. [5]

In summary, rapid urban growth poses enormous challenges worldwide, which are simultaneously concerning water quality and quantity, environmental degradation and social issues. At the same time, many cities have currently untapped blue, green, and social resources to address these challenges.

5 WHO "Health Indicators of sustainable cities" (2012): See http://www.who.int/hia/green_economy/indicators_cities.pdf

The city of Copenhagen, for example, reacted to its vulnerability to extreme rainfall events with its Climate Adaptation Plan[6] and the Cloudburst Adaptation Plan[7]. These plans add blue and green layers of infrastructures to the city as a system to support underground pipes to prevent floods and increase quality of life.

Each of the BGI case studies highlighted in this report shows how the integration of Blue-Green helped the city to address urban challenges and the ways in which obstacles were approached and overcome.

6 City of Copenhagen (2011): "Copenhagen Climate Adaptation Plan." See: http://international.kk.dk/artikel/climate-adaptation
7 The City of Copenhagen (2012): "Cloudburst Management Plan." See: http://en.klimatilpasning.dk/media/665626/cph_-_cloudburst_management_plan.pdf

Img.44

THE GREEN IMPERATIVE

GREEN IMPERATIVE
GREENERY AND ECOLOGY

Biophilic design is an approach that targets and enhances biophilic response and therefore results in positive feelings and experiences, for instance, calmness or satisfaction, and improves overall health and well-being .

During the last century, urbanization has been associated with a loss of green spaces in cities around the world. For instance, in Jakarta, green space has decreased from 24% to 9.9% of city area (Figure 22).[1] This loss and fragmentation of green spaces has negatively impacted not only biodiversity and ecosystem health but also human well-being.

A connection to the natural environment appears to be a crucial element in people's lives. E.O. Wilson, pioneering ecologist and conservation advocate, discussed the relationship between people and nature in his 1984 book, Biophilia, in which he argued that humans have an innate tendency to focus on life and life-like processes.[2]

Indeed, there is growing evidence that the affinity of people for nature is more than just a romantic notion or aesthetic preference. While it can be difficult to quantify directly, the importance of nature to human health and well-being becomes especially apparent when response to individuals given access to nature is compared to the lack thereof. The journalist Richard Louv popularized the term nature deficit disorder to describe the associated costs of human alienation from the natural world, and attributed a variety of mental and physical disorders to it.[3]

In contrast, access to natural outdoor elements is associated with a variety of improved psychological outcomes such as stress reduction.[4] In another recent study, a survey of 10,000 adults in the United Kingdom, found lower mental distress and higher self-reported life satisfaction to be correlated with residence in urban areas with greater amounts of green space.[5]

Other research has shown that well-managed parks and green areas provide communities with a sense of place and belonging, opportunities for recreation, health, fitness and social cohesion[6] besides all other ecosystem services like improvement of air etc. they are delivering. Environmental psychology research has demonstrated that access to natural systems allows for psychological restoration. Research into the relationship between human health, well-being and nature is an ongoing and active area of research in a variety of academic fields, including neuroscience, psychology, and epidemiology.

Biophilic design is an approach that targets and enhances biophilic response and therefore results in positive feelings and experiences, for instance, calmness or satisfaction, and improves overall health and well-being.[7] BGI is a design approach that facilitates blue-green integration in the urban fabric and enhances human connection to nature. Therefore, biophilia and the BGI approach have significant overlap. In addition to providing positive benefits for urban water management and ecosystem health, and injecting greenery in the urban environment through design elements that allow direct connection to nature, BGI enhances human health and well-being.

In another study on American hospitals it was estimated that if patients were offered views of nature, it could save USD 93 million per year in healthcare costs.[8] In the same study, it was argued that Singapore's reputation as a global hub for business is tied directly to its urban greenery, which increases its attraction to businesses (and is thus an example of symbolic and financial capital), as Singapore continues to "identify greenery as part of a strategy to lure investment, and drive economic growth that concurrently increases quality of life and delivers more business to the city every year." (ibid, p. 25) .

As the relationship between biophilia and health and well-being becomes better understood, the value of including BGI in urban spaces (and the consequences of overlooking it) will become more apparent. After all, an ounce of prevention is worth a pound of cure (or more).

1 Drawing from the MSc ISD programme 2015 at the National University of Singapore based on data from Nasa Earth Observatory.
2 Wilson, E. O. (1984): Biophilia. Cambridge, MA: Harvard University Press
3 Louv, R. (2005): Last Child in the Wood, 1st ed; Algonquin Books: New York, NY, USA, 2005.
4 Alcock, I. (2014): "Longitudinal Effects on Mental Health of Moving to Greener and Less Green Urban Areas." Environmental Science & Technology, 48: 1247-1255.
5 White, M. P., Alcock, I., Wheeler, B. W., & Depledge, M. H. (2013): "Would you be happier living in a greener urban area? A fixed-effects analysis of panel data." Psychological science, 0956797612464659.
6 Roe, J. J., Thompson, C. W., Aspinall, P. A., Brewer, M. J., Duff, E. I., Miller, D., Mitchell R., Clow, A. (2013): Green space and stress: Evidence from cortisol measures in deprived urban communities. International journal of environmental research and public health, 10(9), 4086-4103.
7 Kellert, S. R., Heerwagen, J. H., and Mador, M. L. (2015): "Biophilic design" (2008): See http:// www. biophilicdesign. net/ and Human spaces report. "The Global Impact of Biophilic Design in the Workplace". 2015 See http://humanspaces.com/report/
8 Terrapin Bright Green (2012): The Economics of Biophilia: Why designing with nature in mind makes financial sense. See http://www.terrapinbrightgreen.com/wp-content/uploads/2012/06/The-Economics-of-Biophilia_Terrapin-Bright-Green-2012e.pdf

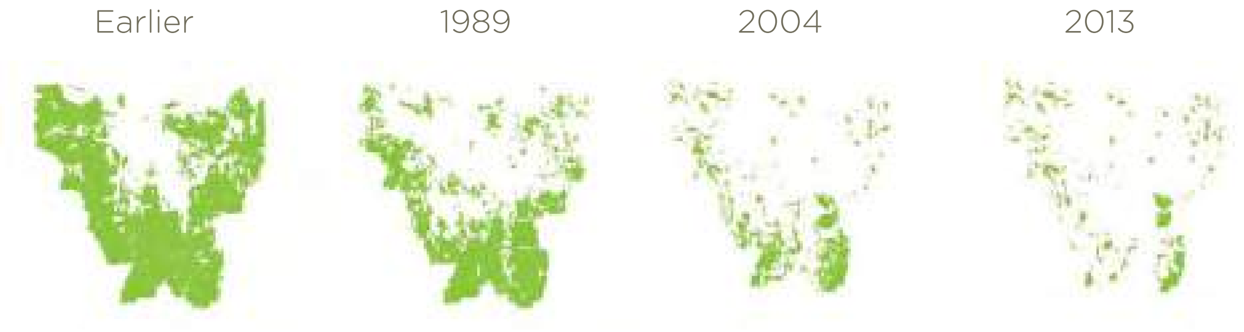


Fig.22 Jakarta, Indonesia, Loss of Urban Greenery within Jakarta city limits (NUS, Msc ISD, 2015)

Fig.22A

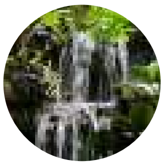
WHY IS BIODIVERSITY OF KEY CONCERN TO URBAN QUALITY OF LIFE?

1. Biodiversity loss reduces ecosystem functioning, such as resource collection and storage, biomass production, decomposition and nutrient recycling. A recent review by Cardinale et al.[1] points to increasing evidence that this statement is applicable across different natural ecosystems and groups of organisms in natural ecosystems. We suggest that the role of biodiversity to maintain ecosystem functions is also applicable to urban ecosystems like cities.

1 Cardinale, B. J., Duffy, J. E., Gonzalez, A., Hooper, D. U., Perrings, C., Venail,P., Narwani, A., Mace, G.M., Tilman, D., Wardle, D.A., Kinzig, A.P., Daily, G.C., Loreau, M., Grace, J.B., Larigauderie, A., Srivastava, D.S., Naeem, S. (2012). Biodiversity loss and its impact on humanity. Nature, 486(7401), 59-67.

2. Biodiversity loss reduces stability of ecosystems to shocks or stress: There is also adequate evidence that a high level of biodiversity increases ecosystem resilience and therefore is essential to reducing adverse impacts from both natural and anthropogenic stresses, e.g. those arising from temporal and spatial variation of temperature, precipitation, human activities, disease outbreak, etc.[1]

1 Cardinale, B. J., Duffy, J. E., Gonzalez, A., Hooper, D. U., Perrings, C., Venail,P., Narwani, A., Mace, G.M., Tilman, D., Wardle, D.A., Kinzig, A.P., Daily, G.C., Loreau, M., Grace, J.B., Larigauderie, A., Srivastava, D.S., Naeem, S. (2012). Biodiversity loss and its impact on humanity. Nature, 486(7401), 59-67. Naeem, S., & Li, S. (1997). Biodiversity enhances ecosystem reliability. Nature, 390(6659), 507-509. Steudel, B., Hector, A., Friedl, T., Löfke, C., Lorenz, M., Wesche, M., & Kessler, M. (2012). Biodiversity effects on ecosystem functioning change along environmental stress gradients. Ecology letters, 15(12), 1397-1405.



3. Global biodiversity loss has become a key environmental driver of change: While climate change as a global environment stressor has now been entrenched as focal area of scientific and policy studies, recent evidence now points to biodiversity loss becoming a key environmental driver in its own right,[1] i.e. that biodiversity can drive urban ecosystem functions.

1 Cardinale, B. J., Duffy, J. E., Gonzalez, A., Hooper, D. U., Perrings, C., Venail,P., Narwani, A., Mace, G.M., Tilman, D., Wardle, D.A., Kinzig, A.P., Daily, G.C., Loreau, M., Grace, J.B., Larigauderie, A., Srivastava, D.S., Naeem, S. (2012). Biodiversity loss and its impact on humanity. Nature, 486(7401), 59-67.

4. Impoverished urban biodiversity has negative impacts on human well-being: This follows logically from the above statements. Biodiversity is an important component of the value-delivery chain from ecosystem to human: ecosystem processes are critical for human well-being through ecosystem services; since biodiversity is critical for ecosystem function and resilience, it follows that it is critical for human well-being as well. The effects are both direct and indirect.

The following case studies provide insight into specific challenges these cities are facing concerning their green infrastructure.

SINGAPORE

Singapore is a useful case for examining urban blue and green infrastructure:

High-density urban environment. Singapore pays regard to balancing demands of compactness and decentralization. Over the next 15 years, three new hubs are planned to support further growth in the commercial, retail, and entertainment sectors to provide all citizens with inner-city amenities and access to public transport while keeping urban sprawl limited according to demands of future sustainability and development.[1]

Policy framework on the use of greenery in the built environment. Since 1963, when the Garden City concept[2] was first proposed, over 80% of Singaporeans live within 10 minutes walking distance of a park or green space. Singapore aims to increase this to 90% by 2030.[3]

Singapore's policy on urban greening is discussed in the context of the six capitals:

- Human: surveys report on benefits of park use on well-being and satisfaction

- Natural: interest in the cooling effects of greenery on urban systems

- Social: proximity of green spaces and parks to public housing is seen to facilitate community interaction

- Financial: Singapore's brand as Asia's 'Garden City' has increased the attractiveness of the city to tourists, business looking for a base in Asia, talented individuals seeking to move to/within Asia

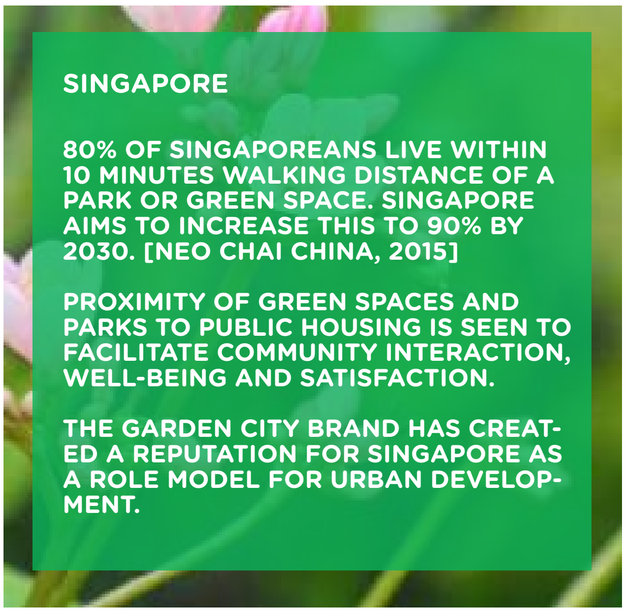
1 Urban Redevelopment Agency (2012): "DESIGNING OUR CITY. Planning for a sustainable Singapore." https://www.ura.gov.sg/skyline/skyline12/skyline12-03/special/URA_Designing%20our%20City%20Supplement_July12.pdf
2 The "garden city" vision was introduced by then Prime Minister Lee Kuan Yew on 11 May 1967 to transform Singapore into a city with abundant lush greenery and a clean environment in order to make life more pleasant for the people, http://eresources.nlb.gov.sg/history/events/a7fac49f-9c96-4030-8709-ce160c58d15c
3 See Ministry of the Environment and Water Resources et al. (2014): "Our Home, Our Environment, Our Future. Sustainable Singapore Blueprint 2015." http://www.mewr.gov.sg/ssb/files/ssb2015.pdf

- Symbolic: the Garden City brand has created a reputation for Singapore as a role model for urban development

- Built: Singapore currently has more than 350 parks that cover more than 2000 ha. It has 17 reservoirs, 32 rivers and over 8000 km of waterways.

Singapore's policy on greenery and water has seen expansion and integration in the last 15 years. There is policy rhetoric on its transition from Garden City to City in a Garden. This refers first to an intensification and distribution of greenery, for instance, integration with buildings (walls and roofs).[1]

1 National Park Boards (2009): "Creating a Variety of Streetscapes." Singapore Government. Accessed August 1, 2012. http://www.ura.gov.sg/pwbid/pwb-streetgreen.htm; National Parks. 2009a. Trees of Our Garden City. Singapore: NParks; National Parks Board. 2011. "National Parks Board" Singapore Government. Accessed August 1, 2012. http://www.nparks.gov.sg/; National Parks Board. 2012a. "Park Connector Network." Singapore Government. Accessed August 1,2012; National Parks Board. 2012b. "Skyrise Greenery Award." Singapore Government. Accessed August 1, 2012.



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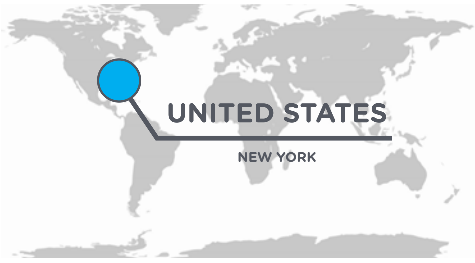


NEW YORK CITY

New York City (NYC) presents a particularly interesting case study of blue-green infrastructure development in modern global cities. NYC is the most populous city in the United States (US), with over eight million residents, according to the 2010 US Census. The area of NYC is 783.8 km2, and its tree canopy covers approximately 20.9% of this area (USFS, 2007)[1]. NYC is located on the northern boundary of the humid sub-tropical climatic zone, with an average of 13.9 days of precipitation greater than 25.4 mm for rain and 12 days for snow.[2]

1 USFS (U.S. Forest Service) (2007): Assessing Urban Forest Effects and Values: New York City's Urban Forest. United States Department of Agriculture. Retrieved from: http://www.milliontreesnyc.org/downloads/pdf/ufore_study.pdf
2 NOAA (2015): Climatalogical Report (annual).
Retrieved from: http://forecast.weather.gov/product.php?site=NWS&issuedby=NYC&product=CLA&format=CI&version=1&glossary=1&highlight=off

Water has always been a crucial element for the city of NY. The topic of water quality was central to the US environmental movement since its inception. Blue-green infrastructure practices have increasingly been adopted on a broad range of land use types over the last several centuries, with a dramatic increase over the last twenty-five years.

Central Park is an example of this approach for blue-green infrastructure. Central Park was among the first major BGI projects in NYC, designed in 1858 by Frederick Law Olmsted and Calvert Vaux, "the winners of a design competition, along with other socially conscious reformers (who) understood that the creation of a great public park would improve public health and contribute greatly to the formation of a civil society".[3]

3 Central Park Conservancy (2015): History. Accessed June 18, 2015 from http://www.centralparknyc.org/about/history.html

Img.44b

BOSTON

The Imagine Boston 2030[1] planning study announcement gives a sense of major challenges facing Boston today. It identifies eight major themes:

1. Housing: Building the housing that keeps Boston accessible to all.

2. Mobility: Creating an efficient, equitable, sustainable transportation system.

3. Environment and Adaptation: Using our natural resources wisely while preparing for the impacts of a changing climate.

4. Parks and Open Space: Providing world-class spaces for recreation and public life.

5. Prosperity and Equity: Creating jobs and supporting education and workforce development infrastructure to broaden economic opportunity.

6. Arts, Culture and Creativity: Enriching Boston and harnessing our creative potential in all endeavor.

7. Land Use, Design and Placemaking: Building on a rich tradition of creating vibrant urban places and neighborhoods

8. Health: Improving and sustaining the health of our population.

The Parks and Open Space theme is most closely associated with BGI, but it is framed in the old language of parks and open space rather than the BGI ideals of urban landscape restoration, biophilia, and ecosystem services. Each of the other themes can be associated with and positively affected by blue-green infrastructure. For example, Housing can acquire greater value through BGI, and climate adaptation can be enhanced by BGI. The arts, culture, creativity, and placemaking goals are all advanced by BGI. The rapidly growing field of the health benefits of environmental design can also be directly linked with BGI. However, the text of current plans indicates that these connections need to be made far more explicit than they are at present.

1 City of Boston (2015): Imagine Boston 2030. http://imagine.boston.gov, accessed October 12, 2015

THE BLUE IMPERATIVE

BLUE IMPERATIVE

WATER AND HYDROLOGY

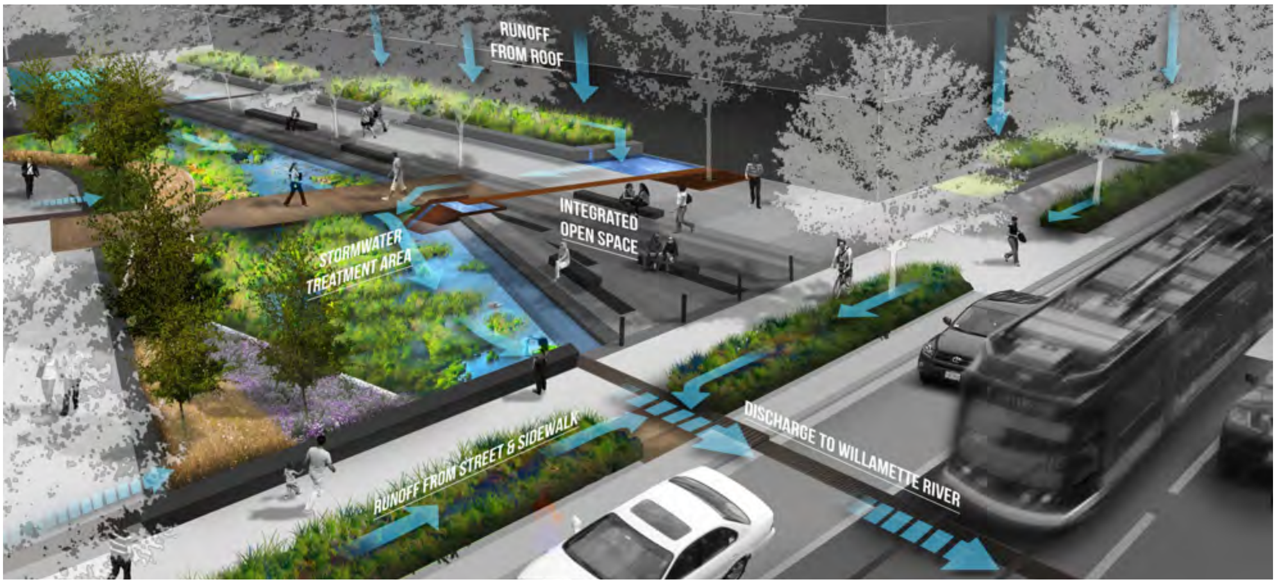
Water is life. Humans need it for metabolic processes, thermoregulation, the conveyance of nutrients, and the ejection of toxins. Its value is reflected in the inclusion and importance of its role in cultures and religions around the world. Whether celebrated (e.g. Songkran Festival, Thailand), revered (e.g. River Ganges, India), or directing architectural aesthetics (Feng Shui, China), water is a substance key to the commonplace as well as the sacred.[1]

There has always been a strong connection between cities, culture and water. Most cities are built near a river, lake, or sea. The ways that cities manage water have undergone several distinctive shifts ever since humans began to live in urban areas. While managing water simultaneously as a critical resource for survival and as a hazard will always remain a key challenge, there have nevertheless been periodic transitions in the approach to control and use of water in urban design.

Changes in the predominant focus of urban water management have been described as: an early preoccupation on water supply access and security for sustenance, to public health protection, flood protection, and pollution management for waterways protection, and more recently to sustainable urban water management in the form of "water sensitive city".[2] These shifts occurred as a response to a suite of socio-political and socio-ecological drivers, and are usually intertwined with the emerging urban development goals of urban sustainability, resilience and liveability.

1 See FuturArc (May June, 2014): Letter from the Editor.

2 See: Brown, R., Keath, N., & Wong, T. (2009): Urban water management in cities: historical, current and future regimes. Wong, T. H. F., & Brown, R. R. (2009): The water sensitive city: principles for practice. Water Science and Technology, 60(3), 673.



Img.45

Changes in water management also mirror the transition in key environmental concerns. The focus of the previous two centuries on the “sanitary” city was driven by the need to deal with the unprecedented production and accumulation of toxic waste that was a natural, though unintended, consequence of the Industrial Revolution. A variety of changes in technologies and policies have in general improved sanitation within cities, at least within the boundaries of the cities. In many cases these changes led to urban waste being externalized, leading to environmental damage at an entirely different scale. As the set of negative environmental impacts that are associated with urbanization grows, awareness has increased that (as mentioned earlier) policy must move beyond a focus on urban inputs and outputs towards a more holistic view. This awareness has transformed the dialogue from a concern with the sanitary to a focus on sustainability.

The challenge for urban decision-makers is to go beyond mitigating the ills of industrial cities, towards developing adaptive management to reduce demands on resources, reducing waste, managing disturbances, and leveraging on ecological processes in cities.[1]

The concept of blue infrastructure is not yet as widely used and understood as green infrastructure. However, as awareness of its many potential benefits increases, BGI is receiving increasing interest from the public health and international development sectors. Because the BGI approach gives focus to the local water balance, including hydrological functioning, it is well-suited to being implemented at a variety of scales, including smaller scales. This is in contrast to the more conventional grey approach to blue infrastructure, which is implemented at a very large scale with a high degree of centralization and therefore requires substantial upfront financial investment and political backing. Securing sufficient financing for large infrastructure projects is notoriously problematic for many developing countries.

As described in Chapter 2, BGI contributes to a variety of hydrologic functions, including slowing down and reducing runoff, groundwater recharge, local storage, evaporative cooling, and improving water quality. While BGI will not eliminate large infrastructure projects, it can substantially reduce the size of the conventional grey infrastructure required and also push back the need for such an investment. It can be implemented at a variety of spatial scales and in a decentralized way.

As mentioned, cities in developing country contexts, such as the Jakarta and Mumbai cases present substantial challenges and obstacles to successful BGI implementation. However, for the reasons just described (such as the ability to implement on a small scale in a decentralized manner), the BGI approach to infrastructure might be particularly well-suited to these contexts. And because these cities often have particularly acute environmental and health issues, the potential benefits of a successful BGI project are substantial.

Since many of these rapidly developing cities have not been able to increase traditional grey infrastructure as quickly as the demand, there often exists a variety of decentralized built infrastructure, the functioning of which could be enhanced with BGI. An example of this is described for the case of Mumbai.

1 Childers, D. L., Pickett, S. T. A., Grove, J. M., Ogden, L., Whitmer, A. (2014): Advancing urban sustainability theory and action: Challenges and opportunities, Landscape and Urban Planning 125:320-328.

Img.45a

JAKARTA

Jakarta has a footprint of 660 km2 and a population of 10.1 million. From 1989 to 2013 its urban density rose from 10,075 to 13,157 people/km2, with peak density now close to 50,000 people/km2.[1]

With this, there has been a substantial loss of green space – from 24% to 9.9% of city area – with a parallel loss of the water footprint from 4% to 2.5%. Green space available to the poor is estimated at 0.19 m2/capita.[2]

Jakarta was once described as a water city. Rooted in culture and religion, water was positively perceived. The city's development has altered this relationship creating new anxieties and phobias for water. Factories, buildings and roads have turned rivers in narrow concrete, polluted canals. Access to rivers and green space has been reduced.

These changes have triggered a change in habits; a new generation of Jakartans pollute rivers with garbage and sewage. The waterways have lost their social value, becoming an open dump.

Hydrological problems have worsened: fewer canals and less greenery have resulted in increased flood frequency and intensity. During flood events, water moves rubbish and pollution into the city´s water-grid, which attracts mosquitos that spread bone diseases, affecting mainly children.

1 D.E.Herwindiati, S.M.Isa, D.Arisandi (2011): The Robust Classification for Large Data. Proceedings of the World Congress of Engineering 2011 volume III.
2 "Beban Berat Jakarta" accessed on December 20, 2013, http://epaper1.kompas.com/kompas/books/131220kompas/#/1/

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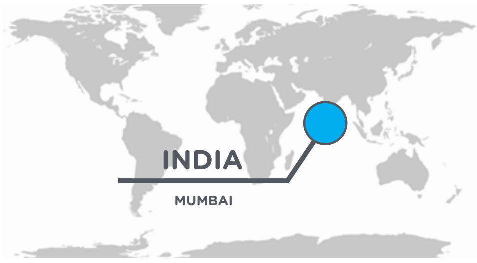


MUMBAI

Studies show that the impact of sea level rise and escalating storms will affect many coastal Indian cities like Mumbai, Kolkata, Surat and Chennai, perhaps more devastatingly than many cities in the west.[1] Mumbai city has been losing its existing blue-green infrastructure to pressures of development and growth, and the city lacks adequate regulatory measures and institutional structures for protection and planning.[2] For example, conservation of wetlands and mangroves is declining in Thane creek and Ulhas River.[3]

The geographic, economic, and cultural history of Mumbai situates it as a place where the people have had a very close association with water.[4] Mumbai´s urban network of fountains, tanks, and wells, which include historic Parsi charities all reflect this close association with water. A large part of these rich networks of association however has been abandoned or submerged as the city continues to grow into its modern mega-city form.[5]

1 Hallegatte, Stéphane, Colin Green, Robert J. Nicholls, and Jan Corfee-Morlot (2013): "Future Flood Losses in Major Coastal Cities." Nature Climate Change 3 (9). Nature Publishing Group: 802–6. doi: 10.1038/nclimate1979.
2 Kirtane, G. (2011): "Making the Sewer a River Again." Observer Research Foundation.
3 Nikam, V. S., Kumar, A., Lalla, K., Gupta, K. (2009): Conservation of Thane Creek and Ulhas River Estuary, India. Journal of environmental science & engineering 51(3), 157-162.
4 Gandy, M. (2008): Landscapes of disaster: water, modernity, and urban fragmentation in Mumbai. Environment and planning. A, 40(1), 108. Gandy, M. (2009): "Liquid city: Reflections on making a film." Cultural Geographies 16.3. 403-408.
5 Belanger, P. (2009): "Landscape As Infrastructure." Landscape Journal 28 (1): 79–95. doi:10.3368/lj.28.1.79.

Today six great reservoirs located more than 150 km north of the city are secured to serve the region's water needs while the city's river system, nullahs, tanks and coastal waters suffer compromised flows and reduced capacity, due to heavy pollution and encroachment posing severe risks of flooding. Resurfacing these lost water geographies, securing them through blue-green infrastructures (mangroves, mudflats, forests, parks, promenades and green corridors), and connecting them to natural flows offers an approach to improving environmental sustainability while reclaiming Mumbai's rich natural heritage and great environmental traditions. This approach of water heritage conservation combined with innovative productive landscape design could offer an opportunity for Mumbai to reclaim its lost association with water while simultaneously responding to the needs of development and risks of climate change.

THE RED (SOCIAL) IMPERATIVE

RED IMPERATIVE

PEOPLE AND COMMUNITIES

Urban population is expected to rapidly grow over the next four decades.[1]

Over the last 60 years there has been a tremendous movement of people from rural to urban areas. Countries like Brazil and Indonesia have seen an increase of people living in urban areas of 51% and 42% respectively. According to the United Nations, 60% of the world's population will live in urban environments by 2030 (Human Spaces, 2015).[2] This process will have a strong impact on cultural and political dimensions and will affect social equity in many countries.

Within urban areas, poor living conditions will mostly be affected by these adverse conditions[3] and cities will eventually experience loss of social cohesion and decline of public trust.

In a context where public perception is becoming more and more important, cities around the world compete for liveability and symbolic capital like urban green and blue can provide. For instance in Asia, financial capital is intrinsically impatient. Buildings and infrastructures are often built without sensitivity to the urban fabric.

Blue-green infrastructure extends the well-established concept of green infrastructure (e.g. open space and tree canopy) to encompass social systems and processes that make enormous contributions to the aesthetic, functional, and cultural values of urban landscapes.

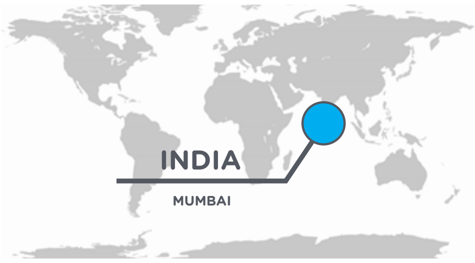
1 UN Habitat (2013): State of the world's cities 2012/2013: Prosperity of cities. Routledge.
2 Human spaces (2015): "The Global Impact of Biophilic Design in the Workplace" humanspaces.com/wp-content/uploads/2014/10/Global-Human-Spaces-report-2015-US-FINAL.pdf
3 Klein Rosenthal, J., et al. (2014): "Intra-urban vulnerability to heat-related mortality in New York City, 1997–2006." Health & Place 30: 45-60.

The Asian Development Bank, in its report on "Green Urbanization in Asia"[4], discusses the pros and cons of rapid urbanization. The report's conclusion was that urbanization must calibrate quality of life and social equity. The dilemma of urban density and diminished green spaces versus social well-being is evident in statistics from various cities in Asia.

While BGI generally tends to lack governmental and legislative support, BGI projects are proliferating in exciting ways in an increasing number of cities. As more and more urban blue-green systems are created and restored, they have enhanced local liveability and quality of life and increased public support for BGI. Research is now focused on identifying and understanding the social benefits of BGI to provide insight into how to further improve design to enhance the human-environmental experience.

The strength of BGI projects has been in actively engaging people. Successful BGI triggers sensorial and cognitive responses, which generate positive emotional reactions that go beyond simple socioeconomic benefits. These reactions evoke powerful associations with BGI that exceed perceived utility to generate a sense of place; these attributes are aligned with memory and expectations, and increase user satisfaction. Positive user experience can help strengthen social support for BGI, and can help to counter institutional opposition or disinterest. It is therefore an aspect of BGI that is important for advocates to keep in mind.

4 Asian Development Bank. "Green Urbanization in Asia – Key Indicators for Asia and the Pacific." 2012. See http://www.adb.org/sites/default/files/publication/29940/ki2012.pdf



MUMBAI

Mumbai has a suite of blue-green infrastructure systems that include watershed headwaters that are protected as a National Park, stream corridors that radiate from those headwaters through the city, and a variety of urban coastal areas some of which have mangrove tidal flats. These systems face enormous pressures and are not yet integrated in a metropolitan BGI system.

Mumbai is also a megacity in a rapidly developing country. A World Bank report indicates that 27% of the world's poor living in coastal cities are in India, and that Mumbai city will bear 6.4 billion US dollars in flood costs annually by 2050, second only to Guanzhou in China. The OECD data indicates that 2.787 million people in Mumbai alone are exposed to climate change risks.[1]

Mumbai has also one of the lowest per capita water uses (135 ltrs/day/person)[2] and a substantial but heavily degraded natural capital[3], that includes its somewhat protected headwaters to polluted urban stream corridors and reclaimed coastal zones.

If Mumbai is able to revitalize and sustain its natural resources through blue-green infrastructure that mitigates global and regional climate risks, it will accrue many urban social benefits.

1 Nicholls, R. J., Wong, P. P., Burkett, V., Codignotto, J., Hay, J., McLean, R. et al. (2007): Coastal systems and low-lying areas. eds Parry ML, et al. (Cambridge Univ Press, Cambridge, UK), pp 315–357.
2 Data Source: Municipal Corporation of Greater Mumbai
3 P K Das & Associates, and Mumbai Waterfronts Centre (2012): "Open Mumbai."

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CHAPTER 4

LESSONS LEARNED FROM SUCCESSFUL BGI CASES

SUPPORTING BGI-IMPLEMENTATION

What are the factors and conditions supporting BGI-implementation? To answer this, we examined selected case studies through extensive literature reviews and stakeholder interviews. These cases form the basis of our research and highlight key lessons in overcoming obstacles during the process of implementing BGI.

The BGI projects and policies examined, as well as the urban contexts in which they were implemented, vary widely across the case studies. This section explores some of the collected stories and summarizes key points and lessons learned of how to successfully implement BGI.

For comparative purposes of this inquiry, the so-called Expanded Process Model was used to document the origins, exploration, implementation, initial performance, and adjustments of urban BGI projects.[1] Standardizing the analysis in this way strengthens the ability to compare and contrast the cases in a meaningful way, and to draw general insights and lessons.

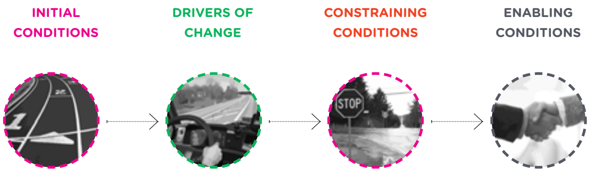


Fig.02b

1 The Expanded Process Model approach is inspired by a pragmatist philosophy of inquiry and action of John Dewey. For further explanation about this analytical approach see report of James Wescoat and team (MIT): "According to Dewey and those who followed him in the fields of planning and design, inquiry begins in a "problematic situation," i.e., environmental experience characterized by uncertainty and concern. Persons in such situations begin to inquire, identifying components of the problem, organizing them, reorganizing them in alternative adjustments to, and of, the situation, deciding on a course of action and continuously assessing and modifying that path until the situation is transformed. See Marks, A., Wescoat Jr., J. L., Noiva, K.,Rawoot, S. (2015): Boston "Emerald Necklace" Case Study. Research and Recommendations for Blue-Green Urban Infrastructure. Final Report of Ramboll´s Research Project "Enhancing Blue-Green and Social Performance in High Density Urban Environments". Massachusetts Institute of Technology (previously unpublished), P.37.

According to the Expanded Process Model, the context for each case study is broken down into:

1. Initial conditions and context of BGI projects including challenges and opportunities that gave rise to the BGI inquiry (e.g. crisis, hazards, pollution) to understand motives, targets and resources for BGI implementation.

2. Drivers of change i.e. agents who take initiative in spearheading BGI project implementation. These change agents may be citizens, leaders, institutions and or social movements.

3. Constraining conditions such as agents and/or institutions opposing BGI; design standards or policy programs that work against BGI; or scientific, technological, or other resource constraints

4. Enabling conditions and supporting features like technical tools, legal regulations, and political and social awareness, financial support that have a secondary effect as a lever for BGI implementation.

The overarching question addressed by this model is: What would be needed to institutionalize the BGI approach as a standard in urban water management?

This analysis of the cases along these topics shows characteristics and details of the implementation process for each individual case and assesses whether these factors appear to be unique to the specific case or whether they reflect a larger trend across cases. This allows us to evaluate the relevance of observed phenomena and to identify which factors appear to be systemically connected with successful implementation and long-term benefits of BGI.

CHALLENGES LEADING TO ADOPTION OF THE BGI APPROACH

What leads some cities to identify the BGI approach as a valid and viable urban design solution, while others still cling to the conventional grey paradigm in exclusion of BGI?

While the grey paradigm for water management is still the dominant practice, there is growing recognition by urban decision-makers, scientists, engineers, and other involved individuals, that there is more to sustainable water management than just getting (and getting rid of) water. In particular, the idea that it is possible to use blue-green elements to achieve certain aspects of the functionality typically met by grey infrastructure, while enhancing social aspects.

This cultural change from conventional systems toward integrated BGI-approaches is fostered in great part by recognition that certain types of challenges in urban water management are difficult to meet, and sometimes exacerbated by the conventional grey infrastructure approach. These types of challenges help leverage the introduction of BGI as a viable alternative or complement to conventional infrastructure.

More particularly, issues of (1) public health and (2) climate change have brought awareness to the shortcomings of the conventional approach to infrastructure. Concerns for climate change, energy security, and sustainability more generally have gained a wider audience over the past decades and spurred innovation in municipal policy. In fact, cities have tended to develop and adopt sustainability and climate change action plans earlier than national-level policies. (3) These green policy programs are policy-drivers that help pave the political landscape for BGI projects. In general, it is important to understand how green policy programs help open the door for the BGI approach, as well as to identify suitable (4) windows of opportunities for pioneering, visionary BGI projects. (5) The urge for innovation and a city´s reputation might also be a driving force for new approaches.

Img.48

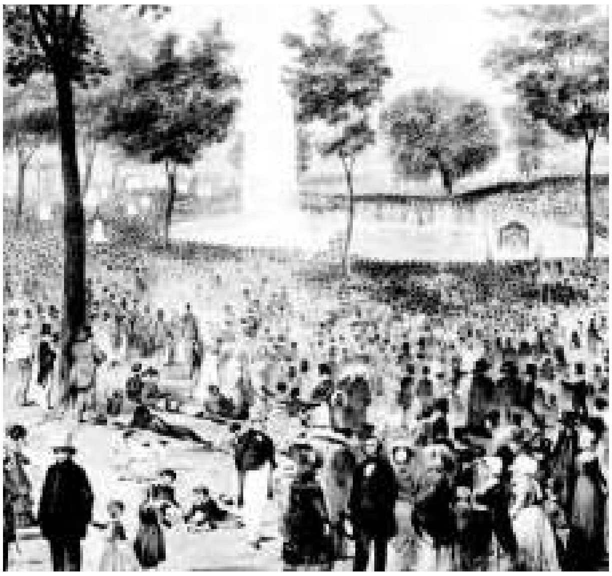
PUBLIC DISEASES AND SEWAGE DEMANDS

In course of industrialization and urbanization all cities must expand water infrastructure to meet the sanitation challenges that come with the growth of population and urban density. The conventional grey approach to water infrastructure has been focused on bringing freshwater into cities, and collecting and exporting stormwater runoff and waste, as quickly, efficiently, and unobtrusively as possible.

Additionally we know from early cases of modern urbanization that BGI was discussed as a complementing tool for health-related infrastructural solutions to ease problems of severe public health issues and unsafe sewage discharge. More recently BGI became a topic in the course of growing water awareness and the ambition to improve and protect urban water resources.

Today we have developed more efficient treatment systems and the knowledge is rising. So recycling instead of wasting rain and stormwater is becoming a megatrend.

Img.49 **BOSTON COMMON 1848**
View of the Water Celebration, on Boston Common, October 25th 1848. National Archives



HYGIENIC NEEDS AS DRIVERS FOR BGI IDEAS

The Emerald Necklace in Boston and the New York City Parks System

In the case of the Emerald Necklace in Boston, a combination of intense real estate development pressures and landfilling of coastal marshlands blocked natural drainage and directly discharged raw urban sewage into the tidal floodplains. This created worsening flood and sanitary health hazards. There were a number of early missteps addressing these problems until the landscape architect Frederick Law Olmsted argued that Boston waterways get a holistic upgrade as a matter of health improvement.[1]

Similar development is found in the traditional blue-green spaces in New York, where a growing and dense urban population was in urgent need of clean water. Main drivers of BGI thinking in the 19th century were the burgeoning immigrant population housed in crowded and poor quality tenements on one side and public health and fire hazards on the other. Reformer efforts to ameliorate the city's unsanitary conditions, and efforts by local boosters to create an elite city led to NYC's initial implementation of BGI.[2]

While a different terminology was used at the time, these historical precedents can help illustrate the importance of BGI by drawing attention to existing and functioning solutions. These early examples of the application of BGI to health and sanitation are important reference points for today's rapidly developing cities in particular their health and sanitation challenges.

1 Marks, A., Wescoat Jr., J. L., Noiva, K.,Rawoot, S. (2015): Boston "Emerald Necklace" Case Study. Research and Recommendations for Blue-Green Urban Infrastructure. Final Report of Ramboll´s Research Project "Enhancing Blue-Green and Social Performance in High Density Urban Environments". Massachusetts Institute of Technology (previously unpublished).
2 Klein-Rosenthal, J., Crauderueff, R., Keesler, V. (2015): A History of Blue-Green Infrastructure in New York City: Creating the Adaptive City. Case study of Ramboll´s Research Project "Enhancing Blue-Green and Social Performance in High Density Urban Environments". Harvard Graduate School of Design (previously unpublished).

Img.50 **EMERALD NECKLACE PARK SYSTEM IN BOSTON**
1894 plan by Frederick Law Olmsted
Source: National Park Service Olmsted Archives

These cases illustrate that grey is not the only technological solution to ensure healthy living conditions; they are in fact augmented by BGI, even under conditions of rapid growth and heavy economic strain. While the successful improvement of urban living conditions is attributed primarily to grey infrastructure, the research shows that investments in BGI often paralleled those in grey infrastructure.

Grey infrastructure helps to solve the immediate health and sanitation concerns associated with the increased sewage and waste that result from urban growth. However, grey infrastructure has a narrow focus and does not replace all of the functionality of the original surface waters, which also offered additional services such as open space, a relevant element for biodiversity, and central social nexus. At the same time that investments in grey water infrastructure were expanding, there was a growth in public support for land to be set aside within the urban fabric for social spaces, such as parks. Biophilia made an appearance in these parks movements, with urban planners, landscape architects, and public health advocates emphasizing natural green spaces and water features within park designs.

These early investments in blue-green infrastructure like Boston's Emerald Necklace are sometimes overlooked by policy-makers. However, they have conveyed many long-term socio-economic benefits. Bringing attention to these existing examples of BGI can help to raise awareness of what BGI can look like. While modern BGI projects are more sophisticated and offer even greater functionality than early BGI, increasing the familiarity of decision-makers with existing BGI in an historical way reduces opposition to BGI that stems from its apparent novelty.

CLIMATE CHANGE AND ADAPTATION

Climate change adaptation is a contemporary issue of high relevance and political visibility. Many of the specific impacts associated with climate change at the urban level like flooding and droughts respectively, can be partly mitigated by BGI. Climate adaptation is therefore a useful platform for increasing awareness of BGI, which not only addresses particular symptoms of climate change but also enhances the overall urban resiliency.

Currently, climate change is top of the agenda of urban planning in many cities and regions. To date, urban planners and decision-makers realize that it is a race against the clock to climate-proof our cities before disaster strikes. BGI can be an important tool in increasing the adaptation and resilience of cities to climate change.

Many cities have already been convinced that BGI enhances resilience and mitigates the negative impacts of climate. Particularly coastal cities are concerned with the increase to flooding due to predicted sea level rise and increased frequency of intense weather events. Many cities have already experienced substantial costs associated with these challenges, e.g. New York City. Recognizing that these costs may be even higher in the future, cities have made substantial efforts in preparing for future disasters. Preliminary studies and the resulting disaster plans have led to increased funding for new infrastructure.

Urban water infrastructure and green infrastructure have both received attention from these plans. In supplying a critical urban resource, water infrastructure has received new scrutiny and secured significant new funding. For instance, New York City recognized the vulnerability of its financial hub, Manhattan, because of a lack of redundancy in water infrastructure.[1] Manhattan has relied on a single water source, Tunnel No. 1, since 1917. Expected to be completed in 2020 at a cost of USD 5 billion (USD 4.7 billion as of 2013) (considered the largest capital outlay for a single project undertaken by the state), Tunnel No. 3 adds a much needed second water source to the borough.[2] The need for an additional water pipelines was recognized as early as 1954, when Tunnel No. 3 was first authorized. Construction did not begin on Tunnel No. 3 until 1970, however, after which progress was stalled several times due to lack of funds (highlighting that more conventional water infrastructure comes with its own risks).[3]

Hurricane Sandy hit New York City hard in 2012, and its impacts were exacerbated by sea-level rise and urban urbanization.[4] Several solutions to protecting the coastline were proposed, and in 2013 in a 438-page proposal allocating USD 20 billion towards arming New York City, "oyster reefs, wetlands and offshore barrier islands around the city" were emphasized.[5] In contrast, the proposal to construct a more conventional sea wall around the city (a project estimated at USD 10 billion) was dismissed by NYC's Mayor Michael Bloomberg as "'impossibly expensive' and 'environmentally unsustainable'".[6]

1 Rosenzweig, C., et al. (2007): Managing climate change risks in New York City's water system: assessment and adaptation planning. Mitigation and Adaptation Strategies for Global Change, 12 (8): 1391-1409.

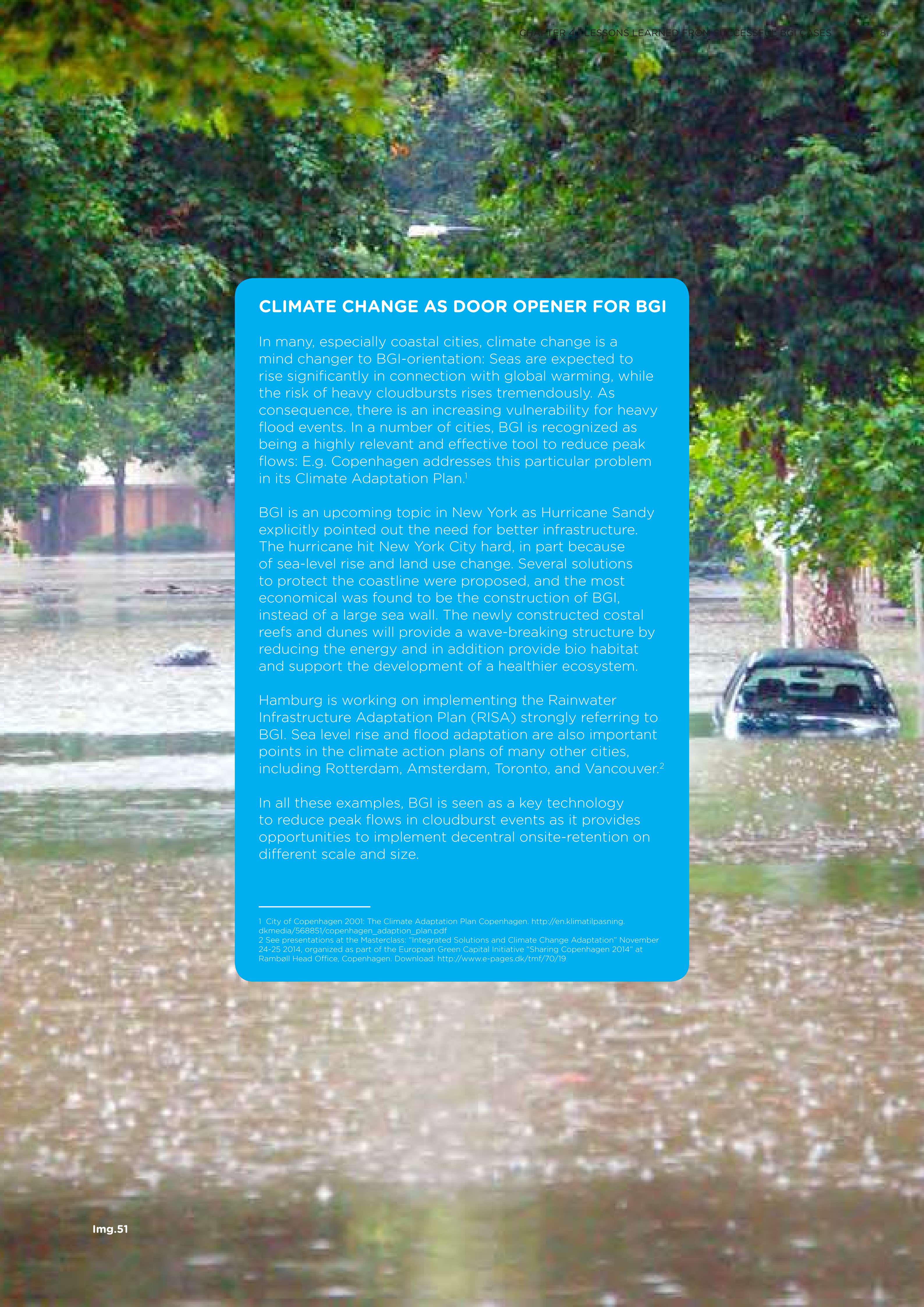
2 Flegenheimer, Matt. (2013): After Decades, a Water Tunnel Can Now Serve All of Manhattan. The New York Times, 13 October 2013. http://www.nytimes.com/2013/10/17/nyregion/new-water-tunnel-can-provide-water-for-all-of-manhattan.html?_r=0.

3 Ibid.

4 Baker, K. (2013): City of Water. The New York Times, 12 October 2013. http://www.nytimes.com/2013/10/13/opinion/sunday/city-of-water.html; The City of New York (2013): A Stronger, More Resilient New York. PlanNYC report. http://www.nyc.gov/html/sirr/html/report/report.shtml

5 Ibid.;Gregory, Kia. (2013): Bloomberg Storm Plan Praised, but Faces Obstacles. The New York Times, 12 June 2013. http://www.nytimes.com/2013/06/13/nyregion/bloomberg-storm-plan-praised-but-faces-obstacles.html

6 Baker, K. (2013): City of Water. The New York Times, 12 October 2013. http://www.nytimes.com/2013/10/13/opinion/sunday/city-of-water.html



CLIMATE CHANGE AS DOOR OPENER FOR BGI

In many, especially coastal cities, climate change is a mind changer to BGI-orientation: Seas are expected to rise significantly in connection with global warming, while the risk of heavy cloudbursts rises tremendously. As consequence, there is an increasing vulnerability for heavy flood events. In a number of cities, BGI is recognized as being a highly relevant and effective tool to reduce peak flows: E.g. Copenhagen addresses this particular problem in its Climate Adaptation Plan.[1]

BGI is an upcoming topic in New York as Hurricane Sandy explicitly pointed out the need for better infrastructure. The hurricane hit New York City hard, in part because of sea-level rise and land use change. Several solutions to protect the coastline were proposed, and the most economical was found to be the construction of BGI, instead of a large sea wall. The newly constructed costal reefs and dunes will provide a wave-breaking structure by reducing the energy and in addition provide bio habitat and support the development of a healthier ecosystem.

Hamburg is working on implementing the Rainwater Infrastructure Adaptation Plan (RISA) strongly referring to BGI. Sea level rise and flood adaptation are also important points in the climate action plans of many other cities, including Rotterdam, Amsterdam, Toronto, and Vancouver.[2]

In all these examples, BGI is seen as a key technology to reduce peak flows in cloudburst events as it provides opportunities to implement decentral onsite-retention on different scale and size.

1 City of Copenhagen 2001: The Climate Adaptation Plan Copenhagen. http://en.klimatilpasning.dkmedia/568851/copenhagen_adaption_plan.pdf

2 See presentations at the Masterclass: "Integrated Solutions and Climate Change Adaptation" November 24-25 2014, organized as part of the European Green Capital Initiative "Sharing Copenhagen 2014" at Rambøll Head Office, Copenhagen. Download: http://www.e-pages.dk/tmf/70/19

Img.51

WINDOWS OF OPPORTUNITY

While the aforementioned factors can serve to positively dispose an urban institutional setting towards considering BGI as a viable design option, possessing a fertile policy environment does not guarantee implementation of BGI. Typically a specific opportunity is required as a crystallization point that draws together potential investors with visionary designers and receptive technical competencies. A survey of the conditions under which the first BGI projects were initiated in the case studies highlighted some common factors concerning both specific projects and time frames that contribute to favorable conditions for introducing a BGI pilot project. These conditions are:

With respect to the project scale - If a positive political environment already exists for BGI and has generally shown acceptance of BGI as a viable approach to urban rainwater management, the next step is to identify suitable opportunities for a pilot BGI project. For instance, BGI is comparatively easy to implement in new developments, where it can be integrated into physical infrastructure without disruption right from the beginning. In fact, BGI can actually facilitate the connection of new developments to the existing drainage system if it is designed to slow water flows, possibly even storing water on-site before discharging it to the citywide system. This can lead to substantial reductions in the costs for upgrading the existing urban drainage system, as has been a key consideration for Singapore and New York City. The restoration of aging infrastructure can also be a window of opportunity for BGI if the spatial on-site conditions allow for BGI construction, as costs for redevelopment projects including BGI often are easy to implement at a competitive cost level (see Box and Chapter 5).

With respect to the time scale - an acute disaster event can provide the impetus to decision-makers signifying the need for and will to change the status quo. Urban challenges like climate change and its impacts (rising sea levels, average temperatures etc.) often stay well below the political radar as they develop slowly enough to be ignored or only partly accepted by short-term oriented policy-makers and ordinary citizens alike. Damage from flooding (e.g. from storm surge or high intensity precipitation events) is an example of disaster-type events that provide such a window of opportunity for BGI.

These types of events serve to focus attention on water management and related infrastructure in the media, which increases pressure on politicians for action and change. Another example of an acute event is major heat waves, which focus attention on the merit of open green spaces and their mitigating, evaporative cooling effects.

CRISIS AS A WINDOW OF OPPORTUNITY

Several cases showed that crisis is an important door opener for BGI implementation. Cloudbursts in the center of Copenhagen[1], the flooding of Orchard Street in Singapore[2] after heavy rainfall, and precipitation-induced landslides in Portland's affluent neighborhoods[3] were found to be powerful levers for increasing public support for BGI in these cities.

In Copenhagen[4] and New York[5], rainwater management gained prominence in political discussion after several incidences of major and extensive flooding in inner city areas. These floods spurred awareness of and demand for decentralized stormwater reduction and storage options as well as an increased willingness to invest in semi-natural treatment structures.

1 Hansen, U. (2012): Rekordskaderefterskybrud- regningtætpå 5 mia.kroner. Børsen, 18.04.2012; and Politiken, (2011): Københavndrukneriskybrud. Politiken. Available at: http://politiken.dk/indland/ECE1324923/koebenhavn drukner-i-skybrud/
2 AsiaOne (2010): Blocked drain caused Orchard Road flood. AsiaOne. Available at: http://news.asiaone.com/print/News/AsiaOne%2BNews/Singapore/Story/A1Story20100618-222731.html; and AsiaOne, 2011. Flash floods hit Liat Towers and other parts of Orchard Road. AsiaOne. Available at: http://news.asiaone.com/News/Latest+News/Singapore/Story/A1Story20111223-317945.html.
3 Portland Bureau of Transportation, 2015. Landslide Prevention. Available at: https://www.portlandoregon.gov/transportation/article/319810; and KGW.com, 2015. Heavy rain causes landslide in West Hills neighborhood. Available at: http://www.kgw.com/story/news/local/2015/03/15/nw-portland-landslide/24815997/
4 City of Copenhagen (2011): Copenhagen Climate Adaptation Plan. http://international.kk.dk/artikel/climate-adaptation.
5 NYC DEP (2010): NYC Green Infrastructure Plan: A sustainable strategy for clean waterways. New York City.

URGE FOR INNOVATION AND A CITY´S REPUTATION

Other suitable time frames for pioneering BGI projects are in situations where a city's reputation is on the line in a highly visible way. An example is in the run-up for big, well-publicized international events such as a bid for the Olympic Games or the World Cup. BGIs were used as arguments for major events like the Olympics in Sydney 2000, Vancouver 2010, and World Cups like the German Soccer World Cup 2006. BGI is inherently well-suited for this type of event since it places heavy emphasis on open space, community integration, aesthetics, and environmental concerns in its design objectives.

These challenges constitute windows of opportunity. But it is not enough to identify these windows of opportunity; they must be acted upon. Both are critical steps in initiating a BGI project. The success of a city in achieving both will depend on its readiness, which in turn depends on its institutional capacity (see Chapter 6). Having a precedent of relevant local projects, a supportive political framework, and historic conditions enhances the institutional capacity of a city. Choosing the right time and project scale for introducing a BGI project influences the cost structure, political support, and public awareness – in short, is crucial for the success of the initial project and therefore the likelihood of future BGI projects.

BGI AS MEASURE TO GAIN REPUTATION OR TO SAVE COSTS

The need for a high-visibility project demonstrating Hannover's innovativeness was a key motivation for the Hannover-Kronsberg construction, which pioneered BGI in Hannover. The desire for a reputation-enhancing project was driven by pressure from efforts to prepare for hosting the World Exhibition 2000.[1]

Today many European and American cities urgently need to replace their aging infrastructure. A comparison of costs of conventional restoration to newly built BGI by holistic cost-benefit analyses economically favors BGI for a number of cases. The restoration of the Kallang River in Bishan-Ang Mo Kio Park is a perfect example as it clearly signifies cost effectiveness of BGI compared to concrete canal restoration.[2]

1 Interview Mönninghoff, H. (03/11/2014) at the KROKUS neighborhood center in Hannover, conducted by Matthias Wörlen.
2 Dreiseitl, H., Leonardsen, A., L., Wanschura, B. (2015): Cost-benefit analysis of BishanAng-Mo Kio Park. National University of Singapore, School of Environment and Design, Department of Architecture.

Img.52

WHO ARE TYPICAL DRIVERS OF BGI?

The research of BGI projects in a variety of political contexts showed that BGI reflects a relatively new technological design paradigm, and thus its implementation within an urban design requires political support beyond what is typically required for more conventional infrastructure. In a meaningful way, BGI implementation is therefore a political intervention. Consequently, pioneering BGI projects typically require a number of strong advocates who can help drive political acceptance and backing. These leaders may be legislators, local political officers, water managers or advocacy groups. They have to take responsibility for the first BGI projects, helping to organize support and the decisions needed for successful project execution.

For instance, citizens play an active role in the municipal governments of Boston, Hannover, and Portland, and the engagement and support of BGI from civic movements was found to be an important part of the BGI process in these cities. In other cases, such as in Singapore, urban water management and infrastructure is typified by a highly centralized, top-down effort. In these cases, the advocacy of government officials such as agency managers was found to be an important driver of this innovation.

As is discussed below, successful BGI projects were found overwhelmingly to share the advocacy, engagement, and leadership of a pivotal personality. In general, successful BGI projects were taken forward by a single individual, one who could call upon a network of experts and other engaged practitioners.

Another factor that emerged as transcending case-specific idiosyncrasies was found to be a correlation between the success of a BGI project and whether or not the local water agency was engaged with the project implementation. Perhaps unsurprisingly, successful BGI projects tended to be those that were overseen by the local water agency, rather than a third party.

In all cases, proponents cited the potential for enhancing liveability, sustainability, and resilience with the BGI approach. An additional motivation was the wish to improve reputation of the city, its governmental body, and the agencies in charge.

To summarize, the following were found to be key aspects of successful BGI projects:

1. The leadership of a single, lynchpin personality with a strong political and entrepreneurial background

2. The legitimacy and strong relationship of this leader with a supporting network of experts and engaged practitioners

3. A mandate for the BGI project and project oversight from local water agencies

4. Green policy and sustainability programs

Img.53

THE POLITICAL BGI ENTREPRENEUR

In several of the cases it was clear that strong personalities had played a key role in the success of the BGI implementation. These individuals served as project lynchpins. They took responsibility for driving the project agenda forward and in doing so were able to pioneer BGI projects in their respective cities. These individuals are perhaps best described with the term "political BGI entrepreneurs" as they were especially engaged in political communication. These political BGI entrepreneurs had to be more than skillful communicators and managers to gain legitimacy for BGI projects.

Often these individuals shared similar traits. They all tended to be charismatic leaders occupying top-management level positions within key public organizations and were in charge of urban planning and/or urban infrastructural engineering. It goes without saying that they are strongly convinced of the advantages BGIs are providing to cities and are experienced in inter-agency coordination; and they enjoy the reputation of being good performers. Characteristically these personalities heavily rely on long-lasting relationships and trust gathering from individuals, high-level politicians, agencies, and the citizens.

PERSONALITIES AS DRIVERS OF BGI IMPLEMENTATION AND POLICY

Looking at the list of people identified as drivers of single BGI projects and of citywide BGI programs, there are a number of impressive persons who all are charismatic, experienced and skillful in political communication. Some examples:

Mr. Hans Mönninghoff was a central driving force when it came to managing the details of Kronsberg's BGI project construction. At the time of the project, Mönninghoff served as Chief Officer of the Department for Ecology and Nature in the city of Hannover, responsible for all ecological issues related to Kronsberg. As a well-qualified engineer, with a charismatic personality, Mönninghoff's technical, political, and managerial experience proved pivotal in the success of BGI in Kronsberg.

Mr. Khoo Teng Chye was a chief planner for the Water Bodies Design Panel of Singapore[1] with the aim to bring nature and parks closer to the people. When Mr. Khoo took over the Public Utility Board chief office in 2002, the ideas from the Water Bodies Panel were delayed. With his new position, Mr. Khoo was able to be a driver that these ideas were transformed from goals into implemented BGI projects.

Consulted by experts like Studio Dreiseitl and other, he set up the specific Program "ABC Waters – Active, Beautiful and Clean Waters" as an "umbrella program (...) to remake (...) Singapore into a vibrant City of Gardens and Water.[2]

Mr. Liak Teng Lit was another key figure in the success of BGI in Singapore. Mr. Liak is CEO of Alexandra Health in Singapore (the owner/operator of Khoo Teck Puat Hospital Singapore, KTPH) and was previously CEO of Changi General Hospital (CGH) and Alexandra Hospital (AH). The successes of CGH and AH, in particular, were important to the making of KTPH. Liak has spoken of accrued trust between himself and high-level decision-makers – resulting from these early successes – that allowed him to push the boundaries of innovation at KTPH. Liak also references conversations with the former Prime Minister of Singapore, Lee Kuan Yew, and senior civil servants, suggesting that they supported him and may have contributed to the acceptance of his ideas.

1 The Water Bodies Design Panel was introduced 1989 under leadership of URA to open up waterfront at canal locations as a measure to green and upgrade residential areas for high standard housing purposes. So the idea to integrate vegetation and urban greenery actively into the Singaporean waterbodies was identified as a relatively early stage in reaction to previously implemented, sub-optimal grey infrastructure.
2 See Wong, T. H. F. (2011): Framework for stormwater quality management in Singapore. In: 12th International Conference on Urban Drainage, Proceedings, Porto Alegre, Brazil, International Water Association, p.8.

All such successful drivers were heavily convinced of the benefits and the feasibility of BGI-solutions. Each of these individuals proved skillful in convincing colleagues, politicians and the wider public to back their vision. Often these political entrepreneurs make use of a vision of liveability and prosperity to bring the advantages of BGI into play (green city vision, biophilia, sustainable urban design, city in a garden, water sensitive city).[1]

Very obviously the change of an urban planning paradigm is no easy task. It touches epistemic cultures and professional practices in a number of different planning agencies. This is especially true for cultures that adopt change slowly – as is true for urban water management. It is no surprise that the individuals who can successfully steer a community through such a change have powerful skills in negotiation and political maneuvering and must be prepared for a long-term commitment.

1 In Singapore the vision to create a "City of Gardens and Water" was successfully employed to gain support for the ABC-Waters program: "We ought to be a Venice, but we are not because much of the blue are ugly concrete drains, or canals (...) If Singapore wants to be more livable as we become more dense (...) you have no choice. To me this is the way to make Singapore more attractive and to me it's almost like a no-brainer. You must do it." Interview with Khoo Teng Chye, 15/5/2015 at the Centre for Liveable Cities in Singapore, conducted by Matthias Wörlen, Cynthia NG and Oliver Tovatt.

DRIVING GROUPS AND NETWORKS

In addition to the importance of charisma and other leadership qualities of those who have successfully driven initial BGI projects, these individuals were also found to be pivotal persons within and between networks of relevant professionals and citizen groups. The exact position and roles occupied within these networks differed in each of the cases. Sometimes they were allies and supporters in other agencies or in the wider institutional setting. Sometimes they had already been engaged with BGI but did not succeed in their earlier projects. In other cases they were engaged citizens or politicians who realized that BGI would be a positive contribution to their city's future. Alternatively, they were mentors of a group of innovative and engaged BGI activists.

The individuals who drove successful BGI implementation relied heavily upon the support of these networks throughout the process. This was particularly important in the early stage of project implementation. Individual drivers leveraged their networks to garner a citywide momentum for change.

Regardless of the political context or governance cultures, the importance of supportive networks in the success of BGI implementation was found to be a common factor across case studies.

Img.53A

SUPPORTIVE NETWORKS FOR BGI PROJECTS

The success of Khoo Teck Puat Hospital (KTPH) in Singapore can be accredited to many individuals. Rosyland Tan, a former occupational therapist who, after retirement, became KTPH's chief gardener, supported Liak Teng Lit.[1] Liak and his deputies created an organizational culture that was open to ideas from within and outside their ranks. They encouraged volunteer participation, opening the door to interest groups that many other institutions typically avoid. Liak's personal connections with senior decision-makers in other public agencies were especially critical in the adoption and integration of Yishun Pond (see Annex, Description of case studies) into the hospital area.[2]

In Hannover the whole World Expo initiative was considered controversial. Former Expo projects had been costly and were criticized as being ecologically unsustainable. Conscious of those criticisms, Hannover's World Expo planners set a high bar for environmental objectives that the final design would have to meet. These requirements included a low material footprint, a long-term use plan, and a low impact on the ecology of the environment. It was in this political context that the local Green Party – once the harshest critics of the project – became some of its strongest proponents and drivers in the sustainable design of the Expo Flagship – the Kronsberg Hill area. Hans Mönninghoff – the focal personal driver of the Kronsberg construction – relied very much on the steady support of this group of green policy advocates. This is also true for the water design on the Kronsberg Hill: Hans Mönninghoff was supported by a group of young water engineers with less experience in the water agency the water agency of Hannover City. As the director of the water agency – Fritz Stolle – had had serious doubts about the functionality of BGI for flood management, it was decisive that young engineers were heavily engaged to push BGI forward.[3] Without the support of individual, very engaged water engineers who were highly convinced of the idea of sustainable urban design, BGI on Kronsberg would have never been possible.

1 LiakTeng Lit was a key figure in the success of BGI in Singapore. Mr. Liak is CEO of Alexandra Health in Singapore (the owner/operator of KhooTeckPuat Hospital Singapore, KTPH) and was previously CEO of Changi General Hospital (CGH) and Alexandra Hospital (AH).
2 Kishnani, N., Cossu, G. (2015):Biophilic Design. Final Report of Ramboll´s Research Project „Enhancing Blue-Green and Social Performance in High Density Urban Environments". National University of Singapore (previously unpublished).
3 Wörlen, M., Moldaschl, M. (2015): Enhanced Socio-Economic Analysis of BGI as Urban Innovation. Final Report of Ramboll´s Research Project "Enhancing Blue-Green and Social Performance in High Density Urban Environments". European Center for Sustainability Research, Zeppelin University (previously unpublished).

WATER AGENCIES AS INSTITUTIONAL BOTTLENECKS

The challenge of water management is a critical urban development issue. Since BGI integrates aspects of urban water management with aspects of landscape architecture and is implemented in the context of urban development, all three different professions overlap. Overseeing a BGI project is split across whichever urban agencies are responsible for the different dimensions of the project design. These agencies, more often than not, do not have clear roles and responsibilities delineated for these types of cases. A key decision to be made is the answer to the question: Which agency is ultimately in charge of BGI projects?

The case studies demonstrated that there was no one-size-fits-all answer to that question. A variety of institutional arrangements emerged for successful projects. However, it was found that where a significant institutional bottleneck occurred in implementing a BGI project, water agencies were that institution.

Img.54

WATER AGENCIES ARE ESSENTIAL AGENTS OF TRANSITION

The ABC-Waters Masterplan of Singapore is a citywide masterplan introduced by the Public Utility Board (PUB), the national water agency of Singapore, in 2006 including about 100 BGI projects to be constructed in 25 years. The Master plan heavily relies on ideas developed already in the 1980s in the Water Bodies Design Panel[1], a project initiated by the Urban Redevelopment Authority (URA) – the Singaporean urban development agency.

As BGI was not explicitly specified as a new task for the Singaporean sewer agency, their pioneering ideas for water infrastructure were only followed for a very short time span, and were soon forgotten until they were revisited by the ABC Waters Masterplan in 2006. As there was no change in the technocratic view on urban water management, the old paradigm of grey infrastructure became the dominant model again. Only after PUB was explicitly given authority for all water management issues in Singapore did the window of opportunity for BGI reopen. As the first BGI projects in the ABC Waters Masterplan (including Bishan-Ang Mo Kio Park) began to move through the planning pipeline Khoo Teng Chye, the then CEO of PUB, recognized the potential for an institutional bottleneck. His solution was to put the engineers in charge. In his own words, he said he realized that "the hardest people to convince are the engineers, engineers in charge. If I put a landscape architect in charge it will be a disaster, you will not succeed. So I made a decision that I need to find 3 teams, multidisciplinary teams but engineers in charge, ok? To me that was important to get that program going. Otherwise it would have been very difficult." [2] [3]

1 The Water Bodies Design Panel was introduced 1989 under leadership of URA to open up waterfront at canal locations as a measure to green and upgrade residential areas for high standard housing purposes. So the idea to integrate vegetation and urban greenery actively into the Singaporean waterbodies was identified as a relatively early stage in reaction to previously implemented, sub-optimal grey infrastructure.
2 Interview Mr. Khoo T., Ch., 15/5/2015 at the Centre for Liveable Cities in Singapore, conducted by Matthias Wörlen, Cynthia NG and Oliver Tovatt.
3 Wörlen, M., Moldaschl, M. (2015): Enhanced Socio-Economic Analysis of BGI as Urban Innovation. Final Report of Ramboll´s Research Project "Enhancing Blue-Green and Social Performance in High Density Urban Environments". European Center for Sustainability Research, Zeppelin University (previously unpublished).

If water agencies and their representatives do not accept the idea of blue-green infrastructure, it is nearly impossible to implement BGI in the urban landscape. Secure water supply and flood prevention are enormous priorities for a city. The risks of failing in either of those mandates can be a huge political, economic, and social disaster for a city. Therefore water agencies are risk-averse and view new paradigms as suspect, apparently following the maxim, "If it ain't broke, don't fix it." For this reason, perhaps more than any other, water agencies are the most frequent institutional bottleneck. Even once water agencies could be convinced of the possibilities and advantages of BGI, it was still found to be the most effective to give the final authority for BGI implementation to them.

While institutional arrangements may seem trivial, it is clear that professional cultures can play an important role in the successful BGI implementation. Where possible, a key lesson from the case studies was to be conscious of these preferences in assigning project roles and responsibilities.

Résumé: The cases studies show that successful projects require strong leadership and skillful political management to pioneer BGI in urban design and planning. In nearly all cases, there were single individuals who emerged as decisive project drivers and took ultimate responsibility for changing the agenda and leveraging the support of their professional and political networks to overcome obstacles. These individuals tended to share similar personal characteristics: They were charismatic leaders at top-management level of key public organizations and in charge of urban planning or urban infrastructural engineering. Characteristically these personalities relied heavily on long-lasting relationships and trust from colleagues, high-level politicians, agencies, and citizen groups. Moreover, all drivers were pivotal persons within their networks of professionals and communities.

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GREEN POLICY AND SUSTAINABILITY PROGRAMS

Green policies and sustainability programs can also serve as convincing reference points for advocacy of BGI innovations. Regardless of whether BGI is explicitly mentioned within a sustainability program, the BGI approach is highly aligned with frequently cited objectives of programs, such as lessening the urban heat island effect, improving air quality, and flood mitigation. An example is the Water Sensitive Urban Design approach[1], but also Eco-City concepts[2] and the Local Agenda 21[3] were levers for bringing BGI onto the table in their respective locations. The Water Framework Directive by the European Commission about the improvement of the water bodies[4] has increased the inclusion of BGI in European urban design. The European Union has indeed been an early proponent of BGI for urban water management. As a result, pioneering BGI projects have been implemented in a number of European cities, including the Kronsberg/Hannover and Copenhagen cases of this report. Also the "Green Infrastructure Strategy" implemented by the European Commission in 2013 gives major support to implement BGI in European cities. Its focus is on "the deployment of green infrastructure in the EU in urban and rural areas [...]". Therefore it set the aim, that "by 2020, ecosystems and their services [have to be] maintained and enhanced by establishing green infrastructure and restoring at least 15% of degraded ecosystems."[5]

BGI received some of its earliest support within Europe, a region that also saw some of the pioneering city action plans for sustainability in climate change. Today there exist a much larger number of cities throughout the world with sustainability-focused policy programs and agendas.

In several Asian cities, like Hongkong[6] and Singapore[7], concern for biodiversity loss has been an important lever for consideration of the BGI approach in urban design. Many parts of Asia have been important biodiversity hotspots, and are increasingly threatened by urbanization. As mentioned previously, Asian cities are some of the largest and have experienced some of the most rapid growth over the past few decades, with negative consequences for biodiversity due to habitat loss. BGI projects provide crucial natural habitat for supporting biodiversity, and enhance ecosystem health by reducing the degree of habitat fragmentation caused by urbanization.

How do sustainability programs help reduce the barrier to adopting the BGI approach in urban design? Once a city has committed to follow a definite green policy program, a structured process is launched: strategies have to be developed, objectives have to be defined and measures have to be specified. The sustainability program often represents a move away from the status quo, which opens a window for considering alternative options that would have been less relevant without the policy change. Cities often face a type of peer pressure from other cities, as well as local citizen groups, to develop and commit to green policy programs. These programs are therefore often launched with substantial media attention and efforts for community awareness and engagement, which then puts pressure on local leaders to follow through with high-profile supporting projects. This is especially true when programs are connected with a special brand and periodical evaluation. A city can suffer a major loss of reputation if they prove unable to meet their stated objectives or if their progress compares poorly to that of other cities.

BGI can be an important tool for cities looking to expand their portfolio of green design and to otherwise support their reputation for sustainability. Relative to other types of ecological urban design policies, like sustainable energy system and minimal impact technologies, BGI has benefits that are comparably easy to show, understand, measure and report.

Higher order sustainability policy programs also facilitate adoption of BGI as they may provide additional funding, especially if these programs participate in ranking or design competitions. Therefore BGI can serve as an important element of a formal green policy program. The potential for BGI to enhance a city's reputation through this channel was a significant lever for adoption e.g. in Malmö and Freiburg (see Chapter 5).

1 Water Sensitive Urban Design is an Australian approach to urban design and stormwater management that is especially prominent in Australian and Southeast Asian water engineering and urban design discourse. See: Wong 2006. Wong, T., HF. (2006): Water sensitive urban design-the journey thus far. Australian Journal of Water Resources 10.3:213.
2 The Eco-City concept introduced by urban ecologist Richard Register in Berkeley, California in 1990 is one of the most prominent guiding principles especially (but not only) in urban development in China. See: Roseland, M. (2007): Dimensions of the eco-city. Cities 14.4: 197-202.
3 Local Agenda 21 is an umbrella term for programs of different local governments that include local measures to reach development goals approved of 178 nations at the Earth Summit (UN Conference on Environment and Development) held in Rio de Janeiro, Brazil, in 1992. To refer to local Agenda 21 for local programs for sustainable regional development is very prominent in Europe and especially in Sweden.
4 Water Framework Directive: Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy. http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32000L0060
5 EU-wide strategy on Green Infrastructure: Communication from the Commission to the European Parliament, the Council, the Economic and Social Committee and the Committee of the Regions: "Our life insurance, our natural capital: EU biodiversity strategy to 2020" /* COM/2011/0244 final */. http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:52011DC0244
6 See The Hong Kong Biodiversity Strategy and Action Plan of the Agriculture, Fisheries and Conservation Department (AFCD), Government of Hongkong; https://www.afcd.gov.hk/english/conservation/con_bsap/con_bsap.html
7 Referring to Singapore's signing of the Convention on Biological Diversity (CBD) NParks developed and launched the National Biodiversity Strategy and Action Plan (NBSAP) for Singapore in 2009. The ABC-Waters Program is explicitly taken as one measure for biodiversity conservation in the NBSAP. See: https://www.nparks.gov.sg/biodiversity/our-national-plan-for-conservation

WHAT TYPICAL OBSTACLES HAVE TO BE OVERCOME?

BGI is still controversial as a potential infrastructure investment. Occasionally cited as criticisms of BGI are high degrees of project complexity, long-term horizons of project time lines, high-level expertise and resource requirements.

Additional challenges are restrictions on land use, securing appropriate zoning, or the lack of availability of land for BGI. A change in urban planning is frequently confronted with the limitations of previously adequate land use regulations, and BGI is no exception.

However, as was seen in the cases in Singapore, when the mindsets of policy-makers are behind the BGI approach, these types of practical challenges are surmountable. Additional challenges are of more cognitive-cultural nature, and emerge when those mindsets are not aligned with the blue-green approach. As discussed in earlier sections, BGI represents a paradigm shift in urban water management. Its success requires a cognitive-cultural change in the mindsets of a number of different stakeholders, across a variety of different organizations and a range of different disciplines.

Changing the mindset of individuals is a less tangible challenge than the limitations of land use regulation.[1] However, survey of the case studies allowed us to identify two specific obstacles to a paradigm shift that supports the BGI approach. These were: doubts of water engineers about the feasibility of BGI as a safe and reliable type of water management infrastructure, and silo thinking and a lack of BGI-oriented professional cultures in the institutional bodies.

In this section, we consider how these obstacles were manifested in the case studies, and how they were overcome in successful BGI implementation.

1 Interview Mr. Khoo T., Ch. (15/5/2015) at the Centre for Liveable Cities in Singapore, conducted by Wörlen, M., Ng, C., and Tovatt, O.

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LAND RESTRICTION

In implementing BGI on a citywide scale, the identification of available and suitable land is only a first step. New construction requires a variety of different types of permits, and must meet a variety of zoning requirements. Because BGI projects integrate several types of land use, BGI may not fit neatly into the framework of existing zoning types and regulations.

Problems related to land restrictions occur very often in dense areas and principally take the form of constraining factors especially for large-scale projects. If a government does not own the land earmarked for a proposed BGI project, or the land desired for the project does not lie within the city´s boundaries, BGI projects may not be able to unfold their full benefits.

This is especially true in the field of stormwater management as effective management of water flows on urban scape depends on the feasibility of a watershed approach. There are two specific hydrologic issues of particular importance when designing with water:

WATER FLOWS DOWNHILL

Water follows the logic of gravity, regardless of political borders and jurisdiction. One of the primary mandates of the BGI approach is to augment and enhance urban hydrology. Thus, the BGI approach is inherently catchment-oriented. The vision for a BGI project designed to improve local water management may clash with a socially induced system of property rights. Aligning the water management objectives of a BGI project with property rights and cognitive-cultural constraints requires finesse in coordinating the interests and cooperation of different shareholders.

SURFACE WATER FLOWS OBEY A NATURALLY DICTATED HIERARCHY

A corollary of the fact that water flows downhill is that in doing so it always follows the path of least resistance. A consequence of this is that in flowing downhill, streams are formed and join others to form streams of increasingly higher order. As the stream order increases, so does the relative size of the catchment area supplying it. The BGI approach, which follows the natural logic of water, suggests a chain of responsibility and ownership that may be distinct from local water laws: Water streams and the responsibility to control and treat them should be increasingly socialized on their way downstream (i.e. as stream order increases). The logic of water management responsibility should progress naturally from private responsibility for small order, peripheral streams to semi-public, community-level flows and finally into fully public streams.

Ensuring sufficient land is set aside for BGI will be an important policy issue for a long-term water-conscious, catchment-oriented urban design. While there exist legal maneuvers around land use obstacles – such as expropriation, reallocation of property rights, and exercise of pre-emption rights – the efficacy of these methods depends at any time on the institutional and financial capacity of the agencies and institutions involved. The strategy of first choice should be a precautionary land use policy for urban planning, and one that explicitly supports a water catchment approach with the aim to reserve corridors and relevant areas for BGI on every scale of urban planning. In the long term, the latter approach will be more convenient and effective – and therefore, will contribute to the success of BGI projects.

BLUE-GREEN INFRASTRUCTURE IN THE NEED FOR PRECAUTIOUS LAND USE PLANNING

In 2005, a citywide flooding in Mumbai resulted in significant loss of human life and unprecedented disruption of services. According to reports, the floods damaged 40,000 commercial establishments, 30,000 vehicles, and disrupted electric supply for 24 hours. Most arterial roads and highways were impacted, the railway services were closed, and 500 people lost their lives. In suburban Mumbai 175,885 houses were partially damaged and 2000 were fully damaged.[1] Some studies estimated the flood costs to the city at 2 billion USD (Flood risk and climate change in Mumbai, OECD)[2] . Hydrological assessments stated afterwards that flows into Mithi River were the primary source of flooding. The Mithi River was accused of failing to perform its dual function as a drain to carry monsoon waters out and as surge protector to accommodate the high tide from the Arabian Sea. However, that was only part of the truth, since capacity of the Mithi River has not only been reduced but also the catchment area of the river has been impacted by increased urbanization. A spatiotemporal analysis using satellite data from the years 1966, 1987 and 2005 indicated significant land use and land profile changes within the Mithi River catchment area over the indicated time period.[3] This included a 50% reduction in river width from encroachments and landfilling. In addition to the reduced capacity of the Mithi River, there had also been significant loss to riparian areas, which act as buffers during high stream flow. There was a 70% decrease in mudflats and other open spaces in the river catchment. Meanwhile the built area increased from 29% to 70%, thus increasing impervious surfaces and therefore stormwater runoff. Further, the study of the river course indicated that landfilling and encroachment reduced the length of the river from 18.8 km to 15.16 km. The lower Mahim Basin showed an increase in landfilled area from 0% in 1966 to 13% in 1986. These changes severely affected the natural drainage of the Mithi catchment: reduced surface porosity (impervious surface has increased from 46% to 85%) caused heavy runoff, which reduced the carrying capacity.[4] Therefore, it would be more accurate to blame, not the Mithi River, but urbanization as the source of the 2005 flood.

Singapore is located on a relatively small island of ~700 km2. Surrounded by a saltwater sea, the city of Singapore has no hinterland from which to obtain additional water resources for its growing population. In the early 1960s, following a couple years of low rainfall, the government began to prioritize an approach to water management where "every drop counts". As a matter of national security, water resources management was given a high priority in planning. Unlike most major cities, Singapore's urban water management focuses on the watershed within its municipal boundaries. For this reason, Singapore's land use planning has, for many decades, prioritized urban green space. The urban infrastructure and city layout is adapted to collect all possible rainwater in rivers, canals and drains in many water reservoirs (by 2014 = 17 reservoirs). This water is treated to potability and then pumped for storage into higher elevation reservoirs. Singapore's water infrastructure currently collects water from 70% of the island area, with projects in planning that will increase this to 95% within the coming decade.[5]

However, while policy-makers recognize the importance of green space for water quality, this type of land use is increasingly in competition with expansion of housing development, which has lagged population growth. While the political landscape is in many ways aligned with and supportive of the BGI approach in principle, in practice there are many obstacles to implementing large-scale BGI. Singapore provides an interesting case for many reasons, and the useful lesson that even when supporting conditions exist, the success of BGI projects cannot be taken for granted.

Singapore also provides an opportunity to consider another lesson. It is important to keep in mind the importance of integrated functionality to the BGI approach. Blue infrastructure elements that exist adjacent to green infrastructure do not necessarily make a BGI. When a design consists of tidy, decorative planters lacking hydrological integration with neighboring blue features, the result is not what we understand by the integrative approach of blue-green elements.

While Singapore has many green spaces, and in many places they are adjacent to open water bodies, these waters are mostly linear, cement-lined canals within dense urban housing districts. While the space immediately adjacent to these canals serves as a connector for cyclists and walkers, and may also contain recreational equipment, social meeting spaces, and extensive gardens, the functional separation between the hydrology of the park and the canal prevent these features from being true BGI.

Integration between blue and green functions is essential to BGI project success and is key to optimizing the benefits for both, water bodies and urban greenery, as will be explained further in Chapter 5.

1 Hallegatte, St., Henriet,F., Patwardhan,A., Narayanan, K., Ghosh, S.,Karmakar, S., Patnaik, U., et al. (2010): Flood Risks, Climate Change Impacts and Adaptation Benefits in Mumbai: An Initial Assessment of Socio-Economic Consequences of Present and Climate Change Induced Flood Risks and of Possible Adaptation Options. http://www.oecd.org/home/.
2 Ibid.
3 Kamini, J., Jayanthi, S.,Raghavswamy, V. (2006): Spatio-Temporal Analysis of Land Use in Urban Mumbai -Using Multi-Sensor Satellite Data and Gis Techniques. Journal of the Indian Society of Remote Sensing 34 (4): 385–96.
4 Rawoot, S., Wescoat Jr., J. L., Noiva, K., Marks, A. (2015): Mumbai Case Study. Research and Recommendations for Blue-Green Urban Infrastructure. Final Report ofRamboll´s Research Project „Enhancing Blue-Green and Social Performance in High Density Urban Environments". Massachusetts Institute of Technology (previously unpublished).
5 Wörlen, M., Moldaschl, M. (2015): Enhanced Socio-Economic Analysis of BGI as Urban Innovation. Final Report ofRamboll´s Research Project „Enhancing Blue-Green and Social Performance in High Density Urban Environments". European Center for Sustainability Research, Zeppelin University (previously unpublished).

DOUBTS ABOUT TECHNICAL FEASIBILITY

BGI is still relatively unknown as a technology and tool for water management. Therefore, a challenge in BGI adoption is that individuals still need to be convinced that BGI is able to guarantee functionality as reliably as established solutions. As standards for BGI design emerge, and as performance data from existing projects is gathered, BGI becomes more comparable to conventional grey infrastructure as a design option. However, this type of documentation is still in its early stages. To avoid the risk of the unknown, many planners and decision-makers prefer a mediocre conventional grey infrastructure design to a promising BGI project. This is particularly true when other supporting conditions for BGI, such as sustainability programs, are not in place.

Another obstacle to convince decision-makers of the viability of blue-green infrastructure as urban water infrastructure is its apparent complex and effective functionality when compared with conventional grey infrastructure. The logic behind conventional infrastructure may appear more straightforward at first glance than a BGI design. Conventional systems consist of elements and services like: an inlet for collecting stormwater runoff; a network of sewers through which the runoff is contained and directed; potentially some degree of wastewater treatment through filtration or settling basins or ponds, and finally have an outlet into the water environment. In combined systems with waste and stormwater the overflow at a storm-event brings pollution directly in the natural water environment. In separated systems, stormwater is discharged very often without treatment directly into waterbodies of the environment. Each function is met by appropriate application and operation of a particular technology – a drain, a sewer pipe, and a settling basin or pond.

In contrast, within a BGI project these functions are less clearly delineated but very effective to cleanse stormwater. The high degree of integration that characterizes such projects makes them more complex and seems to be more confusing to engineers and managers who are used to linear systems and discrete simple technologies.

But, as discussed earlier in this chapter, without the support of local water agencies, large-scale BGI is unlikely to be implemented with success. Therefore it is worth spending time and resources engaging in information exchange, education, and knowledge sharing with these agencies. In several case studies, local water agencies offered initial resistance to BGI. However, after efforts to elaborate on the values, benefits and opportunities of BGI and to understand the concerns of the agency representatives (and explain how the project design addressed their concerns, particularly flood protection and water quality), these agencies became key supporters in the BGI project.

Another potential challenge to BGI adoption that needs to be highlighted is shifting negative public opinion that was shaped by previously attempted BGI or BGI-like projects that failed. Even if a BGI project is successfully constructed, if it is poorly maintained, badly designed, or does not meet important requirements (like failing to substantially address flood protection and water quality), this failure can have a long-term impact on people's will to support such projects in the future. Every effort must therefore be made to ensure that a pioneering BGI project works to build social capacity wherever possible and follows through on promises – in short, pioneering BGI projects need to err on the side of under-promising and over-delivering, rather than the reverse.

Soon after Bishan-Ang Mo Kio Park was completed and the Kallang River was reconstructed in an ABC manner, strong storm events hit Singapore in 2012/2013 and flash floods were happening at Orchard Road. Even though there was no evidence and connection as no ABC project was built upstream, in the media and public opinion, BGI and the ABC Waters Program were associated with this problem. This shows how fast preconceptions are nurtured by such events and pose a real challenge to innovation like new BGI systems.

Img.57

RESISTANCE TO BGI IN WATER AGENCIES

Conservative attitudes towards water infrastructure were culturally embedded in Hannover-Kronsberg´s urban water agency, and strongly affected the BGI solution. Fritz Tolle, the then CEO of Hannover Wasser (i.e. Hannover's water agency), was initially strongly opposed to BGI. He was afraid that the proposed BGI project would lead to a higher risk of flooding compared to a conventional, grey solution. A whole network of BGI supporters tried to demonstrate the safety, feasibility, viability, and advantages of BGI by conducting scientific studies and small-scale test trials. In the end, Tolle gave his permission for the project to move forward, but insisted that the final design includes an extensive trench and sewage system in parallel with the BGI. This resulted in a system that was over-equipped and therefore unnecessarily expensive.[1]

To proceed, the BGI designers for Bishan-Ang Mo Kio Park in Singapore – Studio Dreiseitl – had to convince officials at the water agency (PUB), the parks agency (NParks), and the construction companies of the robustness and capacity of BGI as a drainage and cleansing infrastructure. This required several major efforts by the designers. In the end, the designers decided on their own risk and initiative to build a smaller-scale pilot project to run test trials of the system performance. This pilot project had to be constructed parallel to the original, concrete canal and discharge water from the canal in the newly build riverbed to demonstrate its resilience against soil erosion. For the water engineers of PUB this was of major importance. The engineers were concerned that the BGI design would lead to large quantities of soil erosion, which would reduce the capacity of the system for flood protection and cleansing functionality, and – most importantly – would endanger the quality of drinking water in the water reservoirs downstream.[2] This was a legitimate concern, since these downstream reservoirs provide a substantial amount of Singapore's water. In the end, the ability of the designers and the national agencies to work together to address these concerns led to a very popular, award-winning design – in short, a success.

1 Wörlen, M., Moldaschl, M. (2015) Enhanced Socio-Economic Analysis of BGI as Urban Innovation. Final Report of Ramboll´s Research Project „Enhancing Blue-Green and Social Performance in High Density Urban Environments". European Center for Sustainability Research, Zeppelin University (previously unpublished).
2 Ibid.

In the case of Singapore, the doubts about the viability of the BGI approach were shared not only by the national agencies but also by the wider public. Public awareness campaigns are designed to make Singapore's citizens aware of the precarious position of Singapore's water security. These campaigns are designed to try to ensure that Singaporeans do not take their water for granted, which may explain this adversity to risk from the public. Culturally, Singaporeans are accustomed to a high degree of regulation and oversight in their lives, and are raised to value social conventions. Moreover, Singapore has a tropical rainforest climate. National agencies are constantly fighting against stagnant water, an effort tainted by recurring national outbreaks of dengue fever. People are constantly reminded through public education campaigns that stagnant water poses a serious risk. Singaporeans were worried that the restored river in Bishan-Ang Mo Kio Park would have large quantities of stagnant water, which would substantially increase the risk of dengue. However, the risk of stagnant water and a mosquito-breeding ground is likely lower for BAMK than many of the other parks in Singapore, since the streambed in BAMK has an elevation drop that ensures water flow and also hosts a variety of fish and other insects that prey on mosquitoes and larvae.

Other fears include the presence of invasive species, including snakes, caterpillars, and snails. Park users were also afraid of potentially reduced water quality, the entry of pollutants and poor maintenance. Project designers and the national agencies acknowledged these anxieties, and efforts were made to ameliorate these concerns through public education, onsite information panels, and media coverage. Once the project designers had the backing of the relevant national agencies (PUB, NParks, and others), these agencies proved to be key supporters of the project and heavily engaged with the public through their political platforms to counter these anxieties.

The high degree of integration that characterizes BGI projects makes them more complex and seems to be more confusing to engineers and managers who are used to linear systems and discrete simple technologies.

SILO-THINKING IN THE ADMINISTRATIVE REALM

Across the case studies, silo-thinking was found to be one of the major constraining factors for BGI implementation. We identified two main ways in which silo-thinking manifested itself:

Horizontal silo-thinking occurs when inter-institutional capacity is low and agencies involved with BGI make little or no effort to cooperate across agency interests.

Vertical silo-thinking occurs when a hierarchy exists in authority and responsibilities related to BGI implementation. Low inter-institutional capacity between authorities occupying different governmental levels (e.g. national and local levels) leads to project fragmentation or deliberate attempts to obstruct efforts by another authority.

The inherent complexity of BGI planning and implementation necessitates though the cooperation and coordination of a number of involved institutions and agencies. This cooperation is facilitated or hindered depending on the institutional framework in which these agencies operate, and whether this framework allows adaptation of agency aims of different agencies to one another. The relative ability of the framework to support this type of cooperation and adaptation is a key component of institutional capacity. Cooperation requires the institutional actors to share knowledge and negotiate agendas and aims. Successful BGI implementation demands personal readiness of individuals to understand (or even share) the perspective and values of other actors involved, and to be jointly and actively engaged in the development of innovative solutions.

Where institutional capacity is low, e.g. because the institutional framework is not supportive of the necessary cooperation or individual actors are not prepared to cooperate, it becomes all too easy for a gap of accountability to emerge. Each institution involved comes into the process with individual aims and follows more or less its own agenda. Where conditions for cooperation are not favorable, it is much more difficult to achieve a platform and agenda of mutual understanding, and without shared aims, BGI projects are almost certainly doomed.

Unfortunately, the policy environments into which BGI projects are introduced are often characterized by a lack of cohesive policy framework. Responsibility for the relevant regulations is typically divided between departmental boundaries. Blue-green infrastructure planning and implementation lends itself as a near-perfect example of a complex policy area that cuts across many traditionally established lines of responsibility.

While the existence of an appropriate and supportive policy framework at the institutional level is important, it often is the personal level that ultimately safeguards or hinders eventual project success. For instance, even in the cases implemented in relatively fragmented and divided institutional settings, sometimes the requisite cooperation could be achieved when it was facilitated by individuals with a shared professional socialization or similar educational or social backgrounds.

Certainly, many books have been written on the value of cooperation in a business setting and how to achieve it. To summarize for our cases, in addition to sharing a social network, cooperation was also enhanced when individual actors shared other values, such as professional 'worldviews' or 'belief systems' with one another (e.g. as between legalist perspectives and managerial notions of policy-making, or as between aesthetic or technical considerations with political or economic rationales).

In a similar vein, relevant stakeholders and key actors in policy-making and implementation may adopt a variety of roles amongst themselves that can facilitate or hinder effective cooperation across organizational boundaries. For instance, one individual might adopt a more reactive role (e.g. as of a classical bureaucrat or expert-driven and technocratic role understandings), while another might pursue a proactive approach (e.g. as a policy advocate or as a political activists or 'policy entrepreneur').[1]

On a personal level, shared networks or values can facilitate mutual understanding between actors and can in some cases be enough to compensate lacking institutional capacity. The other side of this coin is that unwillingness or the lack of readiness to cooperate on the part of individuals can also be enough to constrain the progress of BGI implementation even where institutional responsibility for BGI is formally supportive.

In addition to building shared values, the skillful management of cross-sectional dialogue and the installment of independent commissionership for BGI seem to be the most promising ways to deal with this challenge.

Silo-thinking not only leads to disciplinary, conventional solutions, it also impacts the financial results and is very connected to the striving for power.

1 Böcher, M.(2015): The Role of Policy Entrepreneurs in Regional Governance. In: I. N. Aflaki, E. Petridou, L. Miles(ed.) Entrepreneurship in the Polis: Understanding Political Entrepreneurship. Farnham: Ashgate, S. 73–86; Roberts, N.C., King, P.J.(1991): Policy Entrepreneurs: Their Activity Structure and Function in the Policy Process. Journal of Public Administration Re-search and Theory, 1(2), S.147–175; Timmermans, J., van der Heiden, S., Born, M.P.(2014): Policy Entrepreneurs in Sustainability Transitions: Their Personality and Leadership Profiles Assessed. Environmental Innovation and Societal Transitions, 13, S.96–108. For further explanation see Schröter, E., Röber, J. (2015): Urban Governance for Livable Cities: Institutional Capacity Building for 'Blue-Green Infrastructure' Planning and Development. Final Report of Ramboll´s Research Project "Enhancing Blue-Green and Social Performance in High Density Urban Environments". Zeppelin University (previously unpublished).

OVERCOMING SILO-MENTALITY IN BGI IMPLEMENTATION

In Portland's case, while the political representation within the city council is limited to a small number of elected officials, the urban governance system is generally open and inclusive for a variety of citizens' groups, neighborhood committees, investors' interests and non-governmental organizations.[1] Citizens are also engaged through instruments of direct democracy.[2] As a consequence the "grey-to-green"[3] approach is embedded within a relatively active political climate. Moreover, the political culture of Portland is dominated by a worldview that values grass-roots politics, bottom-up policy-making and an eco-friendly approach to urban issues. These shared values facilitate Portland's consistent marketing strategy for its grey-to-green strategy.[4] That widespread support for BGI pervades Portland's politics and has supported efforts to advocate BGI projects for a wide range of urban renewal projects as solutions to revitalize inner-city neighborhoods and as unique urban developments marketed to draw the "creative class" and entrepreneurs to the city.[5]

In Copenhagen, the planning and implementation of large BGI projects also benefited from a shared planning culture embedded in the Danish and Scandinavian tradition. This planning culture revolves around a cross of managerial and technocratic notions of public service provision and infrastructure development.[6] Eckhard Schröter and Jörg Röber[7] argue that BGI implementation benefited from this shared culture valuing institutional capacity. Most of the key players in the BGI project management teams, private-sector consultancy firms, and HOFOR (Copenhagen's Technical Department and public utility) also share a common professional network, as well as educational background and organizational cultures. Consequently, a widely shared 'worldview' of how large and complex infrastructure projects ought to be managed effectively, helps to span inter-organizational boundaries.[8]

In Singapore the ABC Waters program was only possible after PUB reorganization, which occurred in 2001. After this reorganization, PUB now manages the entire process of collection, production, distribution and reclamation of water in Singapore, leading to significant reduction in institutional fragmentation for water management. Since it is PUB's responsibility and core mission to oversee one of Singapore's most crucial resources – water – this reorganization enhanced institutional capacity by centralizing and integrating the functions of the different agencies. The public mandate of securing water, combined with a highly integrated, top-down approach to water management, gives PUB a powerful position in decisions about water management. This position allows PUB to reconsider Singapore's approach to water management. For instance, when the Water Bodies Design Panel was organized in 1989 its original mission was related to the aesthetic value of water. However, since PUB recognized that aesthetics were fundamentally related to many aspects of water management, it was able to leverage the panel into an opportunity to educate the public on the link between aesthetics and the challenges of providing potable water. This increased awareness helped create facilitating conditions where BGI could be introduced into the city in a major way. Through the opportunity created by the Water Bodies Design Panel, the proposed BGI projects were marketed as rainwater infrastructure that consisted of semi-natural elements and integrated into the built urban fabric, which maximized ecosystem services (especially cleansing) and helped reduce treatment costs.[9]

In the Boston case we see, that local BGI projects increasingly involve collaboration between public agencies and citizen organization across multiple scales. The Muddy River Restoration Project is an excellent example of a BGI project that resulted from this collaboration. Initiated after major 1996 flooding caused severe damage in several affluent neighborhoods adjacent to the Muddy River, the Restoration Project's initial mandate was to increase local storage for stormwater runoff. The project was led by the U.S. Army Corps of Engineers, who actively engaged with the State of Massachusetts, the Massachusetts Water Resources Authority, the Boston Water and Sewer Commission, and Boston Parks and Recreation. It also has an Oversight Committee (MMOC) that includes leading civil society organizations.[10]

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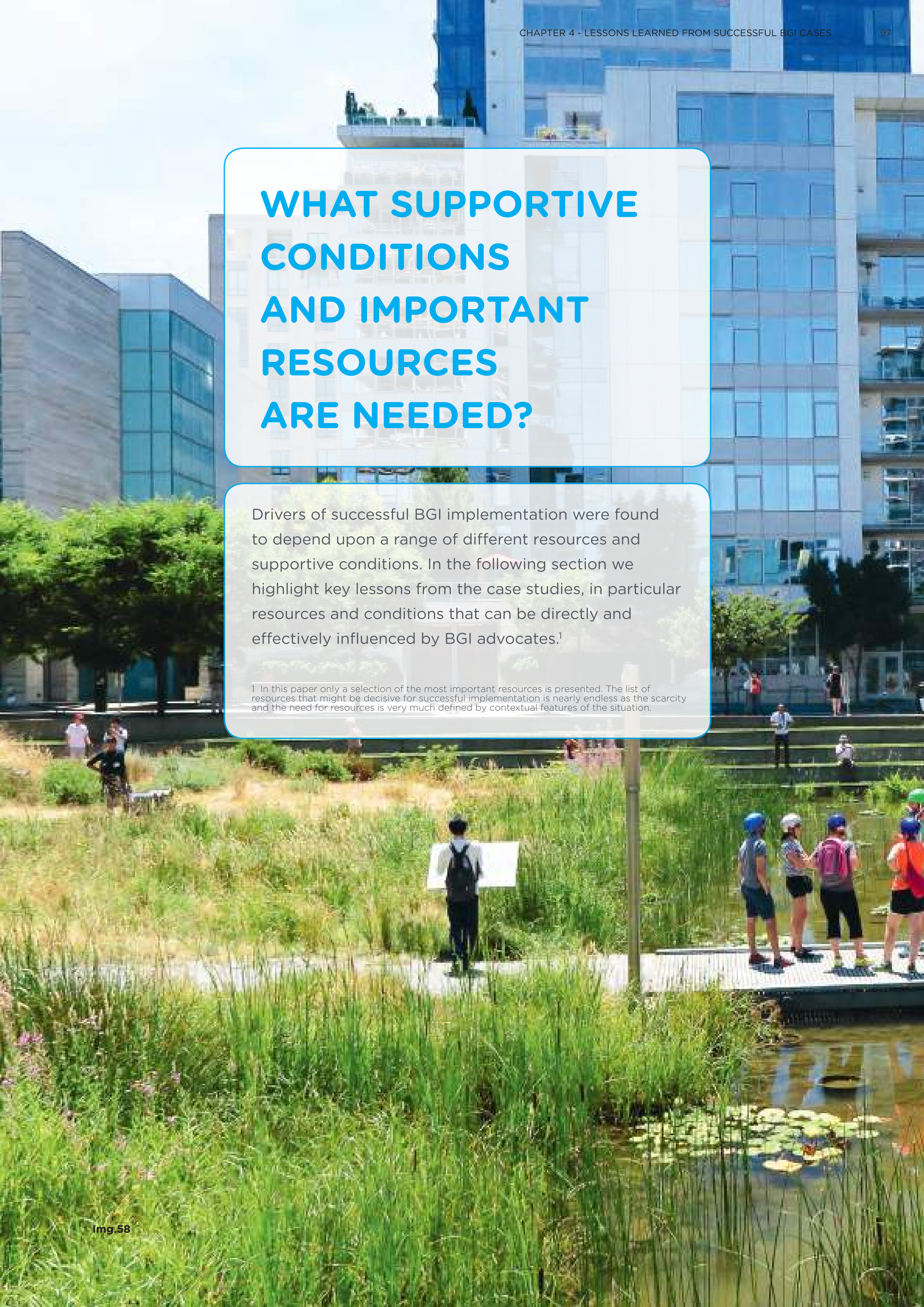
1 Mayer, H., Provo, J. (2004): The Portland Edge in Context, in: Ozawa, Connie (Ed.): The Portland Edge. Washington: Island Press, 9-34. See also: Florida, R. (2008; 175-177) Who's Your City? New York, NY: Basic Books.
2 Gibson, K., Abbott, C. (2002): City Profile Portland, Oregon. Cities, 19(6), S.425–436.
3 Grey2Green is a program introduced by the City of Portland. "Grey to Green was a five-year Environmental Services initiative with other city bureaus and community partners to boost green infrastructure in Portland. The Grey to Green initiative and Environmental Services' ongoing investment in green infrastructure projects and programs helps implement the Portland Watershed Management Plan, protect existing sewer and stormwater infrastructure, and meet other city goals." See: https://www.portlandoregon.gov/bes/47203
4 Florida, R. (2008): Who's Your City? New York, NY: Basic Books; Johnson, St. (2004): The Myth and Reality of Portland's Engaged Citizenry and Process-Oriented Governance in: Ozawa, Connie (Ed.): The Portland Edge. Washington: Island Press, 102-117.
5 Kippenberger, S. (2015): Portland: progressiv und selbstironisch. Der Tagesspiegel, 07.06.2015, p. 5. See also explanation about the Grey2Green strategy in Portland in Fn. above.
6 Hedensted Lund, D. (2012): Climate Change adaptation in Denmark. Enhancement through Collaboration and Meta-Governance. In: Local Environment, 17(6-7), pp. 613-628.
7 Schröter, E., Röber, J. (2015): Urban Governance for Livable Cities: Institutional Capacity Building for 'Blue-Green Infrastructure' Planning and Development. Final Report of Ramboll´s Research Project „Enhancing Blue-Green and Social Performance in High Density Urban Environments". Zeppelin University (previously unpublished).
8 Ibid.
9 Wörlen, M., Moldaschl, M. (2015): Enhanced Socio-Economic Analysis of BGI as Urban Innovation. Final Report of Ramboll´s Research Project „Enhancing Blue-Green and Social Performance in High Density Urban Environments". European Center for Sustainability Research, Zeppelin University (previously unpublished).
10 Marks, A., Wescoat Jr., J. L., Noiva, K., Rawoot, S. (2015): Boston "Emerald Necklace" Case Study. Research and Recommendations for Blue-Green Urban Infrastructure. Final Report of Ramboll´s Research Project „Enhancing Blue-Green and Social Performance in High Density Urban Environments". Massachusetts Institute of Technology (previously unpublished).

WHAT SUPPORTIVE CONDITIONS AND IMPORTANT RESOURCES ARE NEEDED?

Drivers of successful BGI implementation were found to depend upon a range of different resources and supportive conditions. In the following section we highlight key lessons from the case studies, in particular resources and conditions that can be directly and effectively influenced by BGI advocates.[1]

1 In this paper only a selection of the most important resources is presented. The list of resources that might be decisive for successful implementation is nearly endless as the scarcity and the need for resources is very much defined by contextual features of the situation.



Img.58

SUPPORTIVE CONDITIONS AND IMPORTANT RESOURCES

MONEY, MONEY, MONEY: BUDGETS AND FUNDING

Without a doubt, financial resources are one of the most crucial resources for the success of BGI projects. We found that insufficient or badly managed funding is one of the main reasons for the success or failure of BGI project implementation. Why is this so?

The focus of many typical urban planning projects is the provision of housing or other municipally owned buildings; transportation projects; or the construction of other large infrastructures such as the energy grids. The combination of water resources with open green spaces that are characteristic of a BGI project can therefore be easily misinterpreted by some individuals as more of a pet project than an urban necessity. Where BGI projects are in competition with more conventional infrastructure projects, which is a common situation, BGI is unfortunately often seen as not affordable compared to a more "necessary" service. This mindset is unfortunately common in water resources management in general, where the infrastructure is less visible than that for other urban services. This leads to the existing situation, where BGI projects end up last on the list of potential infrastructure investments and are the first to be cut – a situation exacerbated by the fact that BGI projects are seen as high-risk ventures, even to infrastructure investors.

However, as elaborated upon in Chapter 5, it is therefore important to bring awareness to the many benefits and values of BGI projects. Many of these added values are not typically included in a cost-benefit analysis of conventional infrastructure – in part because conventional infrastructure projects do not perform well in these areas. It can be particularly effective to stress the many social, socioeconomic, and ecologic benefits generated by a typical BGI project for a city and its residents. Even looking at direct costs and benefits only, BGI projects are at least as economical as equivalent conventional grey infrastructure. With this in mind, a main recommendation of this report is to increase documentation, data, and understanding of the multiple long-term benefits of BGI.

Especially for financial reasons, it is of major importance that the many different public agencies, investors, and private developers have a strong commitment to BGI. These stakeholders must work together to coordinate on budgeting and to cooperate carefully throughout the project planning process. Effective leadership is particularly important in navigating the planning process where budgets are tight.

In fact, the research suggested for several cases that the total costs would have been significantly lower if the different agencies involved had coordinated their objectives and the timing of their plans. Where this did not happen, there were a number of costly delays and mistakes. In other words, it is particularly important that agencies effectively communicate and coordinate on project timelines, project specifications, and the management of the construction process. In addition, attention should be given to the project timeline post-construction. Agencies should coordinate and cooperate on how they intend to approach operation of the BGI project and share budgeting and responsibility for services and maintenance.

Numerous obstacles to optimal inter-agency coordination exist. As discussed in a previous section, each agency has their own particular authorities, tasks, and responsibilities and these tend to be very strictly delineated. Even when the best intentions exist, the ability for each agency to transcend these silos may be restricted. In these situations, a structural change in the institutional framework is prescribed. Where cooperating agencies are able to recognize the limitations of the existing arrangements, a discussion between leaders can occur with respect to how to promote more effective leadership, and what needs to change for agencies to move past their silos. Within our research, we found the most successful BGI projects occurred in cities that supported and implemented appropriate structural changes.

For example, in the cities of Copenhagen, Portland, and New York City, BGI adoption was facilitated by the creation of a position for a person to coordinate climate change efforts under the offices of the mayor. Notably, for all three cities, these climate change coordinators were granted far-reaching authorities. These coordinates were able to facilitate cooperation between different agencies and stakeholders. An important part of this coordination was found to be a negotiation, facilitated by the climate change coordinators, to outline a role for each agency that was consistent with levels of project commitment, interest, and expertise. This negotiation led to better working relationships and a better balance between responsibilities and agency expertise. For all three cases, budgets were found to be more efficiently executed than for projects implemented under less favorable conditions.

Finally for a long-term success we found that a cultural capacity needs to be developed. Individuals engaged with the project should be educated as to the purpose and goals of BGI systems, especially in their potential to support climate change mitigation and enhance resilience. Additionally, if several stakeholders are involved, financing and budgeting must be transparent and a long-term commitment to operational management made explicit. The development of this cultural capacity requires commitment and more effort than for grey infrastructure systems because of the relative novelty of BGI. However, climate change, water scarcity, and urban resilience are issues of growing relevance, and this commitment fits a larger trend throughout society. Therefore, this should not be considered an undue burden.

As you see, we found multiple sources of funding for BGI including properly managed Public Private Partnerships (PPP), allocation of BGI-related costs onto existing water tariffs, and the safeguarding of costs for future operation and maintenance with fixed budgets. For successful financial results it seems to be indispensable to stress the multiple benefits BGI usually provides (according to local conditions), to implement effective project management, and to use opportunities (timely and spatial) for cost-effectiveness.

EXAMPLES FOR JOINT BUDGETING AND BEYOND

BGI in Singaporean projects (Koo Teck Puat Hospital and Bishan-Ang Mo Kio Park) is widely financed by joint budgeting of different agencies and private investors. KTPH Hospital in Singapore provides an excellent example: From an early planning stage there was the idea to integrate the Yishun Pond element with the recreational area of the hospital. Yishun Pond was originally a large water reservoir, framed and embedded in concrete – epitomizing the aesthetics of the conventional grey infrastructure approach. The KTPH Hospital renovation called for better integration of Yishun Pond with other parts of the hospital's landscape, as well as for more multi-functional use. These targets were considered significant functional changes by the agency overseeing Yishun Pond (PUB) and which required efforts between relevant agencies to collaborate and negotiate on matters of construction and operation costs. Finally KTPH paid SGD2 million for the construction of the waterfront promenade. NParks (the park agency) paid SGD1.2 million for landscaping, footpath upgrading and park lightening. PUB invested SGD2.5 million for the softening of spillway channel, the marshland, and the soft edge treatment of a vertical drain wall. The Housing and Development Board of Singapore (HDB) paid SGD4.0 million for the construction of a lookout tower, a sheltered pathway, and pedestrian bridge.[1]

It seems to have been a necessary experience for these agencies to cooperate on coordinate project plans and budget for KTPH. The experience provided an opportunity for these agencies to work through some of the obstacles to integration and cooperation that would continue to impede the implementation of future BGI. Fortunately, these agencies were able to successfully negotiate and navigate these regulatory hurdles, and in doing so built institutional capacity. The existence of these working relationships and changes to institutional structure will facilitate these agencies working together in the future for additional large-scale BGI projects. Whereas in the past these agencies were frequently unaware of future plans beyond their own, they are now actively collaborating again on another projects. In additional collaboration with a few private developers, these agencies are using a township as a pilot project. In the process, they are drafting additional guidelines for the coordination and integration of the different development agencies.[2]

In addition to the potential for agencies to use a joint financing approach to BGI, there are increasingly options for more direct forms of financing. An example is for BGI costs to be financed through users, such as by a surcharge on the existing water tariff: BGIs in Hannover-Kronsberg are financed by allocation on citywide water charge and PUB, the Singapore's National Water Agency, has the sole competence for charging.[3]

1 Kishnani, N., Cossu, G. (2015):Biophilic Design. Final Report of Ramboll´s Research Project „Enhancing Blue-Green and Social Performance in High Density Urban Environments". National University of Singapore (previously unpublished).
2 Wörlen, M., Moldaschl, M. (2015): Enhanced Socio-Economic Analysis of BGI as Urban Innovation. Final Report of Ramboll´s Research Project "Enhancing Blue-Green and Social Performance in High Density Urban Environments". European Center for Sustainability Research, Zeppelin University (previously unpublished).
3 Ibid.

THE IMPORTANCE OF RELEVANT, MULTI-DISCIPLINARY KNOW-HOW AND EXPERTISE

To build and operate highly valuable BGI for multiple-use purposes is a complex task requiring coordination of objectives between urban planning, landscaping, water management, and ecology. These projects require expertise in all of these areas. Plants and other aspects of the blue-green infrastructure must be designed to be relevant to the local climatic and hydrological conditions while meeting the functional requirements for water management. For instance, swales and retention elements must be able to retain appropriate volumes; these volumes may depend on climatic considerations and potentially on local water use if the BGI is to include water reuse. Reducing erosion, ensuring water cleansing, the demands of aesthetics and recreation requirements – each function requires careful design and consideration and must be balanced with those imposed by other project objectives. To do this effectively and well requires a very particular multidisciplinary skillset.

Even in cases where the individuals driving BGI adoption are themselves experts disposing of the relevant skills, the success of the project is more likely when a number of other actors throughout different agencies are also qualified and knowledgeable about BGI-specific demands and requirements. Planners, construction companies, and operations managers are only a few examples of types of actors who must possess a broad skillset and the ability to work across disciplines.

As discussed before, the holistic approach to water management that is characteristic of BGI is still relatively novel in almost every urban planning environment.

Even in cities with some of the most progressive water management practices, such as Singapore, capacity must frequently be built. In fact, generating the local knowledge base was found to be important in all of the successful BGI projects. The following approach has proven to be very effective to develop up a long-term local knowledge base for BGI construction in Singapore (ABC, BAMKP, KTPH) and in Hannover (Kronsberg):

- The project planners were active members of BGI-professional communities and therefore managed to gain appropriate know-how through foreign projects.

- Regional developers, planners, and construction managers were able to refer to this base of knowledge and drew upon it in implementing individual pilot projects. These pilot projects were then used as examples and test cases for future projects.

- Tests and trials adapting the BGI approach to local conditions were used as opportunities to build know-how.

- Throughout the process, project planners worked closely with scientific experts, which ensured that technical aspects of the design were aligned with aesthetic considerations and vice versa.

- The experience of implementing a pilot project was codified and documented in handbooks for construction. These handbooks were designed to effectively convey knowledge and multiply the learning effects at the local scale.

img.59

THE ABC-WATERS PROGRAM AS LEVER FOR BGI EXPERTISE

In Singapore, the ABC Waters Program Guidelines, educational programs, and certifications in BGI were all used to build the local knowledge base for BGI. These efforts supported the qualification of local planners to adapt the BGI approach to the local conditions. These programs still exist and continue to expand the network of individuals educated in the BGI approach. Since 2011, about 200 professionals have attended and close to 40 are fully certified.[1] Meanwhile, Singapore's ABC Waters Program has issued the third edition of their official ABC Waters Design Guidelines. Overseen by the Public Utilities Board (PUB), the goals of these guidelines are to implement innovative stormwater management elements and increase awareness of this approach throughout the city. Not only did they invent, as the name states, official Design Guidelines for BGI for urban planners and other interested professionals, but they also achieved their stated goal of establishing a certification program. This program exists since 2006 and numerous projects following these guidelines have now been completed, ensuring that BGI throughout Singapore meets standards of professionalism, sustainability, and state-of-the-art technology. Still one can observe some backslides in old gray engineering solutions (like Sungei Pandan Kechil Canal next to West Coast Park) but generally with every new ABC project more skills, knowledge and cultural capacity are developed.

1 Center for Livable Cities (2015):CLC Lecture Series: Urban Transformation of Singapore. Part 1 of 4.http://www.clc.gov.sg/documents/Lectures/2014/UrbanTransformationtranscript.pdf, P.4.

THE IMPORTANCE OF INSTITUTIONAL AND POLITICAL SUPPORT

Institutional and political support should be considered a necessary and irreplaceable resource for successful BGI implementation. As discussed, BGI is inherently an interdisciplinary and therefore inter-agency topic. BGI represents a paradigm different from conventional water infrastructure projects. The successful implementation of BGI projects is more than standard infrastructural projects dependent on the political support of different institutional bodies, including top-level political leaders. The backing of top-ranking politicians typically legitimated individuals who successfully drove adoption of BGI. Even with the support of these political powerhouses and the charisma of BGI drivers, these drivers still struggled to gain the support from all relevant parties, especially for the larger-scale projects. To some extent, the translation of political support to more general buy-in from relevant actors was facilitated by citywide institutions with an established political base.

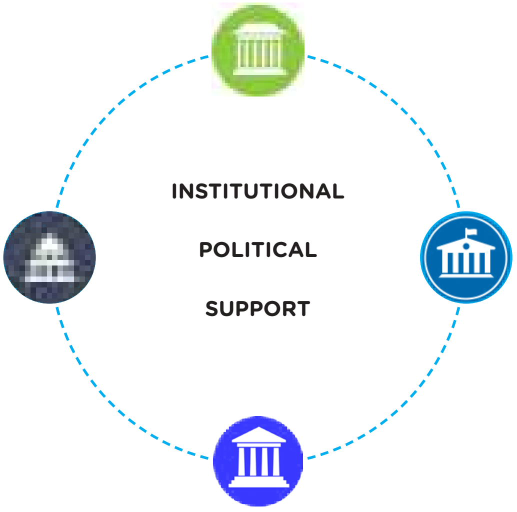


Fig.23

INSTITUTIONAL SUPPORT IS ESSENTIAL

All cases prove the importance of higher-level political support. If drivers of BGI do not manage to get this support (such as in the case of Hamburg), it is practically impossible to be successful.

In contrast, in Singapore, the Prime Minister was a strong and loud supporter of the BGI-focused ABC Waters Program, while in Hannover-Kronsberg the importance of the project to the World Expo 2000 garnered strong backing from the City of Hannover and the regional government of Lower Saxony.

Institutions, acting as intermediaries can also provide the effective political support that is required for a successful BGI adoption. For instance, in the Boston case, the Parks Commission was the initial driving force for the Necklace construction, while in Hannover-Kronsberg the need for sustainable rainwater management brought political support from a regional forest commission.

In some cases the implementation of BGI was only possible because of broad civic support and community engagement. Portland is an example of a city where adoption of BGI was very much a community-driven effort. Even Singapore, where the support for BGI was originally top-down-driven, keeps its BGI momentum now extremely popular with citizens in part because of a large public awareness campaign to overcome objections and in part because of the huge success of Bishan-Ang Mo Kio Park as a pilot BGI project.

HOW CAN THE BGI APPROACH BE INSTITUTIONALIZED AS A STANDARD FOR URBAN WATER MANAGEMENT?

Changing the paradigm of urban water infrastructure towards BGI-thinking is a political-institutional and a cultural task. In general the obstacle to shifting the paradigm is much less about the technical demands of implementing BGI within the urban space, and much more about organizing responsibility for different BGI responsibilities. Most people are averse to change and to accepting new or different responsibilities. However, providing convincing arguments that demonstrate the many benefits of BGI can go a long way towards gaining support from experts. In turn, rallying experts is an important step in institutionalizing the BGI approach in a more general way within a city.

Once the first projects are executed the next step should be to establish BGI as the standard technology for urban water management. BGI has a specific need to be institutionalized in urban planning programs and procedures as other, more short-term infrastructural demands (housing, traffic, commerce, industry, business etc.) compete with BGI for funding, recognition and land. As these demands often are driven by strong individual interests, BGI relies on skillful advocacy that is based on strong arguments.

The political support for BGI does tend to be precarious. Therefore, one recommendation is that advocates of BGI be advised to look for opportunities to stabilize this support through institutionalization, i.e. by shaping planning and construction guidelines to formally guarantee consideration of BGI at an early stage in urban planning projects. In institutionalizing BGI within urban planning culture five supportive tools are regarded to be effective: pilot projects, profound documentation, umbrella programs, guidelines and regulations, building local capacity, and the importance of formal institutions.

Img.60

PILOT PROJECTS

It is promising to start citywide BGI implementation with one or several pilot projects that can then provide middle and long-term perspective as such projects break with daily standard procedures and create room for innovation.

Pilot projects are a measure of first choice in nearly all attempts to innovate social practice. While in general pilot projects often suffer from low visibility, low replicability, and are not always able to meet stated benefits, pilot projects for BGI have proven to be highly effective as a lever to change collective cultures in a city's urban design and engineering sectors. It is promising to start citywide BGI implementation with one or several pilot projects that can then serve to provide middle and long-term perspective as such projects break with daily standard procedures and create room for innovation. Therefore pilot projects as door openers for BGI, provide opportunities for a city's water engineering community to test new ideas, deepen knowledge about on-site conditions, and elaborate expertise of hydrological and environmental processes. A pilot project can also serve as a reference point for both technical feasibility and the range of different potential blue-green and social added values of BGI. Nearly all cases have shown this effect. Regardless of the size of the project, once completed, BGI pilot projects help convey theses added values to decision-makers and the larger public in a tangible way.

Most prominently, Bishan-Ang Mo Kio Park (BAMK) in Singapore now serves as the flagship project for the ABC Waters program in Singapore. The ABC Waters program is the umbrella for about 100 other BGI-related projects in the next 25 years. While the public initially resisted BAMK, this resistance was reduced with awareness campaigns and all disappeared after BAMK was implemented. BAMK is considered a resounding success, both within Singapore and internationally[1], and the wide public acceptance and support engendered by this pilot project will facilitate implementation of the other BGI projects in planning.

1 Bishan-Ang Mo Kio Park has received a number of awards like LIAS Awards of Excellence Silver, Playground & Amenities 2013, Architecture of Necessity, Honorable Mention 2013, President's Design Award 2012, Singapore Design Award, Adventure Playground 2012, WAF Landscape of the Year 2012, WAN Engineering Award Longlist 2012, Finalist LivComLiveable Communities, category: Natural Project 2012, Waterfront Center Honor Award, Excellence on the Waterfront 2012.

DIRECT ADVANTAGES CONVEYED BY WELL-DESIGNED BGI PILOT PROJECTS ARE:

- As BGI projects (even pilot projects) are part of the public realm, they have very high visibility and therefore are suitable measures for creating support in the public and political sphere

- BGI depends upon inter-agency collaboration. Pilot projects provide an opportunity to practice the demands that BGI places on coordination and cooperation. The collaborative effort also creates a shared experience between agencies that can serve as a platform for future BGI projects.

- BGI pilot projects are physical manifestations of design and planning ideas. They can be experienced directly; their results (and benefits) are tangible. BGI pilot projects can also be used to exhibit other innovative ideas in urban design and water management. Therefore they can serve as powerful symbols for inspiration and learning.

- They allow construction practices associated with common BGI elements (e.g. landscaping, maintenance requirements, etc.) to be tested under local conditions.

DIRECT DISADVANTAGES AND PROBLEMS THAT MIGHT OCCUR WITH BGI PILOT PROJECTS:

- The risk of pilot projects is that their frame conditions are often exceptional and therefore untypical, so follow-up projects will have the difficulty to be measured on the high expectations that cannot be fulfilled within standard conditions.

- As frame conditions might be different for follow-up projects, this fact could be an easy excuse not to follow pilot projects and to go for the old habits and conventional systems.

THE IMPORTANCE OF DOCUMENTATION

Since the BGI approach is still relatively novel, techniques are not fully integrated into the established professional planning and engineering education. Successful BGI depends strongly upon the expertise and experience of engineers and designers. Creating relevant and beautiful solutions adapted for local conditions requires a minimum of expertise by a critical mass of partners. Since this range of expertise is not currently common, building up the necessary knowledge base is very demanding and requires foresight, time, and resources.

One important step in this process (in addition to pilot projects) is the codification of knowledge in handbooks. The importance of providing this type of documentation as one of the first steps in building the knowledge base cannot be overestimated. Handbooks are an incredibly efficient way to do this as they provide codified knowledge in a standardized way to a large and broad audience. A good handbook that contains useful advice and design guidelines can lead to rapid growth in the number of BGI projects within a city. In such a planning and construction handbook, it also helps to document lessons learned from early pilot projects, including advice for navigating the interdisciplinary approach.

Especially in Hannover[1] and in Singapore[2] (ABC Guidelines), handbooks have proven to have a high impact. In the construction of Hannover-Kronsberg, twenty-two private construction companies were involved as developers. All of them had to fulfill the same functional requirements for social housing and sustainable neighborhoods. The original planning handbook developed for this project proved to be a crucial tool in coordinating these companies and in ensuring standards were met. After construction, the handbook was re-edited to include documentation of the successful pilot project and lessons learned. It has since proven to be an important tool for communicating the benefits of the project and enhancing the reputation of Kronsberg as an Expo Town project.

Handbooks can focus on different scales and purposes. While in Singapore ABC Guidelines are written for the entire city and state of Singapore, in Hannover the focus has been primarily on the Kronsberg project.

1 Rumming, K.(2004): Hannover Kronsberg Handbook: Planningand Realisation. Landeshauptstadt Hannover, Umweltdezernat, Baudezernat.

2 PUB, ed. (2014): ABC Waters Design Guidelines, 3rd Edition.

Fig.24

THE IMPORTANCE OF UMBRELLA PROGRAMS

Practitioners in urban planning and civil engineering might lose sight of BGI in the course of a relevance shift. As projects are most often focusing on a very specific site, the broader context of water related BGI themes are often overlooked.

To embed BGI in a broader umbrella program for infrastructural planning is an effective countermeasure. Particularly programs focusing on water quality seem to work as a good lever. An example is the European Water Framework Directive[1], which was launched in 2000. This Directive imposes the European member states to care for their water resources in order that all surface water bodies as well as the groundwater achieves the status of "good quality". This implies the need for purification, conservation, and cleansing of surface and groundwater bodies.

1 European Water Framework Directive is published as EC Directive 2000/60/EC of the European Parliament and of theCouncil of October 23, 2000 (L 327 of 22-12-2000). See also http://ec.europa.eu/environment/water/water-framework/index_en.html

On the state and regional level, too we know programs caring about the water resources like "Act on Decentralized Elimination of Rainwater" in Baden-Württemberg, Germany.[2]

While the management of surface and groundwater water bodies has a long tradition at least in the more developed countries, harvesting rainwater has been neglected during the last centuries although it was part of the daily life in many countries. This historically led to enormous know-how and appreciation of rainwater – a culture worth remembering for our water "insensitive" world.

2 Verordnung über die dezentrale Beseitigung von Niederschlagswasser vom 22.03.1999 (§ 45 b, Abs. 3, Wassergesetz Baden-Württemberg); downloaded 2016/04/04; https://www.bodenseekreis.de/fileadmin/bodenseekreis/aemter/wbo/downloads/9-Niederschlagswasserverordnung_mit_Begruendung.pdf

THE IMPORTANCE OF EFFECTIVE, ENFORCEABLE, AND SANCTIONABLE GUIDELINES AND REGULATIONS

Urban wastewater management is a highly regulated field due to the risks of poorly treated wastewater for public health. Regulations for wastewater flows cover the coordination of wastewater transportation on its way downstream and the treatment of this wastewater, including retention facilities. BGI-oriented urban planning can facilitate adoption of the BGI approach through appropriate wastewater regulations. For example, if on-site retention is possible (as a matter of available space, soil conditions and rain volumes), the volume for wastewater discharge can be restricted and on-site infiltration can be required in the building plan. These requirements ensure that developers must consider BGI as part of the development while having the advantage of mitigating the pressure of a new development on existing municipal infrastructure. To be sure, changing existing regulatory frameworks requires substantial institutional capacity and hydrological expertise. Regulations must be defined and tested, and should be implemented in pilot projects, before they can be sanctioned.

As an example of a change to regulations that supports BGI, the sewage regulations in Hannover were altered to allow water authorities to release homeowners from an obligatory water charge in cases where on-site water retention was practiced. Water authorities were also able to force private investors to provide complete onsite retention for future developments. In Hannover, these changes to the regulatory framework have proved highly effective in increasing implementation of BGI throughout the city.

Img.61

THE IMPORTANCE OF BUILDING LOCAL CAPACITY

Cities interested in adopting the BGI approach should invest in efforts to develop this knowledge base locally. In particular, they should begin to invest in qualifying local actors with the relevant expertise. This requires the will for a long-term commitment; however, without this commitment the city will have to depend on external capacities, which can be costly and also unreliable. Local experts will be the most familiar with local conditions and local needs and will be more likely to be in positions to leverage support from their professional and social networks – all of which, as discussed previously, are important for the successful implementation of BGI.

In addition to building a knowledge base within the community of relevant experts, an important long-term measure for BGI adoption is to increase awareness of the benefits of BGI and educate the public on BGI-appropriate technology and sustainable urban design. The goals of a public education campaign should be to build up a strong local base of BGI-relevant knowledge. This knowledge base can then be levered in the process of implementing individual BGI projects and can be crucial in facilitating project coordination and collaboration.

Within a particular urban context, it is most reasonable to expect that the first BGI projects will draw and perhaps rely upon external knowledge. Many cities will not have the BGI-relevant expertise in both landscape architecture and water engineering. However, this should be considered a short-term solution. Long-term, it is important to keep in mind that the more quickly a critical mass of citizens – especially local agency officials, construction managers, developers, and designers – possess some BGI-relevant knowledge, the sooner a momentum in awareness and creativity can be achieved.

Young professionals – especially engineers and designers – may be still looking to find their niche and should be encouraged to consider specialization in BGI as a potential career path. Whether as a freelancer, a more corporate position, or as an actor in the public sector, BGI is an excellent field to shape one's professional profile in the field of urban water design and management. These young professional will be key in the long-term in supporting future BGI implementation. However, these young potentials need support in the form of opportunities for BGI-relevant education, such as workshops, and they also need practical opportunities to build up expertise. Cities should be aware of this and look for opportunities to help support young professionals in this endeavor.

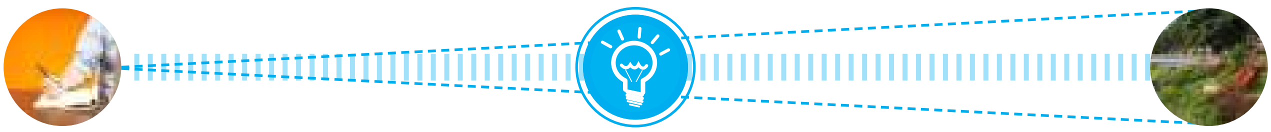


Fig.25

THE IMPORTANCE OF FORMAL INSTITUTIONS FOR BGI

As discussed earlier, having a single individual who coordinates agency responsibilities can greatly facilitate BGI project implementation. Coordinative capacities can be further enhanced by the creation of an agency responsible primarily for the planning and implementation of BGI. Such a BGI agency should be given authorities reaching across existing departmental lines and jurisdictions. The political capacity of such an agency to coordinate BGI can further be enhanced by the creation and designation of a BGI "commissioner", i.e. a role charged with coordinating and overseeing BGI-relevant policy development. Their work can be further enhanced by the creation of joint planning units or joint working groups with an eye towards BGI.

Img.62

CHAPTER 5

EFFECTS AND ADDED VALUES OF BGI

ADDED VALUES

Well-designed BGI has multiple benefits – especially compared to conventional grey alternatives. But still many cities, engineers, planners and decision-makers are initially resistant to BGI. For BGI to have a fair chance against other infrastructure options in urban planning discussions, all involved parties should be aware of the range of added values a BGI solution might bring to their city.

This chapter provides arguments for the positive impact of blue-green infrastructure and its impact on social life and liveability of a city, as well as its financial advantages and potential to enhance the Symbolic Capital of a city. In our discussion, we consider a wide range of impacts relevant to all parties participating in an urban society.

The discussion does address direct benefits of BGI that are relevant to private and/or public shareholders, but special attention is given to the often unattended social benefits for residents, neighborhoods, citizens, and the city as a whole – a social entity unto itself.

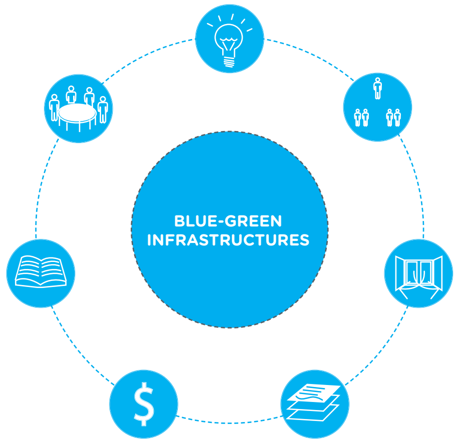


Fig.26A

Fig.26

CAPITAL-BASED ACCOUNTING MODEL FOR ADDED VALUES OF BGI

In order to assess the societal (including ecological and economic) impacts of BGI implementation, we modelled the BGI-induced change of an urban society's capability for liveability, sustainability and resilience. In particular we employed a socio-economic capital-based accounting model, based on the "Polychrome Sustainability" approach of Manfred Moldaschl[1]. This approach allowed us to consider how BGI projects and policies help to build up urban resources for liveability, sustainability and resilience.

THE POLYCHROME CAPITAL APPROACH

In this study, the term "capital" is used for all relevant societal resources. While the term capital is usually understood as financial capital, i.e. a final monetizable outcome of economic transactions, the modern understanding of the term has broadened this meaning, applying it more generally to other types of resources used in society. In a nutshell: We follow a Triple-Bottom-Line methodology in so far as we hang on its idea to take economical, ecological (defined as natural capital)[2], and social sustainability as three pillars that represent distinct dimensions for evaluation. But as an extension of this basic concept, we suggest applying a more detailed and elaborated version of the social pillar.

Therefore we define Societal Capital as immaterial capital that takes certain forms: Human Capital, Social Capital, and Symbolic Capital.

1 See e.g.: Moldaschl, M. (ed.) (2007): Immaterielle Ressourcen: Nachhaltigkeit von Unternehmensführung und Arbeit I. Vol. 3. Rainer Hampp Verlag; Moldaschl, M. (2013): Ressourcenkulturen messen, bewerten und verstehen: Ein Analyseansatz der Evolutorischen Theorie der Unternehmung. In: Klinke, S., Rohn, H., and Becke. G. (ed.): RessourcenKultur. Vertrauenskulturen und Innovationen für Ressourceneffizienz im Spannungsfeld normativer Orientierung und betrieblicher Praxis, p. 111-140.

2 The more we use nature for our purposes, as a bundle of resources that allows for creating products and services desired by humans, nature, too becomes seen as capital – the natural capital. See for similar use of terms e.g. Jansson, A. (1994): Investing in natural capital: the ecological economics approach to sustainability. Island Press; Costanza, R., and Daly, H., E. (1992): Natural capital and sustainable development. Conservation biology 6.1: 37-46.

THE IDEA OF IMMATERIAL CAPITAL

One of the early broadenings of the more classical notion of capital was the expansion of the concept to Human Capital. Gary Becker[1] considered Human Capital to include resources accrued from investments in abilities that are inherently bound to the human body including health, knowledge and personal skills. Theodore Schultz used Human Capital in his book "Investing in People"[2], hypothesizing that that we – both as a society and individually – build up this capital through education.

Later – drawing upon the work of the French sociologist Pierre Bourdieu[3] – categories of Social Capital and Symbolic Capital were added to capture the value embedded in social relationships– a value that becomes evident, for instance, if individuals draw upon these connections to enhance their own capabilities significantly. These relationships can include friendships between persons; trust between management and employees, – even on a larger scale, the level of solidarity within a whole society.[4]

Symbolic Capital follows a similar logic. The image of a person or a country, the brand name of a product or a firm are types of Symbolic Capital, that have to be built up over time through investment, and that can be used to gain trust in a product, an activity, or a plan. In other words, Symbolic Capital can be spent to reduce initial opposition to an idea. Symbolic Capital explains, for instance, how a firm with a valuable brand name can have a market value that is five or twenty times higher than its book value.

1 Becker, G. S. (1992): Investment in Human Capital: A theoretical analysis.The journal of political economy: 9-49.
2 Schultz, T. W. (1982): Investing in people: The economics of population quality. Univ. of California Press.
3 E.g. Bourdieu, P. (1979): Les troisétats du capital culturel.Actes de la recherche en sciences sociales 30.1: 3-6; Bourdieu, P. (1980): Le capital social.Actes de la rechercheen sciences sociales 31.1: 2-3; Bourdieu, P. (1989): Social space and symbolic power. Sociological theory 7.1: 14-25.
4 This idea of Social Capital as capabilities based on social relations is very much established in certain fields of socio-economics. The World Banks Social Capital Implementation Framework applies very similar criteria to define Social Capital; see http://go.worldbank.org/YUKNPQ4MY0.

Human, Social, and Symbolic Capitals are types of immaterial capital, a type of capital that is considered to differ crucially from financial capital and natural capital both in their forms of manifestation as well as in their forms of (re-)production. Immaterial capital may or may not be monetized. The different categories of immaterial capital are inseparably linked to human competences and/or social relations. Immaterial capitals often follow a more generic logic as e.g. trustful behavior is built on trust and enhances trust. From corporate strategic management research we know that immaterial capital can be especially valuable in cutthroat markets since they convey competitive advantages that are hard (or impossible) to imitate by any other competitor. Even in less competitive areas of life, immaterial capital conveys tangible benefits, as seen, for instance, in the long-term impacts of knowledge, social relations, reputation, etc. on social development.

In our discussion of the benefits of BGI we considered these different types of capital and used the so-called Polychrome Sustainability Approach to emphasize dimensions beyond the "green" sustainability of natural resources. The Polychrome Sustainability Approach recognizes the importance of immaterial capital to sustainability. This is of major relevance as sustainability is a general guiding principle not only for natural resources but also for social development. For example Social Capital plays an enormous role in a city's development – drawn upon as a resource for collaboration, participation, self-organization, as well as enhancing aspects of urban life – including social well-being, city identity and identification, social equity, etc.

For some purposes – especially in urban planning and development – it can also make sense to distinguish another physical or "material" capital category: the Built Capital[1], which includes buildings, roads, other infrastructure or parks, etc. Investments in built capital are made to support essential urban services, like providing cooling of the city. The Built Capital can be increased through new development, for instance as new buildings in dense environments.

1 Therefore the approach employed here ("Polychrome Sustainability" plus built capital) is similar to the Community Capitals Framework introduced by Cornelia Flora and Jan Flora; for further information see: Flora, C. B., Emery, M., Fey, S., & Bregendahl, C. (2005): Community capitals: A tool for evaluating strategic interventions and projects. Available from www.ag.iastate.edu/centers/rdev/projects/commcap/7-capitalshandout.pdf (accessed 6. April 2005); and Emery, M., and Flora, C. (2006): Spiraling-up: Mapping community transformation with community capitals framework. Community Development 37.1: 19-35.

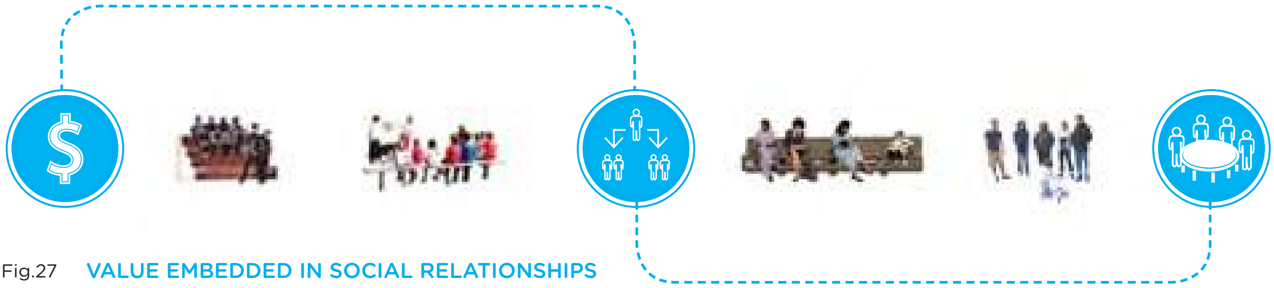


Fig.27 VALUE EMBEDDED IN SOCIAL RELATIONSHIPS

WHY USE THE POLYCHROME CAPITAL APPROACH?

Our model relies on the idea that implementation of BGI, when oriented along the principles highlighted by the Polychrome Capital Approach – induces a positive change in the structural conditions of citizens' lives. As defined in capital terms, we used the Polychrome Capital Approach to assess the added values of BGI by examining post-implementation changes in the capital resources of a society.

The change of capital stocks can be considered as an expression of a society's ability to act: a growth in capital implies increased collective and/or individual abilities to act in the future while a capital reduction denotes a diminished capability for future action. An assumption of the approach is that we can measure, more or less precisely, how different project designs and design strategies contributed to the target criteria being assessed.

With the selection of capitals we follow very much two ideas: (1) We define capitals to take into account an anthropocentric perspective, as human beings are responsible for and can control the employment of the resources (for example by implementing BGI in the urban landscape). (2) All forms of capital can be understood as sources of power. But different capital forms provide different capabilities for activity and follow different logics of reproduction. Knowledge, personal networks, and money are enabling in different ways and get reproduced following different logics. Therefore they do not reduce one another; they are non-equivalent and therefore it is useful to consider each category separately from the others.

We apply the Polychrome Capital Approach to this research for a number of reasons: (1) To make experts, practitioners, decision-makers in urban Infrastructure and interested citizens aware of the value of these different resources. (2) To make them aware of their own utilization styles, consumption modes, and necessary contributions to their reproduction or creation. (3) To emphasize conflicts and contradictions between purposes and target values of strategies using these capitals (e.g. creating more living space while reducing public space and natural space; increasing resilience against floods by channels while losing natural water flows and their aesthetic and biodiversity value, etc.), which usually affect stakeholders and citizens in very different aspects and to different extents. (4) To contribute to accounting methods that can help to create better oversight of costs and benefits, requirements, and resources in complex modern societies; here, this is applied to urban development which has to balance liveability and growth, sustainability and resilience all at the same time.

THE CAPITAL-BASED FRAMEWORK FOR BGI ASSESSMENT

To evaluate the socioeconomic impacts of BGI, we employed the perspective of BGI implementation as a social innovation within a city's process of modernization. This means we defined BGI projects as political interventions in a city's process of shaping its future. From this perspective, we looked for evidence of a potential change to the society's pool of resources (in form of different capitals) that were induced by BGI projects.

We highlight this perspective to explain our approach to monitoring and assessing whether and to what extent a society's pool of resources was impacted by BGI.

Following the Polychrome Sustainability Approach, six capitals were taken as perspectives with which to assess added values of BGI. These capitals were used to evaluate changes in a city's available pool of resources – changes attributable to the implementation of BGI in dense urban areas.

Fig.28

CAPITAL-BASED ASSESSMENT OF VALUES ADDED BY BGI

We applied this system of societal capitals as a heuristic to understand the results and effects of BGI implementation in the specific cases. Evidence of added values with respect to the following benefits was gathered from the case studies. The following list is an overview of the added values that were created in the BGI case studies. It shows the correlation of the capital forms. (As a matter of course, the list is expandable.)

Natural capital is defined as an urban **Ecosystem Services provider** as it supports the reproduction of natural resources for human purposes such as energy, water, air, soil, biodiversity, etc.

Built capital relates to the designed character of **material/physical features of BGI.** Built capital is used regularly in evaluation of infrastructure to report physical assets as well as designed functionalities.

Human capital refers to **personal competences and capabilities** taking different forms like physical and mental health, basic potentials and strengths of persons, knowledge (education, qualification, creativity, etc.).

Social Capital is a power source based on affiliations (e.g. memberships), **personal or impersonal relations to other people** and exists in the form of **trust, commitment and cohesion.**

Symbolic capital is power derived from **attributions of positive value of others,** e.g. reputation or image. Symbolic capital can be based on individual attributes, or generalised, e.g. bound to nobility titles or educational titles.

Financial capital includes **relevant direct as well as indirect costs and benefits** resulting from financial effects or from effects that are frictionlessly transferable in monetary terms.

THE CASE STUDY & THE CAPITALS: SUMMARY

Fig.29

CAPITALS	EFFECT FIELDS
NATURAL CAPITAL	WATER-RELATED ECO-SYSTEM SERVICES
	BIODIVERSITY
	MODERATING URBAN CLIMATE
BUILT CAPITAL	FUNCTIONALITY, PATH-DEPENDENCY, RESILIENCE
	BEAUTY
HUMAN CAPITAL	WELL-BEING
	BIOPHILIA
	LEARNING ABOUT AND EXPERIENCE OF NATURE – ITS VALUES AND PROCESSES
SOCIAL CAPITAL	SOCIAL INTERACTION AND SOCIAL INTEGRATION
	SOCIAL IDENTITY
SYMBOLIC CAPITAL	ICONIC VALUE AND TOURISM
	REPUTATION OF BEING INNOVATIVE
FINANCIAL CAPITAL	PROPERTY VALUE
	HEALTH BENEFITS
	STORMWATER MANAGEMENT BENEFITS

OBSERVED BGI BENEFITS
RE-BALANCE OF GROUND WATER LEVEL - REDUCE PEAK DISCHARGE OF STORMWATER - REDUCED SOIL EROSION - REDUCE INSTREAM DISTURBANCES - PROVIDE STORMWATER CLEANSING
IMPROVED LANDSCAPE CONNECTIVITY - PROTECT AQUATIC ECOSYSTEMS - CREATE BIODIVERSITY RICH ZONES
REDUCE URBAN HEAT ISLAND EFFECT - REDUCED IMPERVIOUSNESS AND REDUCED BIOPHYSICAL AND BIOCHEMICAL IMPACTS OF LAND COVER CHANGES - REDUCED DRY-OUT OF THE URBAN SOIL
IMPROVED WATER MANAGEMENT FUNCTIONS - IMPROVED CAPACITY AND RESILIENCE TO HANDLE WEATHER EXTREMES
IMPROVED AND MORE POSITIVE COGNITIVE RESPONSE OF USERS
IMPROVED PHYSICAL AND MENTAL HEALTH DUE TO UPGRADED SPACE FOR RECREATION, EXERCISE, AND SOCIAL ACTIVITIES
CONNECTING PEOPLE TO NATURAL FORMS, ELEMENTS OR PROCESSES
INCREASED USAGE OF BGI PARKS BY SCHOOL CLASSES AS ADDITIONAL LEARNING EXPERIENCE - IMPROVED KNOWLEDGE ABOUT URBAN WATER CYCLES, WATER QUALITY AND ECO-SYSTEM SERVICES
INCREASED TENDENCY TO USE THE OPEN SPACES FOR ACTIVITIES IN GROUPS - HIGHER TOLERANCE FOR STRANGERS/ FOREIGNERS IN THE BGI PARK AREAS - HIGHER COMMITMENT TO SPEND TIME WITH FAMILY AND FRIENDS
BGI AS UNITING IMAGE AND POINT OF REFERENCE FOR CIVIC IDENTITY - ENHANCED SENSE OF MUTUAL RELATEDNESS WITHIN NEIGHBORHOODS
PROVIDING ICONIC MANIFESTATION OF FUTURE-ORIENTED CITY-DESIGN - SIGNALLING A CITY'S OVERALL ATTRACTIVENESS AND LIVEABILITY
INCREASED REPUTATION OF CITIES FOR BEING LIVEABLE, SUSTAINABLE AND INNOVATIVE - INCREASED LEGITIMACY AND SOCIAL STATUS OF INSTITUTIONAL BODIES, PUBLIC UTILITIES AND PRIVATE COMPANIES, THEREBY GAINING SUPPORT FOR FURTHER DEVELOPMENT PROJECTS - ENHANCED PERSONAL REPUTATION AS VISIONARY THINKERS, SUCCESSFUL LEADERS AND SKILLFUL MANAGERS
INCREASED PROPERTY VALUES ADJACENT TO BGI OF BETWEEN TWO AND FOUR PERCENT
2-5 TIMES LOWER HEALTH COSTS COMPARED TO GREY SOLUTIONS DUE TO MORE PHYSICAL AND SOCIAL ACTIVITIES
LOWER STORMWATER MANAGEMENT COSTS COMPARED TO GREY INFRASTRUCTURE SOLUTIONS

NATURAL CAPITAL

To assess the impacts of BGI, we employed an anthropocentric perspective and defined natural capital as any element of the urban ecosystem that provides services to society, especially those that support the reproduction of natural resources for human purposes such as energy, water, air, soil, biodiversity, minerals, absorption capacities of waste, etc. In short, any element of nature is considered to be a "natural capital" if and in so far as it contributes to any human endeavor, particularly to basic services.[1]

With regard to natural capital, the most significant values across the case studies added by BGI are in the fields of (1) Enhancement of water-related ecosystem services; (2) Support for biodiversity; and (3) Moderation of the urban climate. This should not be considered an exhaustive list of the impacts of BGI on natural capital. Indeed, there may be other relevant BGI impacts on urban ecosystems, however, these were considered to be the three impacts most relevant to this study at this time.

1 Commodification of nature is a double-edged process: on the one hand, the accounting of nature as natural capital could be criticized as neoliberal instrumentalization that ignores the limits of transferability, reproducibility and monetizability of nature. For critique of natural capital and the commodification of nature as ecosystem service provider see: e.g. Robertson, M. M. (2006): The nature that capital can see: science, state, and market in the commodification of ecosystem services. Environment and Planning D 24.3 : 367; Castree, N. (2008): Neoliberalising nature: the logics of deregulation and reregulation. Environment and planning. A 40.1 (2008): 131; Kosoy, N., Corbera, E. (2010): Payments for ecosystem services as commodity fetishism. Ecological economics 69.6 : 1228-1236. On the other hand, it could also be argued that the capitalization of natural resources is necessary to signify their true societal value, which is necessary for protection from further exploitation. Following this second perspective, the functions of nature that must be protected include nature as a sink (e.g., a forest for CO2-sequestration); as a refuge for stressed citizens; as a source of biodiversity, useful for countless human purposes; as an aesthetic value; etc. For further reading on this second perspective see: e.g. Balmford, A., et al. (2002): Economic reasons for conserving wild nature. science 297.5583 (2002): 950-953; Daily, G., Ellison, K. (2002): The new economy of nature: the quest to make conservation profitable. Island Press. For discussion of both perspectives see Gómez-Baggethun, E., Ruiz-Pérez, M. (2011): Economic valuation and the commodification of ecosystem services. Progress in Physical Geography 35.5: 613-628.

Img.63

ENHANCEMENT OF WATER-RELATED ECOSYSTEM SERVICES

Soil sealing in course of urbanization leads to an increase in built area and pervious surfaces reduces the infiltration of the soil beneath the city. It turns out that this process has a very direct disturbing effect on the urban water cycle. While the specific problems differ from city to city – depending upon, for instance, local conditions of soil and geology and also the degree and extent of urbanization – BGI can be an important tool to reconfigure the urban water cycle. It can be particularly effective in addressing problems resulting in unbalanced urban water regimes.

THROUGHOUT THE CASE STUDIES, BGI DEMONSTRATED A NUMBER OF WATER-RELATED BENEFITS:

- Re-balancing of the groundwater level: BGI enhanced on-site retention and infiltration, which protected valuable wetland areas and reduced the need for designation of downstream areas as flood buffer zones.

- Cleansing of storm water runoff: Particularly where BGI projects included biological and ecological elements to enhance cleansing near to the source of pollution, BGI projects were found to improve the general water quality in urban catchment areas, thereby reducing energy demands and costs associated with water treatment.

- Avoiding of overheating and oxygen shortage caused by high temperatures of concrete materials in the riverbed.

- Reduction of peak discharge of stormwater runoff, which reduced the risk and impact of flooding.

- Reduction of disturbance in riparian and freshwater ecosystems: BGI is a near-natural system in so far as the technologies applied should be as near to natural systems as possible.

- Reduction of soil erosion: Reduction of peak discharges reduced the impact, particularly of high-intensity precipitation events, on soil erosion. Soil erosion threatens ecosystem functioning and reduces water quality.

Fig.30

WATER-RELATED ECOSYSTEM SERVICES OF BGI

A study developed by Singh and Mishra[1] documented the impacts of deforestation at the Sanjay Gandhi National Park and the costs associated for drinking water supply in Mumbai. Mumbai forests are the catchment area for a number of reservoirs that supply freshwater to the city, and are Mumbai's primary source of freshwater. The forests in these catchments play important hydrological roles in stream stabilization, reduction of stormwater runoff, improving water quality and reducing siltation. Until the 1970s the water from these sources could be treated to potability primarily through chlorination. However, augmenting urbanization increased pollution, and led to the need for new treatment plants to be installed at Bhandup and Panjrapur. Singh and Mishra documented the rate of deforestation in these forests over the past decades through the study of orthorectified landstat images from landstat.org and digitized land use maps from the National Remote Sensing Centre. The study also analysed information on water quality through the records of Municipal Corporation of Greater Mumbai (MCGM) and a state hydrological project that maintains data on water quality and turbidity levels and controlled for rainfall through the time series. The study estimated that for every one percent decrease in the forest cover, turbidity increased by 8.41% and water treatment cost increased by 1.58%. That analysis concluded that an annual rate of change of forest cover at -0.0088% (1994-2007), the deforestation-induced costs of water treatment translated to 3.73 million Indian rupees/year (ca. 54 USD thousands/year) according to the 2010-11 prices for the Panjrapur treatment plant.

In the design of the Hannover-Kronsberg BGI project, management of stormwater runoff became a central issue. Preliminary hydrological and technical studies showed that a residential district with standard drainage system in this area would have major impacts on the quantitative balance of regional water flows. In order to make construction and development more environmentally sound, a semi-natural drainage concept was designed to minimize the effects of development on the natural water balance. The original water balance for the Kronsberg Hill area prior to construction in 1994 was measured to be 304 mm/year of evaporation, 256 mm/year of infiltration and 14 mm/year of runoff. With a conventional (grey) infrastructure solution, the new development was expected to increase runoff to 165 mm/year with an infiltration of only 145 mm/year. The consequences of these changes to the urban hydrology were predicted to be: (1) extreme variations in the volumes carried by the "Rohrgraben" stream – the only watercourse providing drainage to this area (risks of overflows in the downstream drainage system would be critical); (2) reduction of recharge to the local water aquifer, which would endanger the natural water balance in the wider area including a lowering of the groundwater level of 20-30 cm in the Seelhorst[2], a wetland near Kronsberg with high degree of biodiversity and a much appreciated recreational area. In contrast to the conventional system, the newly developed BGI system with swales, underground storage and limited flow shaft was predicted to lead to an additional runoff of only 19 mm/year (compared to 1994) and also stabilized local infiltration at a level of 287 mm/year.[3] The Kronsberg BGI project design was chosen over the conventional, and a more recent hydrological study of the groundwater development in the Seelhorst testifies a constant refill in spite of the Kronsberg construction.[4]

Another important consideration is the urban water-energy nexus. Electricity is used in the city to pump stormwater runoff and to heat and cool buildings. A study of Entrix[5] in 2010 looked at the relationship between the green roofs advocated by Portland´s Grey-to-Green (G2G) program, and found that these were expected to reduce the electricity usage: "Based on 37 inches of annual rainfall, it is estimated that there are an estimated 1,004,700 gallons of rain falling per surface acre. BES (Portland Bureau of Environmental Services) ecoroof monitoring data from the 2008 BES Ecoroof Report indicates that Portland ecoroofs retain and evaporate approximately 55 percent of annual rainfall. Although not all ecoroofs are equally effective at reducing stormwater, it is the intention of BES to develop ecoroofs with maximum stormwater benefit. Multiplying these figures indicates that every acre of ecoroof will reduce stormwater runoff by 552,600 gallons. Energy savings are expected to result primarily from reduced pumping in the combined sewer system, so it is necessary to estimate the proportion of ecoroofs that are located in the combined sewer area. Although siting of ecoroofs in the G2G Initiative is not known at this time, BES estimates that 80 percent will be located in the combined sewer area. This indicates that every acre of ecoroof will result, on average, in reduction of approximately 442,100 gallons of stormwater annually to the combined sewer system. Using the BES estimate of USD 0.0002 of electricity cost per gallon on combined sewer stormwater[6] and an energy price of USD 0.06 per kilowatt hour (kWh) provides estimated annual energy savings per ecoroof acre of 1,470 kWh. The G2G target is to construct 43 acres of ecoroofs, so the total annual energy savings once this target is reached are estimated at 63,400 kWh annually."[7]

1 Singh, S., Mishra, A. (2014): Deforestation-induced costs on the drinking water supplies of the Mumbai metropolitan, India. Global Environmental Change. 27: 73-83.

2 Mull, R., Lange, A. (1992): Endbericht zum Gutachten, Grundwasserverhältnisse im Kronsberggebiet. Institut für Wasserwirtschaft, Hydrologie und landwirtschaftlichen Wasserbau der Universität Hannover.
3 Stadtentwässerung Hannover (2000): Wasserkonzept Kronsberg. Teil des EXPO-Projektes „Ökologische Optimierung Kronsberg". Hannover.
4 Grotehusmann, D., Schröder, J. (2012): Gutachten zur orientierenden Bewertung zu den Auswirkungen der geplanten Bebauung (B-Plan 1764) auf das Wasserregime. Ingenieurgesellschaft für Stadthydrologie mbH, Hannover.
5 Entrix is a consulting agency in Portland, Oregon, specialized in water resource management. Since 2010 Entrix is member of the Cardno-group. Cardno is an ASX-listed professional infrastructure and environmental services company, with Head Office in Fortitude Valley, Queensland, Australia.
6 i.e. costs of management of stormwater in a combined sewer system.

SUPPORT FOR BIODIVERSITY

Blue-green infrastructure was found to be a highly effective instrument to create, restore, or protect aquatic and terrestrial habitats. For instance, Lin et al.[1] showed that with the naturalization of the canal in Bishan-Ang Mo Kio Park, there was an increase in habitat complexity, which was seen in the type of in-stream substrate, range of vegetation, and flow characteristics. The structure of bank-side vegetation had also been altered. Concomitant with these changes was the increased presence of dragonflies, damselflies, and caddisflies; species associated with "clean" water. Reports of BGI enhancing biodiversity of various types have also been reported in the large majority of scientific studies reviewed in our study. The effects can be attributed to BGI providing habitat, supporting meta-populations across landscapes by reducing habitat fragmentation, and providing refuge for species during critical stages in species' life cycles or in response to disturbances.

Following the results of our research, BGI can be a means to:

- Increase urban biodiversity by enriching biotopes and landscape connectivity, restoring and protecting aquatic ecosystems, and supporting biodiversity-rich zones to sustain flora and fauna.

- Reduce imperviousness and reduce biophysical and biochemical impacts of land cover changes.

- Demonstrate natural ecosystem processes for educational purposes.

- Improve soil quality, which supports biological and mechanical cleansing processes and enhances water quality and ecosystem health.

However, it should be noted that while the influence of BGI on biodiversity can be manifold, its actual impact in practice strongly depends on its individual design features and its local integration with urban hydrology and ecology. In addition, positive and negative consequences of BGI on biodiversity should be carefully and consistently monitored, since these systems are still vulnerable to the spread of invasive species.

Img.64

1 Lin Y, QuekR.F, Yoon H.L, Fung T.K, Kwan W.MI, EikaasH.S and Clews E. (2012): Ecological evaluation of the regeneration of the Kallang River at Bishan Park, Singapore under the active beautiful, clean waters programme, PUB.

BIODIVERSITY-RELATED ECOSYSTEM SERVICES IN THE CASE STUDIES OF BGI

Through the integration between aquatic and terrestrial environments in urban areas, BGI can be a means to support and recreate biodiversity-rich natural transition zones, also known as ecotones in natural ecosystems.[1] For example, areas adjacent to aquatic – lentic, lotic, coastal – areas like riparian zones are known to support a higher level of biodiversity than uplands.[2] BGI implementation in the form of constructed wetlands and riparian vegetation zones help to create and enhance local biodiversity. Implementation of BGI in the form of stormwater ponds and bioretention systems reintroduces forms of landscapes into the urban fabric that existed prior to development. Creation of such habitats enhances landscape diversity in urban areas, which enriches the offerings of different ecological niches that can support higher biodiversity groups. In addition, appropriately designed BGI can be specifically provided as habitats for specific groups or species of biodiversity currently threatened, e.g. amphibians, which are under threat worldwide because of reduction in freshwater habitats.[3] In this way, BGI in the form of urban stormwater ponds in this example can be directly used as a conservation tool.

BGI implementation usually requires planning with catchment-scale considerations in mind, for instance, the water flow across interconnected waterways and waterbodies.[4] Similar connectivity considerations are also important in the ecological management of floodplains.[5] Such planning considerations provide a useful means for creating interconnected blue and green spaces, which is in turn a key strategy for biodiversity conservation traditionally considered in the form of ecological networks. BGI therefore provides opportunities to link fragmented green spaces through a network of corridors in a catchment, thereby connecting isolated populations of species through functional connectivity between aquatic and terrestrial habitats. BGIs themselves can be "stepping stones" or "nodes" through which fauna and flora could move across larger landscapes.[6]

BGI is also a means to reduce total impervious area (TIA), which is well documented as a major predictor of health of stream ecology. Reducing TIA through wide-scale implementation of BGI in urban areas can potentially improve ecological conditions of aquatic ecosystems. In addition, as it is also expected that blue-green infrastructure improves water retention in urban areas, it can also support urban microclimatic changes that improve conditions for terrestrial vegetation and biodiversity.[7]

Many urban areas still contain freshwater habitats or native vegetation with high biodiversity or functional integrity. These areas are often under threat due to fragmentation of landscapes and other adverse effects of urbanization. Urban stormwater runoff is a key stressor of freshwater habitats since it frequently carries high level of toxins and pollutants. Low rates of infiltration in urban environments lead to large volumes of runoff, which can overwhelm and damage fragile stream ecosystems. Since BGI improves the quality of stormwater runoff while attenuating stormwater discharge, it also protects the downstream receiving water bodies and remnant vegetation patches from adverse effects of urban stormwater runoff. When implemented as an upstream mitigation strategy, BGI contributes to a broader mission of protecting aquatic and terrestrial habitats with high biodiversity or ecological values even beyond the bounds of the city, as suggested by Price and colleagues. Specifically, the authors suggested: "placement of stormwater management ponds adjacent to streams and wetlands prevents chemical contamination, sedimentation, and the variability of water flow, benefitting fish, amphibian and reptile populations".[8] This was similarly suggested by Booth and Bledsoe for application of LID[9] to preserve "elements of the natural hydrologic system …[such as] channels and wetlands; … highly infiltrative soil with undisturbed vegetative cover; and intact mature forest canopy".[10]

Furthermore BGI is also a means to demonstrate natural ecosystem processes. Flow of water is a basic natural process, which has been hidden in urban areas. For instance, in most urban areas stormwater is channeled through underground pipes or concealed drains away from the view of urban dwellers. BGI helps to make visible natural water flows in urban areas and provides opportunities for environmental education by connecting people with nature. The latter is a means of raising awareness that humans, despite living in a highly human-influenced urban ecosystem, are still very much dependent on the functional quality of natural ecological flows and cycles of water and other forms of materials. BGI, because of its multiple values, is a good instrument for this purpose. Hassall advocated this added value of BGI[11]; support for this concept is also found in a recently published study by Church on the educational value of bioswales in Portland.[12]

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10 Booth, D. B., Bledsoe, B. P. (2009). Streams and urbanization, In: The Water Environment of Cities, Springer US, pp. 93-123, see p.114.
11 Hassall, C. (2014): The ecology and biodiversity of urban ponds, Wiley Interdisciplinary Reviews: Water 1(2): 187-206.
12 Church, S. P. (2015): Exploring Green Streets and rain gardens as instances of small-scale nature and environmental learning tools, Landscape and Urban Planning 134:229-240.

MODERATION OF THE URBAN CLIMATE

The idea of urban metabolism paraphrases the biological concept of metabolism and highlights the interactions of natural and human systems within in a specific region or district. BGI has significant potential to balance the current material and energy flows of conventional grey infrastructure. For instance, sealing of urban surfaces with built infrastructure directly leads to an increase in urban temperature (urban heat island effect) and a decrease in soil quality. Moreover, since conventional urban water systems are designed to move water into and out of the city as quickly and efficiently as possible, when left to its own devices urbanization can lead to a very arid environment. Growth and densification of cities increases the harmful effects of soil sealing; BGI is a tool to bring the urban metabolism closer to an optimal balance. It has proven to rebalance an urban system even under conditions of high densification.

BGI CAN CONTRIBUTE TO:

- **Modulation of urban climates** by reducing urban heat island effects, balancing diurnal temperature fluctuation, and supporting natural air ventilation. It also reduces the bioclimatic impacts of land cover changes (e.g. desiccation of urban soils and associated wind-borne air pollution and dust hazards). BGI fights the urban heat island effect by providing green and blue elements that cool the city through evapotranspiration.

- **Enhancing the adaptability and resilience** of urban infrastructure by managing and modulating hydroclimatic variability and weather extremes.

Img.65

CLIMATE-RELATED ECOSYSTEM SERVICES OF BGI

Cynthia Rosenzweig from the Columbia University Center for Climate Systems Research led an interdisciplinary research project on behalf of the Energy Research and Development Authority of New York State, modelling planting trees along streets and in open spaces, building living (or green) roofs (i.e. ecological infrastructure) light surfaces, light roofs, and living roofs as measures for New York City's heat island mitigation. The resume: "The most effective way to reduce urban air temperature is to maximize the amount of vegetation in the city with a combination of tree planting and green roofs. Applying this strategy reduced simulated citywide urban air temperature by 0.4°C on average, and 0.7°C at 1500 EST, a time of day that corresponds to the peak commercial electricity load. Simulated reductions of up to 1.1°C at 1500 EST occurred in some neighborhoods in Manhattan and Brooklyn, primarily because there was more available area in which to plant trees and install vegetated roofs in these boroughs. In Manhattan, most of the mitigation would involve greening rooftops high above the street, whereas in Brooklyn, a more balanced combination of the two strategies could be employed."[1]

The Heat Island Group at the Berkeley Lab made a very prominent study about the relation of urban heat Island to urban surfaces in California, reporting: "Cities that have been 'paved over' do not receive the benefit of the natural cooling effect of vegetation. As the air temperature rises, so does the demand for air-conditioning (A/C). This leads to higher emissions from power plants, as well as increased smog formation as a result of warmer temperatures. In the United States, we have found that this increase in air temperature is responsible for 5–10% of urban peak electric demand for a/c use, and as much as 20% of population-weighted smog concentrations in urban areas. (...) On a large scale, the evapotranspiration from vegetation and increased reflection of incoming solar radiation by reflective surfaces will cool a community a few degrees in the summer. As an example, computer simulations for Los Angeles, CA show that resurfacing about two-thirds of the pavements and rooftops with reflective surfaces and planting three trees per house can cool down LA by an average of 2-3K. This reduction in air temperature will reduce urban smog exposure in the LA basin by roughly the same amount as removing the basin entire on-road vehicle exhaust."[2]

1 Rosenzweig, C., et al. (2009): Mitigating New York City's heat island: Integrating stakeholder perspectives and scientific evaluation. Bulletin of the American Meteorological Society 90.9: 1297-1312, see p.1306.The study used a regional climate model in combination with meteorological, satellite, and GIS data to determine the impact of urban forestry, living (green) roofs, and light-colored surfaces on near-surface air temperature and the urban heat island in New York City. The research group evaluated nine mitigation scenarios city-wide and in six case study areas. Temperature impacts were calculated on a per-unit area basis, as well as taking into account the available land area for implementation, and other physical constraints. The scenarios are then evaluated based on their cost-effectiveness at reducing air temperature and resulting energy demand.
2 Akbari, H. (2005): Energy Saving Potentials and Air Quality Benefits of Urban Heat Island Mitigation. Lawrence Berkeley National Laboratory, Pp. 2-20, see p.2.

Img.66

BUILT CAPITAL

Img.67 **BLUE-GREEN INFRASTRUCTURE - ZIDELL**
Strategic stormwater management techniques become uniquely tailored to groups of buildings in order to create distinct neighborhoods.

Built capital relates to the designed character of material and physical features of a city's infrastructure. Here, we consider built capital with particular respect to BGI. Built capital as a category is regularly used in evaluations of infrastructure to report financial assets as well as designed functionalities.

BGI is by nature and design a type of built capital. As built capital, it contributes to the multi-functionality of urban landscapes. Land use and cost optimization is a critical factor in integrated features. Built capital affects people's affiliation to single places as well as to the wider social space, as variable social awareness and significance is attached to built environment.

Each BGI case study documents, first and foremost, its contribution to the built capital of its urban landscape. In many cases, particularly coastal cities, we found that these projects reclaimed spaces that were otherwise overlooked or wasted. All cases show that BGI projects created forms of built capital that were significant in and of themselves (i.e. as valued socio-environmental spaces and places) but also helped to shape other forms of capital like social, symbolic, or human capital.

In our research, we found clear evidence that the following impacts of blue-green infrastructure are of specific relevance: (1) BGI as blue infrastructure increases effectiveness, adaptability and resilience, (2) BGI enhances the beauty and aesthetics of the urban fabric. Additionally there might be other impact fields.

BLUE-GREEN INFRASTRUCTURE INCREASES EFFECTIVENESS, ADAPTABILITY AND RESILIENCE

BGI is a very effective tool for effectively managing the water flow through the urban watershed as it allows for retention and infiltration on various scales, and thereby increases resilience to drought as well as to urban flooding in case of cloudbursts; it bears great potential to slow downstream rainwater flows and consequently reduce peaks.

Therefore urban water management gains particular importance in the face of climate change, which is predicted to increase the volatility and intensity of temperature and precipitation patterns. The weather in many regions around the world, including those in which the case studies were located, has already exhibited deviation from the norm. An increase in the prevalence and severity of droughts is expected, as is an increase in the frequency and intensity of precipitation events.

The increased frequency of high intensity precipitation events multiplies the risk of flooding and flood-related impacts associated with urbanization. Simultaneously, this flood risk is further exacerbated by sea level rise associated with climate change. The devastation to New Orleans caused by Hurricane Katrina in 2005 and the damage to New York City caused by Hurricane Sandy in 2012 demonstrate the vulnerability of cities to climate change. The destruction caused by these two hurricanes raised awareness of the limitations of the conventional grey infrastructure approach to flood mitigation. As a consequence, New York City and New Orleans[1] have begun to invest in BGI to enhance their adaptability to climate change. An example of this in New York City has been a decision to invest in the construction and preservation of coastal dunes to act as a buffer to storm surge. These coastal dunes also help improve the water quality of urban runoff before it reaches the ocean.[2]

For many regions, climate change increases not only the frequency and severity of high precipitation events but also the severity of droughts. The city of Los Angeles provides an example of the challenges associated with these climate change impacts. Several very dry years have severely stressed Los Angeles' water resources. This drought has been occasionally interrupted by precipitation events of incredibly high intensity. Ironically, the drought has increased the imperviousness even of natural surfaces, multiplying the intensity of stormwater runoff associated with these high intensity precipitation events. The consequence is that during the drought, these high intensity precipitation events have induced devastating landslides in urban areas and decreased water quality. In response to these events, Los Angeles has recently invested in an expansion of BGI within the city. This move reflects a recognition that BGI will help to retain stormwater runoff. This will first mitigate flooding and then mitigate the urban heat island effect through evapotranspirative cooling associated with the BGI[3].

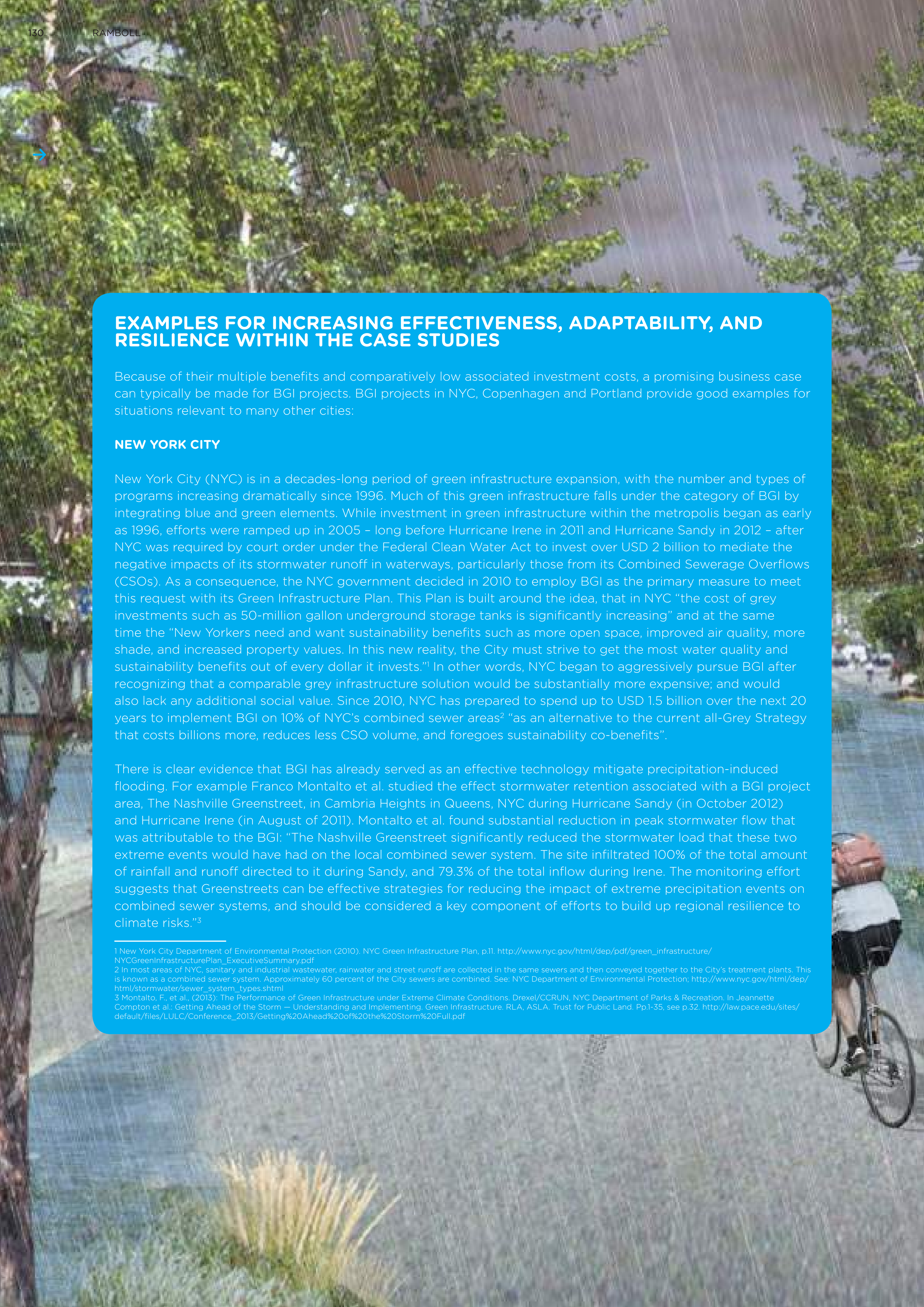
Climate change has highlighted the limitations of grey infrastructure, while opening windows of opportunity for introducing BGI into cities around the world. BGI bears great potential as a measure for climate change adaptation and the reconfiguration of the urban water system.

1 In the face of tremendous damages caused by Hurricane Katrina in New Orleans and the obvious benefits of green infrastructure as a measure for resilient stormwater management the Sewerage and Water Board of New Orleans approved the Green Infrastructure Plan´ in April 2014. It aims to identify projects for integrated water management following a triple bottom line approach. See: Water and Sewerage Board of New Orleans (2014): Green Infrastructure Plan. https://www.documentcloud.org/documents/2511737-greeninfrastructusewerage-and-water-board-of-new.html

2 In the course of Hurricane Sandy, Mayor Bill de Blasio released One New York: The Plan for a Strong and Just New City´ in April 2015 as an upgrade of PlaNYC. A Greener, Greater New York released in 2007. See: City of New York (2015): One New York: the plan for a strong and just New York City. http://www.nyc.gov/html/onenyc/downloads/pdf/publications/OneNYC.pdf

3 Chau, H.-F. (2009): Green Infrastructure for Los Angeles: Addressing Urban Runoff and Water Supply Through Low Impact Development. http://www.environmentla.org/pdf/LID-Paper_4-1-09_530pm.pdf

Img.68 RESILIENT URBAN FABRIC
When BGI is fully integrated, cities become resilient because they behave like green fields, by detaining, infiltrating and giving more time and space for rainwater



EXAMPLES FOR INCREASING EFFECTIVENESS, ADAPTABILITY, AND RESILIENCE WITHIN THE CASE STUDIES

Because of their multiple benefits and comparatively low associated investment costs, a promising business case can typically be made for BGI projects. BGI projects in NYC, Copenhagen and Portland provide good examples for situations relevant to many other cities:

NEW YORK CITY

New York City (NYC) is in a decades-long period of green infrastructure expansion, with the number and types of programs increasing dramatically since 1996. Much of this green infrastructure falls under the category of BGI by integrating blue and green elements. While investment in green infrastructure within the metropolis began as early as 1996, efforts were ramped up in 2005 – long before Hurricane Irene in 2011 and Hurricane Sandy in 2012 – after NYC was required by court order under the Federal Clean Water Act to invest over USD 2 billion to mediate the negative impacts of its stormwater runoff in waterways, particularly those from its Combined Sewerage Overflows (CSOs). As a consequence, the NYC government decided in 2010 to employ BGI as the primary measure to meet this request with its Green Infrastructure Plan. This Plan is built around the idea, that in NYC "the cost of grey investments such as 50-million gallon underground storage tanks is significantly increasing" and at the same time the "New Yorkers need and want sustainability benefits such as more open space, improved air quality, more shade, and increased property values. In this new reality, the City must strive to get the most water quality and sustainability benefits out of every dollar it invests."[1] In other words, NYC began to aggressively pursue BGI after recognizing that a comparable grey infrastructure solution would be substantially more expensive; and would also lack any additional social value. Since 2010, NYC has prepared to spend up to USD 1.5 billion over the next 20 years to implement BGI on 10% of NYC's combined sewer areas[2] "as an alternative to the current all-Grey Strategy that costs billions more, reduces less CSO volume, and foregoes sustainability co-benefits".

There is clear evidence that BGI has already served as an effective technology mitigate precipitation-induced flooding. For example Franco Montalto et al. studied the effect stormwater retention associated with a BGI project area, The Nashville Greenstreet, in Cambria Heights in Queens, NYC during Hurricane Sandy (in October 2012) and Hurricane Irene (in August of 2011). Montalto et al. found substantial reduction in peak stormwater flow that was attributable to the BGI: "The Nashville Greenstreet significantly reduced the stormwater load that these two extreme events would have had on the local combined sewer system. The site infiltrated 100% of the total amount of rainfall and runoff directed to it during Sandy, and 79.3% of the total inflow during Irene. The monitoring effort suggests that Greenstreets can be effective strategies for reducing the impact of extreme precipitation events on combined sewer systems, and should be considered a key component of efforts to build up regional resilience to climate risks."[3]

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1 New York City Department of Environmental Protection (2010). NYC Green Infrastructure Plan, p.11. http://www.nyc.gov/html/dep/pdf/green_infrastructure/NYCGreenInfrastructurePlan_ExecutiveSummary.pdf

2 In most areas of NYC, sanitary and industrial wastewater, rainwater and street runoff are collected in the same sewers and then conveyed together to the City's treatment plants. This is known as a combined sewer system. Approximately 60 percent of the City sewers are combined. See: NYC Department of Environmental Protection; http://www.nyc.gov/html/dep/html/stormwater/sewer_system_types.shtml

3 Montalto, F., et al., (2013): The Performance of Green Infrastructure under Extreme Climate Conditions. Drexel/CCRUN, NYC Department of Parks & Recreation. In Jeannette Compton et al.: Getting Ahead of the Storm — Understanding and Implementing. Green Infrastructure. RLA, ASLA. Trust for Public Land. Pp.1-35, see p.32. http://law.pace.edu/sites/default/files/LULC/Conference_2013/Getting%20Ahead%20of%20the%20Storm%20Full.pdf

COPENHAGEN

Ramboll Management Consulting conducted a socio-economic analysis of two alternative masterplans to fight flooding in the catchment areas of Vesterbro and Ladegårdsåen in Copenhagen during the course of precipitation events. This socio-economic analysis compared the cost-benefits of a grey subterranean with those of a comparable BGI solution, focusing on the overall Net Present Value (NPV)[1] of both projects. The benefits considered included reduction of air pollution, real estate taxes, reduction of insurance damages, increase in real estate value and upgrade savings. The analysis found a positive NPV for both types of infrastructure – in other words, the benefits were found to exceed the combined costs of investment and operational costs. However, the NPV of the BGI project was found to outperform that of grey infrastructure – 142 million EUR to 72 million EUR, respectively, which is 187 million USD to 95 million USD in terms of 2013 exchange rates. Inspection of the costs and benefits indicated that these differences arose primarily from the significantly lower investment costs associated with the BGI vs. the grey: (260 million EUR vs. 368 million EUR, respectively), which is 343 million USD vs. 486 million USD in terms of 2013 exchange rates.[2]

PORTLAND

An analysis by the Center for Clean Air Policy[3] of Portland's citywide BGI implementation of urban stormwater management were found to be highly profitable: "Portland invested USD 8 million in green infrastructure to save USD 250 million in hard infrastructure costs. A single green infrastructure sewer rehabilitation project saved USD 63 million, not counting other benefits associated with green practices such as cleaner air and groundwater recharge benefits. Portland's Green Street projects retain and infiltrate about 43 million gallons of water per year and have the potential to manage nearly 8 billion gallons, or 40% of Portland's runoff annually. Portland estimated that downspout disconnection alone would lead to a reduction in local peak CSO volume of 20%".[4]

SUMMARY

BGI was found to be an economical approach to infrastructure in New York City, Copenhagen, and Portland, demonstrating the viability of the business case under a variety of contexts. The case studies highlighted the use of BGI for stormwater management, additionally BGI is an instrument for mitigating heat island effects in dense urban areas (and for combining the two functions); this is proven in many other cities like e.g., London, Rotterdam, Vancouver, Paris, and Philadelphia – among others.[5]

1 Net Present Value (NPV) is the difference between the present value of total cash inflows and the present value of total cash outflows. In the analysis mentioned here costs of financing are taken as discount rate for private utilities (serial loans with maturity of 40 years at 3 % interest rates). Municipality's costs of financing are neglected.
2 Leonardsen, J. (2013): Cloudburst Adaptation. A cost-benefit Analysis. Ramboll Management Consulting.
3 Center for Clean Air Policy (CCAP) is the an independent, non-profit think tank working on climate and air quality policy with Head Office in Washington, D.C.
4 Foster, J, Lowe, A., Winkelman, S. (2011): The value of green infrastructure for urban climate adaptation. Center for Clean Air Policy.
5 Based on presentations made in the Masterclass on Climate Change Adaptation on November 24th-25th 2014 in Copenhagen organized by the City of Copenhagen and Ramboll as part of the European Capital initiative. http://sharingcopenhagen.dk/english/calendar/events/masterclass-on-climate-change-adaptation/

Img.69

BGI ENHANCES A CITY'S BEAUTY AND AESTHETICS

That "beauty is in the eye of the beholder" is only half of the truth. According to Detlev Ipsen, spatial perception is neither a purely subjective issue based in sensorial perception, nor is it a simple feature dependent upon the physical world of objects. It results from and is embedded in a learning process built upon anthropological needs, embodied experience, and external inspiration; it is different for each individual and evolves over time.[1]

For decades, the ideal of subjective beauty in design was subverted by an emphasis on efficiency of form for function. However, the topic of aesthetics has become increasingly important to the discussion of sustainable development. The Living Building Challenge (LBC), for instance, stipulates 'beauty' as a category in its framework for design compliance. In giving aesthetics its own category, the LBC has taken a noteworthy departure from other sustainability assessment tools in the building industry. In evaluating a project design for compliance, LBC looks for "features intended solely for human delight and the celebration of culture, spirit and place appropriate to its function"[2]. Within the same category, the LBC looks for design elements that enhance the creation of awareness – such as acts of advocacy or education that increase the buy-in of the public and/or the user.

For any given requirements, a project can be designed in multiple ways, not all of which will be deemed beautiful by a majority of its users. The relative beauty of a design can be shown in its impact on a user, through measurable physical and cognitive response. In other words, beauty and aesthetics are more than subjective attributes of a project: they have a measurable user response and can therefore be compared between projects.

1 Ipsen, D., (2006). Ort und Landschaft. Wiesbaden: VS Verlag für Sozialwissenschaften.
2 Living Building Challenge Version 3.0. http://living-future.org/lbc/about

For these reasons, the attribute of beauty is considered an attribute of a project design and an attribute of a BGI project. More specifically, beauty is an attribute associated with Built and Natural Capital.

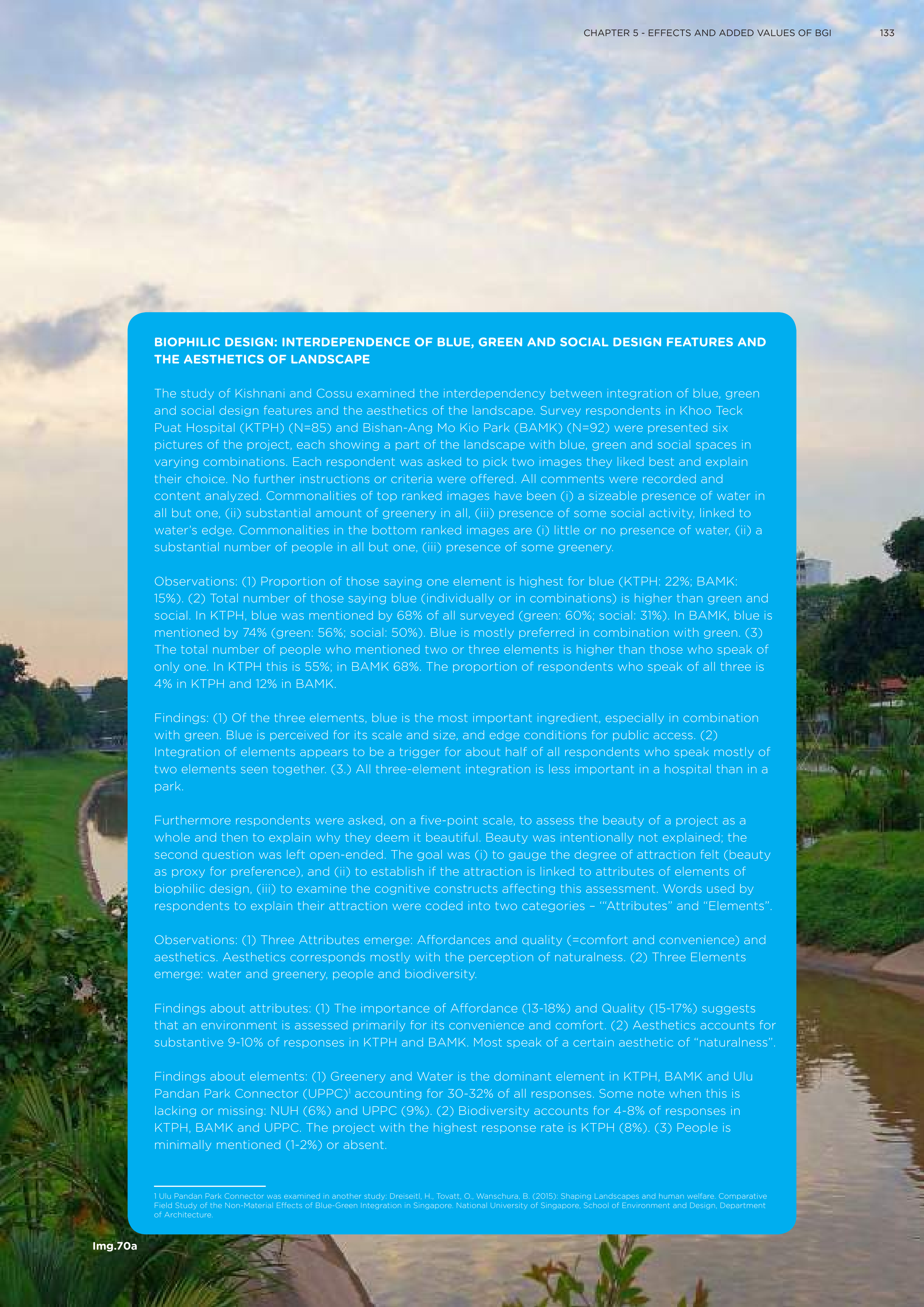
A BGI project provides an important opportunity to upgrade a city´s appearance, as there is a shared human disposition to perceive the combination of blue and green as being especially beautiful. In this research, the preferred aesthetic associated with blue and green elements is referred to as naturalness. The study about Biophilic Design[3] that is part of the overall research project presented here showed that the arrangement of social, green, and blue spatial elements triggered a user´s expression of preference. This preference is linked with the underlying arrangement of elements in the blue-green design.

- **BGI helps to reconnect people with the natural environment** through the active integration of water and greenery in which the boundaries between the two are blurred and made accessible. This integration appears to trigger a positive response for up to two-thirds of all respondents.

- **Blue elements of design have the strongest positive associations**, and when combined with green elements this positive effect is magnified. The perception of the relative beauty of the blue elements seems to be related to their scale and size, as well as how the edge conditions for public access are implemented.

3 Kishnani, N., Cossu, G. (2015): Biophilic Design. Final Report of Research Project Enhancing Blue-Green and Social Performance in Dense Urban Environments. National University of Singapore (previously unpublished). Funded by the Ramboll Foundation.

Img.70



BIOPHILIC DESIGN: INTERDEPENDENCE OF BLUE, GREEN AND SOCIAL DESIGN FEATURES AND THE AESTHETICS OF LANDSCAPE

The study of Kishnani and Cossu examined the interdependency between integration of blue, green and social design features and the aesthetics of the landscape. Survey respondents in Khoo Teck Puat Hospital (KTPH) (N=85) and Bishan-Ang Mo Kio Park (BAMK) (N=92) were presented six pictures of the project, each showing a part of the landscape with blue, green and social spaces in varying combinations. Each respondent was asked to pick two images they liked best and explain their choice. No further instructions or criteria were offered. All comments were recorded and content analyzed. Commonalities of top ranked images have been (i) a sizeable presence of water in all but one, (ii) substantial amount of greenery in all, (iii) presence of some social activity, linked to water's edge. Commonalities in the bottom ranked images are (i) little or no presence of water, (ii) a substantial number of people in all but one, (iii) presence of some greenery.

Observations: (1) Proportion of those saying one element is highest for blue (KTPH: 22%; BAMK: 15%). (2) Total number of those saying blue (individually or in combinations) is higher than green and social. In KTPH, blue was mentioned by 68% of all surveyed (green: 60%; social: 31%). In BAMK, blue is mentioned by 74% (green: 56%; social: 50%). Blue is mostly preferred in combination with green. (3) The total number of people who mentioned two or three elements is higher than those who speak of only one. In KTPH this is 55%; in BAMK 68%. The proportion of respondents who speak of all three is 4% in KTPH and 12% in BAMK.

Findings: (1) Of the three elements, blue is the most important ingredient, especially in combination with green. Blue is perceived for its scale and size, and edge conditions for public access. (2) Integration of elements appears to be a trigger for about half of all respondents who speak mostly of two elements seen together. (3.) All three-element integration is less important in a hospital than in a park.

Furthermore respondents were asked, on a five-point scale, to assess the beauty of a project as a whole and then to explain why they deem it beautiful. Beauty was intentionally not explained; the second question was left open-ended. The goal was (i) to gauge the degree of attraction felt (beauty as proxy for preference), and (ii) to establish if the attraction is linked to attributes of elements of biophilic design, (iii) to examine the cognitive constructs affecting this assessment. Words used by respondents to explain their attraction were coded into two categories – '"Attributes" and "Elements".

Observations: (1) Three Attributes emerge: Affordances and quality (=comfort and convenience) and aesthetics. Aesthetics corresponds mostly with the perception of naturalness. (2) Three Elements emerge: water and greenery, people and biodiversity.

Findings about attributes: (1) The importance of Affordance (13-18%) and Quality (15-17%) suggests that an environment is assessed primarily for its convenience and comfort. (2) Aesthetics accounts for substantive 9-10% of responses in KTPH and BAMK. Most speak of a certain aesthetic of "naturalness".

Findings about elements: (1) Greenery and Water is the dominant element in KTPH, BAMK and Ulu Pandan Park Connector (UPPC)[1] accounting for 30-32% of all responses. Some note when this is lacking or missing: NUH (6%) and UPPC (9%). (2) Biodiversity accounts for 4-8% of responses in KTPH, BAMK and UPPC. The project with the highest response rate is KTPH (8%). (3) People is minimally mentioned (1-2%) or absent.

1 Ulu Pandan Park Connector was examined in another study: Dreiseitl, H., Tovatt, O., Wanschura, B. (2015): Shaping Landscapes and human welfare. Comparative Field Study of the Non-Material Effects of Blue-Green Integration in Singapore. National University of Singapore, School of Environment and Design, Department of Architecture.

Img.70a

HUMAN CAPITAL

Human Capital[1] is an umbrella concept encompassing personal competences and capabilities that may take different forms, such as physical and mental health, the basic potentials and strengths of persons (e.g. resilience), or knowledge (education, qualification, creativity, etc.). Human capital resides in individuals and in social aggregates, such as communities of different scales (which is where they are generated). An important element of urban growth is how effectively they integrate human capabilities within complex and multifarious processes of value creation.[2]

BGI provides many services that enhance Human Capital. For instance, BGI provides natural spaces that support more active lifestyles, the recreation of life energy, the relief of work. A community having access to nature has positive effects on mental refreshment through stress relief and the reduction of sensory overload. These effects are well documented for social spaces provided by high quality, well-integrated BGI. BGI helps urbanites feel more connected to nature and other people – emotionally and intellectually.

In our research we found clear evidence that the following fields of impacts of BGI were of particular relevance (additionally there might be other impact fields): (1) BGI has positive effects on health and well-being, (2) BGI helps to experience a connectedness with nature, and (3) offers a chance for learning about and experience of nature – its values and processes.

BGI AND WELL-BEING

Few things affect an individual's well-being as much as social connections to other people. People who report being happier tend to have stronger ties to friends and family and are more committed to spending time with them.

1 Schultz, T. W. (1961): Investment in Human Capital. The American economic review: 1-17. For an early and reliable study of the impact of individual Human Capital lifetime earnings see: Ben-Porath, Y. (1967): The production of Human Capital and the life cycle of earnings. The Journal of Political Economy: 352-365.

2 For the very interesting discussion on the relation between a city's Human Capital and it's prosperity see Florida, R. (2005): Cities and the creative class. Routledge; Storper, M., Scott, A., J. (2009): Rethinking Human Capital, creativity and urban growth. Journal of economic geography 9(2), 147-167.

One of the great drivers to urban growth is that cities have proven to provide great socio-economic opportunities, yet there are also constraints to healthy living in a city. In addition to economic development and growing affluence, urbanization seems to be accompanied by a widespread rise in mental and behavioral disorders, increasing social isolation, breakdown of the traditional family unit, social fragmentation and exclusion, and diminished social trust. Low social integration is a particularly important issue in urban areas. People living in neighborhoods with low level of trust, and who lack strong social networks and bonds, are increasingly likely to suffer from poor mental health.

Urbanization has also been associated with a new set of negative impacts on physical health. Living in cities has been found to be associated with an increased prevalence of lifestyle-related diseases, including hypertension, diabetes, and obesity in both developed and emerging economies. A main reason is insufficient physical activity, as is the case for two-thirds of the Europeans living in cities.

Across the case studies, a positive relationship was found between BGI and well-being, a component of human capital. A primary finding of this research project has been that the integration of blue and green elements in BGI has a strong supportive impact on the health metrics in high-density urban environments. Supporting the benefits of BGI to health and well-being, it was also found that BGI enhances the:

- Tendency to use the open spaces, which increases physical activity and physical and mental health;

- Commitment to spending time with and connecting socially with others, especially in the parks, with positive consequences for mental (and therefore physical) health;

- Reconnection of people to their natural environment.

EXAMPLES OF THE BENEFITS OF BGI ON HEALTH AND WELL-BEING:

Bishan-Ang Mo Kio Park (BAMK), Singapore

The restored park enhances the access of neighboring communities to this open space. This has led to benefits for social life and improved awareness of these communities to ecology and the environment.

It was found that after the BGI upgrade to BAMK, nearly 50% of all park users were engaging in active physical activities, such as jogging, bicycling, skating or intense walking. As a result of the redevelopment of BAMK into a naturalized park, the number of park visits has doubled from 3 to 6 million persons/year, which implies a substantial positive impact on physical health estimated at SGD 16-43 million (which is 12-31 million USD to 2013 exchange rate). It is hypothesized by the researchers that the mental benefits of the BGI are attributable to BAMK's ability to attract social life and to encourage social integration.

For instance, when compared to Ulu Pandan Park Connector (UPPC)[1] , which is a Singaporean open space along a canal with mainly grey water infrastructure, a substantially larger fraction of the Bishan-Park users were found to be spending time with family and friends. Ulu Pandan is divided in a pure grey part and a part with greenery, but with nearly no blue-green integration. 330 park users of Ulu Pandan and BAMK were asked if they were using the park alone or in company with other people, such as friends and family. Only 22% of the Grey UPPC users were spending time with others in the park, compared to 37% in the green section of UPPC and as much as 81% in BAMK.[2]

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1 Ulu Pandan Park Connector (UPPC) is another park in Singapore that is comparable in size to BAMK that contains blue and green elements but lacks integration between them. In this park, mental well-being was found to be enhanced primarily by the recreational potential of the park: for example, in provide spaces to stop and stretch. For further information see below.

2 Dreiseitl, H., Tovatt, O., Wanschura, B. (2015): Shaping Landscapes and Human Welfare. Comparative Field Study of the Non-Material Effects of Blue-Green Integration in Singapore. National University of Singapore, School of Environment and Design, Department of Architecture.

Img.71

BGI AND BIOPHILIA: ENHANCING CONNECTEDNESS WITH NATURE

Recall that biophilia is a phenomenon rooted in neuroscience and psychology, characterized by an affinity of human beings for nature[1] . Popularized by the ecologist E. O. Wilson in 1984 in a book of the same name, the concept of biophilia is linked to environmental psychology. Over the past few decades, paralleling a growing environmental awareness the literature on biophilia has been growing[2]. We know now that there is universal preference of people for natural landscapes over built environments, and for built environments that contain natural elements over ones without. This preference has tangible impacts on human health and well-being. "Nature deficit disorder", for instance, describes problems in childhood behavior where there is persistent separation from nature[3]. Conversely, access to natural elements has been found to improve human health and well-being, resulting in salutogenic effects like quickened recovery from illness.

Drawing on that literature and the concept of biophilia, Biophilic Design (BD)[4] has emerged as a design philosophy that aims to integrate elements that satisfies the biophilic response, thereby resulting in positive feelings and experiences. In other words, BD is the integration of elements, processes and flows, patterns or attributes – derived from nature – into the design of the built environment. These elements may have an indirect effect, acting simply as sensorial triggers, or may be designed to stimulate more complex cognitive processes – such as actively stimulating a user to consider his or her underlying expectations of nature.

Because BGI projects are built infrastructure with natural elements that are designed for public use and with attention to beauty and aesthetics, BGI inherently provides a sensorial experience to its users. The research by the NUS team demonstrates, however, that BGI projects can also trigger deeper, emotional responses in their users, which appear to be linked with the particular arrangement of blue and green elements. More specifically, it appears that the integration of these elements satisfies the biophilic need for exposure to nature and generates a preference in the user, which is then converted into benefits – especially enhancement of health and well-being.[5] Visitors to BGI projects in general say that after their visit they are calmer and more relaxed. This phenomenon has recursive benefits for human happiness for individuals and communities, and also leads to a stronger commitment to protecting nature.

1 Wilson, E., O. (1984): Biophilia. Harvard University Press.
2 See eg. Ryan, C. O., et al. (2014): Biophilic Design Patterns. Emerging Nature-Based Parameters for Health and Well-Being in the Built Environment. International Journal of Architectural Research: ArchNet-IJAR 8.2: 62-76; Kaplan, R., Kaplan, St., Ryan, R. (1998): With people in mind: Design and management of everyday nature. Island Press; Kahn, P. H. (1997): Developmental psychology and the biophilia hypothesis: Children's affiliation with nature. Developmental review 17.1: 1-61.
3 Louv, R. (2005): Last child in the woods: Saving our kids from nature deficit disorder.
4 Beatley, T. (2011): Biophilic cities: integrating nature into urban design and planning. Island Press.
5 See section on Beauty for more information on the relationship between well-being and beauty.

BIOPHILIA – CONNECTEDNESS WITH NATURE AND WELL-BEING

Singapore/KhooTeckPuat Hospital (KTPH) and BAMK

The study on Biophilic Design[1] examined the interdependency between biophilic design and high level of integration of blue and green design features with self-reported well-being in a user survey comparing Khoo Teck Puat Hospital (N= 193) and Bishan-Ang Mo Kio Park (N= 198) as examples of high integration with National University Hospital (N= 70) and Ulu Pandan Park Connector (N= 124).

Results: KTPH does better on self-reported well-being than NUH. There is also higher preference for, and greater satisfaction with KTPH compared with other hospitals in Singapore. It is not yet clear if well-being, preference or satisfaction are linked directly to KTPH's biophilic design. (In later sections it will be shown that preference is triggered by the presence of water and greenery that are central to the KTPH experience). There are also no known studies supporting KTPH's goal of a healing environment, linking biophilic design to patient recovery rates.

Findings on well-being in BAMK vs. UPPC are less conclusive. BAMK does no better on the question of 'calm and relaxed' and worse on the question of 'less stressed'. The geographical reach of BAMK however suggests that it attracts more people from further away. Visitorship figures and other user surveys affirm that BAMK is one of the most preferred parks in Singapore.

1 Kishnani, N., Cossu, G. (2015): Biophilic Design. Final Report of Ramboll´s Research Project „Enhancing Blue-Green and Social Performance in High Density Urban Environments". National University of Singapore (previously unpublished).

LEARNING ABOUT AND EXPERIENCE OF NATURE

Individuals who live and work in dense urban areas tend to be less connected to nature, as it is less visible in their day-to-day environment. In addition to the emotional dimension of connectedness with nature (i.e. biophilia, discussed in the previous section), attention must also be paid to the importance of knowledge and understanding of the natural processes upon which human life depends. Urban water cycles and ecosystem services are both subjects of high complexity. At the same time, they are comparably easy to relate to when presented as living systems in the local environment. It is critical to sustainable development to provide opportunities for hands-on learning experiences with natural systems – especially for children. Exposing children to nature helps to install, at an early age, awareness of and belief in the value and the vulnerability of our ecosystems and natural resources. BGI provides opportunities for both, by bringing natural ecosystems back into the neighborhood of families and schools.

The results of the research across case studies demonstrated that:

- School classes use parks with high quality BGI as additional learning experiences.

- Public utilities for parks and water use urban BGI as a visible example to help communicate information about urban water cycle, water quality, and eco-system services and provide context for relevant urban policies.

Img.72

EXAMPLES FOR LEARNING ABOUT AND EXPERIENCE OF NATURE – ITS VALUES AND PROCESSES

In Singapore, the Active, Beautiful and Clean Water program (ABC Water) was explicitly introduced to foster people's feelings of emotional and intellectual connectedness to nature. The aim was to educate for water awareness following the idea of Singapore's Prime Minister Lee Hsien Loong "that if Singaporeans can develop a closer relationship with water, they will come to appreciate, cherish and conserve it more"[1]. As part of the ABC Waters program, the educational program "ABC Learning Trails" was introduced by the Public Utilities Board into selected school curricula (PUB, Singapore's water agency). Developed in collaboration with partner schools and curriculum planners, the ABC Waters Learning Trails were designed with students and the lower secondary curriculum in mind to provide active, field-based learning. The lessons are designed around walking tours (i.e. "trails") and are supported by additional learning documentaries and even a set of educational toys. The themes covered by the Trails include: water quality, water sustainability, the water cycle, Singapore's future water plans, local water heritage, biodiversity and conservation, human impact and the importance of stewardship for urban waters. Since the launch of ABC Waters Learning Trails in 2011, more than 49,470 students from over 90% of all secondary schools have experienced the 10 Trails.[2]

1 See Speech of Lee Hsien Loong at the ABC Waters Public Exhibition Opening Ceremony on 6th Feb 2007; See Transcript of speech by PUB http://www.pub.gov.sg/mpublications/Speeches/speech06022007.pdf
2 Public Utilities Board - PUB (2013): Annual Report 2012/2013. PUB, Singapore, p. 76.

SOCIAL CAPITAL

Social Capital[1] is a category of immaterial capital that is related to value derived from an individual's institutional affiliations (e.g. memberships) and personal or impersonal relations to others. It can be stored in a variety of different forms including trust, commitment, cohesion, social support and solidarity. It can be used individually or collectively for social support and social integration, to influence others (e.g. to enhance stability and resilience of a social system)[2] or to enhance people's readiness to exchange knowledge or accept innovation and change.[3] Individuals may possess Social Capital in general, but (as opposed to individual Human Capital) cannot spend it.[4] Some forms of Human Capital can be additive, such as the generalized trust of a population in each other or in a government; others are not additive: e.g. if one group mobilizes Social Capital against another.

Urbanization leads to changes, such as densification of buildings and people, which alters the conditions of social interaction. In high density urban environments, people tend to have more social contacts, but these relationships or the time spent with these contacts is shorter. These relationships may also be more functional in nature and less community-oriented. High quality social spaces can help to counter the negative impacts of urbanization on social relationships, including tendencies towards isolation and depersonalization. The BGI implemented in the case studies was found to provide enormous benefits to neighboring communities in its provision of communal space, large enough to support multiple social groups (families, friends, associations etc.), in a beautiful natural setting for various forms of interaction and recreation.

In our research we found clear evidence that BGI benefitted Social Capital with particular impact on[5]: (1) Social interaction and integration, and (2) Civic identity and relatedness.

SOCIAL INTERACTION AND INTEGRATION

When BGI is a well-integrated element in the urban landscape, it acts as a strong motivator for social interaction. BGI is particularly effectively as tool for social interaction as it provides public space where people can engage in recreation and be physically active – alone, in social groups, or with their families. People can use BGI to engage with their own social networks at the same time as they can look and see how others spend their leisure time.

In examining the case studies, the research showed that a high level of integration of BGI into the urban fabric has strong benefits for enhancing social interaction and integration, including:

- Increasing activity of people interacting in groups outdoors.
- Increasing the tolerance of BGI users to foreigners, with whom they come to identify through sharing a common space for socializing.
- Increasing people's predisposition to spending time with family and friends.

Therefore, well-integrated BGI has many social benefits, such as inspiring individuals to spend more time with their relatives and friends and proving an aesthetically pleasing space in which to interact. Interestingly, since BGI increases socialization of communities in open public spaces, it had the unexpected and additional benefit of providing more opportunities for individuals to see foreigners in their day-to-day lives in a non-threatening way that increased their tolerance to strangers.

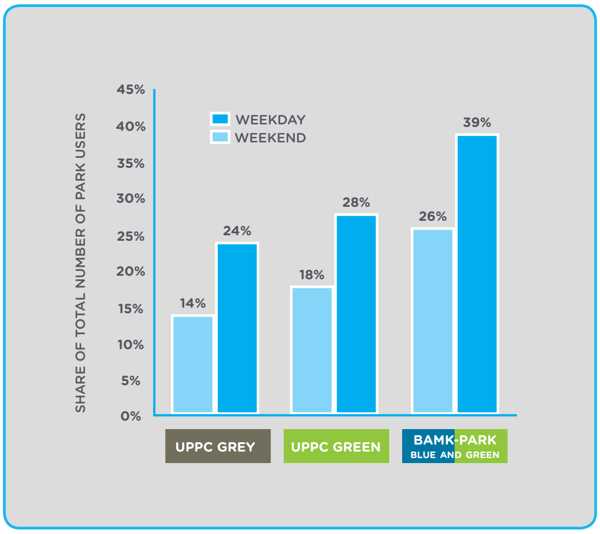

Fig.31 Dreiseitl, H., Tovatt, O., Wanschura, B. (2015): Shaping Landscapes and Human Welfare. Comparative Field Study of the Non-Material Effects of Blue-Green Integration in Singapore. National University of Singapore.

1 For the concept of Social Capital see: Putnam, R. D. (1995): Bowling alone: America's declining Social Capital. Journal of democracy 6.1: Pp. 65-78. The approach to Social Capital divers significantly from a pure individualistic approach used in Coleman, J., S., (1988): Social Capital in the creation of Human Capital. American journal of sociology: Pp. 95-S120.
2 For discussion of the relation between Social Capital and urban resilience see: Adger, W. N. (2010): Social Capital, collective action, and adaptation to climate change. Der Klimawandel. VS Verlag für Sozialwissenschaften. 327-345; Aldrich, D., P., (2012) Building resilience: Social Capital in post-disaster recovery. University of Chicago Press.
3 For the benefits derived of Social Capital in the field of innovation and knowledge creation see: Wenger, E., McDermott, R., A., Snyder, W. (2002): Cultivating communities of practice: A guide to managing knowledge. Harvard Business Press. Nahapiet, J., Goshal, S. (1998). Social Capital, intellectual capital, and the organizational advantage. Academy of management review 23.2: 242-266.
4 Moldaschl, M. (2008): Wem gehört das Sozialkapital. Papers and Preprints of the Department of Innovation Research and Sustainable Resource Management (BWL IX), Chemnitz University of Technology.
5 As mentioned for other forms of capital in this study, this should be considered a representative (i.e. not exhaustive) list.

Img.73

EXAMPLES OF THE BENEFITS OF BGI FOR SOCIAL INTERACTION AND INTEGRATION

Bishan-Ang Mo Kio Park (BAMK) and UluPandan Park Connector (UPPC), Singapore

The comparison of the use of Bishan-Ang Mo Kio Park and the two parts of Ulu Pandan Park Connector in a recent study[1] shows that in BAMK, BGI is well-integrated, while in UPPC the integration is moderate or non-existent. At the BAMK, a concrete canal was transformed into a more natural streambed, which was the focus element in a larger landscape design where green and blue elements were closely integrated. The BGI intervention of BAMK strengthened the Social Capital of the area by providing a more attractive place for social life and social integration than what had been there previously. More specifically, the research showed that the higher the levels of blue-green integration into the existing urban fabric, the more that BGI was found to increase social activities (see Figure 1).

Moreover, a higher level of BGI integration into the urban fabric seems to have a positive effect on social integration. In the case studies it was measured how the social benefits of diversity are experienced by everyone in each park. This data was collected to provide a measure of the extent to which BGI provides a meeting point for everyone, compared to Ulu Pandan, as a place with no green (Ulu Pandan Grey) and with less integration (Ulu Pandan Green). In all three parks users were asked to what extent they agree or disagree (on a scale from 1 to 5) that the park is a place where people from different backgrounds can associate positively together. While there was no significant difference between UPPC Green and BAMK, UPPC Grey performed significantly lower than the other parks. Comparing BAMK and Ulu Pandan as a whole the data provides some evidence of a weak but significant relationship between BGI and social integration on a perception level ($r=0{,}20$; $N=319$; $p<0{,}01$).[2]

In addition, people were found to feel more connected to other people in environments with a higher level of integration, although the differences were only statistically significant at the 10% level.[3]

In the interviews, BAMK users expressed an interest in the park's recreational potential in terms of its ability to provide sociable open spaces to relax, sit on the benches or on the grass, have fun, but also to exercise. In contrast, at UPPC, the park connectors with less blue-green integration, exercising as recreational potential seemed to be the primary benefit.[4]

1 Dreiseitl, H., Tovatt, O., Wanschura, B. (2015): Shaping Landscapes and human welfare. Comparative Field Study of the Non-Material Effects of Blue-Green Integration in Singapore. National University of Singapore, School of Environment and Design, Department of Architecture.
2 Ibid. page 19f.
3 Ibid. page 20
4 Ibid. page 24

THE BENEFITS OF BGI FOR CIVIC IDENTITY AND RELATEDNESS

Processes of identity building are complex. They are usually based on learning through social interactions and mutual perception – e.g. in seeing oneself through the eye of another under conditions that are socially structured by norms, expectations, practices, and opportunities[1]. These processes play a decisive role in determining the answer to the question of whether individuals define themselves as part of a bigger group that shares conditions that benefit their individual condition.

This identity-based relatedness is of tremendous importance for the consumption, reproduction, and generation of common resources (e.g. liveable urban conditions, public infrastructure, peace, trust etc.). It provides the basis for pro-social sharing of resources and the sanctioning of antisocial behavior[2]. Urban societies rely heavily on people's readiness to be connected with and support their neighbors, to be engaged in their towns, and to take active part in the urban social system. These forms of relatedness are particularly important in cities, where more traditional, community- and family-based types of solidarity are getting weaker through social fragmentation.

While BGI should not be considered the only (or even the most prominent) factor in the complex process of evolving and strengthening a civic identity, its potential contribution is enormous. BGI has to be considered as a very practical way to provide high quality, accessible, and easy-to-relate-to public places.

1 See Mead, G., H. (2009): Mind, self, and society: From the standpoint of a social behaviorist. Vol. 1. University of Chicago press; Blumer, H. (1986): Symbolic interactionism: Perspective and method. Univ of California Press.
2 Ostrom, E. (1990): Governing the commons: The evolution of institutions for collective action. Cambridge University Press.

THE CASE STUDIES SHOW THAT IN PROVIDING AN OPEN SPACE WITH BGI:

- It typically becomes an important element in the residents´ image of their city, serving as a point of reference for civic identity.

- It provides a high quality, highly accessible space-gathering place for a neighborhood, thereby assisting in the construction of a sense of mutual relatedness.

The open park stringes and green areas in Hannover Kronsberg integrate BGI functions not only visibly but provide seating areas and places to play and rest. We have observed a very strong biophilic effect, where people of different age, gender, or ethnic backgrounds come together to enjoy and interact. Depending on the weather conditions, children find it fun to go outside in rubber boots and play together in the little creeks and ponds formed by the rain.

In several places like "Hameau de la Fontaine" in Echallens in Switzerland, "Schafbrühl" in Tübingen, and "Arcadien" in Asperg both in Germany, BGI projects were designed and function also as a social magnet and community meeting place where families meet, parents talk to each other while their children are playing.

The places and restaurants next to the blue-green infrastructure of Kallang River in Bishan-Ang Mo Kio Park are always full and actively visited. The number of park visitors being about 3 million in 2008, has increased after the restauration and implementation of BGI up to 7 million visitors per year.

Img.74

SYMBOLIC CAPITAL

Symbolic Capital[1] is a type of immaterial capital related to attributions of positive value to persons, organizations, firms, cities, states or even transnational entities (e.g. UNHCR). Symbolic Capital exists in different forms, including reputation, image, and tradable brand names.

As Symbolic Capital is perhaps a less familiar category in the socio-economic assessment of urban infrastructure, we provide some background information on the concept:

Symbolic Capital can be earned: for instance, when evidence of desirable performance can be presented in a relevant audience. Academic titles are a very good example for Symbolic Capital that can be earned by individuals. It can also be ascribed on the basis of tradition: e.g. hereditary nobility, and it also exists at the level of the social system. For instance, a city may accrue Symbolic Capital through recognition of good governance or in its historical importance or on the basis of possessing physical attributes. In general, social entities (e.g. individuals or cities) are capable of driving their Symbolic Capital in different directions; in other words, their Symbolic Capital can undergo further development depending on the type of reputation they have (earned) and how that compares to that of other entities with which they share a joint competition for status.

Consider for a moment how the competition between cities is organized on a global scale: The notion that a city may exert effort to enhance its international reputation is not a new phenomenon. For instance, during the Italian Renaissance – from the 14th century until the 16th century – Venice, Florence, Milan, and Genua were in constant and cutthroat competition to gain reputation and status through achievements in culture and liveability. Their ultimate driving motivation at the time was to improve their position within a European hierarchy of leading cities[2]. The symbolic reputation through highly visible cultural achievements was seen as a strategic resource to attract innovative artists and scientists and to acquire new international trade relations.

In other words: competition for reputation between cities is not a new phenomenon. However, whereas in the past the sphere of influence of a city might be regional or even continental, today a city's reputation and status can have a global reach. Moreover, a number of international ranking systems now exist that explicitly codify and quantify what was once a more subjective assessment[3].

An increasing number of cities – and their representatives, decision-makers, and planners – realize the value of global recognition. A global reputation can improve the ability of a city to recruit resources with respect to any sector of city life – public, cultural, private and economic – including the attraction of investors, artists, tourists, universities and other core elements of a "knowledge society". Cities are increasingly competing for awareness and recognition from expatriate professionals, tourists, etc. and in this competition the "symbolic logic of distinction"[4] is the primary rule of structuration. Therefore cities have to work hard to show valuable and unique features.

One could argue that rivalry between cities is not fair: How can cities like Hannover or Detroit ever achieve the same status of recognition as Paris or New York? Or in the words of Bourdieu: "the structure of the field, i.e. the unequal distribution of capital, is the source of the specific effects of capital"[5]. The status of being "special" is undoubtedly relational. But do the traditional centers for urban culture possess unchallengeable positions in an oligopolistic market?

Of course this is not the fact. While it is true that the relative hierarchy of cities does show inertia, a survey of history can quickly identify examples of cities that have risen to power, maintained that position for many years, and then fallen. Criteria of recognition might change in course of newly established demands and values. What yesterday might be seen as an indicator of under-industrialization is tomorrow's opportunity for high bikeability. And where in past decades the most valued architecture was characterized by concrete, steel, and glass, this approach may soon be unfashionable in the course of increased interest in green architecture and biophilia.

In consequence of this potential for cities to change their relative status in the global hierarchy, there are increasingly innovative ways for strategic positioning in these urban

1 Symbolic Capital refers to Pierre Bourdieu's work about the reproduction of social structure. The term is introduced in his book Bourdieu, P. (1977): Outline of a Theory of Practice. Vol. 16. Cambridge University Press.
2 Clark, P. (2009): European cities and towns: 400-2000. Oxford University Press.
3 See e.g. (1.) Global Cities Index: Ranking of the most global cities based on five aspects of globalization: business activity, Human Capital, information exchange, cultural experience, and political engagement. This index is a collaboration of A.T. Kearney, Foreign Policy and the Chicago Council on Global Affairs. http://www.atkearney.de/research-studies/global-cities-index/2015; (2.) Economist's Most Liveable Cities – EIU's ranking of the liveability of world cities on a scale of 0-100 based on 30 indicators grouped in five categories: stability (25%); healthcare (20%); culture and environment (25%); education (10%); and infrastructure (20%); http://www.eiu.com/public/topical_report.aspx?campaignid=Liveability2015 (3.) Global Metro Monitor: Ranking of the economic performance of world cities during three time periods: 1993-2007 (pre-recession); 2007-2010 (recession); and 2009-2010 (recovery). The study is a collaboration of the Brookings Institution and the London School of Economics and Political Science (LSE). http://www.brookings.edu/research/interactives/metromonitor#/M10420 (4.) Green City Index: Regional indexes that evaluate and rank the environmental performance of cities around the world based on eight categories: Energy and CO2, Land Use and Buildings, Transport, Waste, Water, Sanitation, Air Quality and Environmental Governance. Developed by the Economist Intelligence Unit (EIU) and sponsored by Siemens. http://www.siemens.com/entry/cc/de/greencityindex.htm (5.) Global Power Cities Index: Ranking of the "magnetism" or overall urban competitiveness of 35 of the world's most influential global cities. The GPCI evaluates cities based on six functional areas: Economy, R&D, Cultural Interaction, Livability, Environment and Accessibility. http://www.mori-m-foundation.or.jp/english/ius2/gpci2/
4 Bourdieu, P. (1986): The forms of capital. Bourdieu, P. (2011). Cultural theory: An anthology, p.96.
5 Ibid

competitions and there is a lively and contested discussion about criteria for valuable urban modernization. There is not only a competition for Symbolic Capital (e.g. to gain more reputation and awareness) but there are "symbolic struggles"[6] for standards of Symbolic Capital accounting. That is, cities do not only try to score high on given indicators, but they try to influence the normative base of indicator systems.[7]

The issue of BGI is widely affected by urban competitions. Notions of sustainability, resilience, liveability, etc. are modern urban values that have the potential to stir up the existing hierarchy of cities. These concepts have been operationalized and codified in various ways to organize urban competition for Symbolic Capital around these notions. But we should consider that there are also certain limits to the instrumentation of urban achievements as symbols for reputation enhancement. For instance, projects may in fact lose symbolic value through their reframing as commodities or value drivers[8]. This shift in meaning might erode the perceived authenticity of the project both within and outside of the city.

It is important to remember that entrepreneurial and innovative approaches to urban design rely (at least in the long term) on support and legitimation from local residents and interest groups. With BGI implementation, urban governments and public utilities are demonstrating that they care about the quality of life for the city's residents. This has significantly enhanced local legitimacy of these institutions and can also augment the city's reputation outside of the city through the global competition for liveability, image, hipness, and attractiveness. Local stakeholders in a variety of functional fields, like park agencies, nighttime entrepreneurs, public relations managers of industrial corporations, and community workers are increasingly looking for opportunities to contribute to the urban branding. BGI can be particularly useful instrument in realizing this goal, as it is an issue of great visibility.[9]

In our research we found clear evidence that BGI enhanced the Symbolic Capital in the following ways:

6 Bourdieu, P. (1989): Social space and symbolic power. Sociological theory 7.1, p.21.
7 See e.g. for creative city labelling Chatterton, P. (2000): Will the real Creative City please stand up? City 4.3: 390-397.
8 The more Europe becomes Disneyfied, the less unique and special it becomes. The bland homogeneity that goes with pure commodification erases monopoly advantages. Cultural products become no different from commodities in general. See: Harvey, D. (2009): The art of rent: globalisation, monopoly and the commodification of culture. Socialist Register 38.38, p. 96.
9 As mentioned for other types of capital, this should not be considered an exhaustive list.

(1) BGI helped a city to improve its reputation as a driver of liveability, sustainability and innovation, and

(2) BGI raised the iconic value of a city, which had positive effects for tourism.

BGI AS A MEASURE TO ENHANCE A CITY´S REPUTATION AS A DRIVER OF LIVEABILITY, SUSTAINABILITY, AND INNOVATION

BGI is appreciated for different reasons and by different interest groups. As already mentioned above, BGI is an innovative instrument that fosters the sustainability of natural resources and enhances the resilience of urban infrastructure. It helps to promote improved quality of life, health, and well-being for residents and it enhances social identity and integration. Political parties, private companies, and public agencies – as well as their leaders – can turn the increased value of BGI (reputation, image, and legitimacy) directly into profits if they engage in successful BGI implementation. Therefore drivers of BGI can gain Social Capital that grows their power and support for other projects and activities.

Across the case studies, BGI was found to:

- Increase a city's reputation by enhancing the perception of a city's overall attractiveness and liveability and by increasing the reputation of the governmental institutions to care for the quality of life of citizens. These benefits were also found to boost a city's reputation outside of its local, regional sphere, which would have benefits in the global competition for human and financial capital.

- Increase legitimacy and social status of institutional bodies, public utilities and private companies and therefore supports other development projects.

- Increase the reputation of individual BGI drivers: Leading successful implementation of a highly visible BGI project helped to shed light on the BGI drivers, and enhanced their reputation as visionary thinkers, successful leaders, and skillful managers. BGI projects were found to be important milestones in the professional careers of the individual BGI drivers.

BGI AS MEASURE TO INCREASE A CITY'S REPUTATION IN MALMÖ AND FREIBURG

MALMÖ, SWEDEN

The city of Malmö, historically an industrial city, was faced with both declining population and economic activity in the 1990s. Today Malmö is marketing its image as an "eco-center"[1]. A key part of their image is a recent development project that also features BGI elements. Malmo's Western Harbor transformed what was previously an industrial site into an eco-residential development. The new development showcases an attractive development focused on sustainable design. The project was funded through a joint partnership between private and public ventures and also integrated community engagement. The project met its sustainability objectives, which included energy neutral, on-site waste recycling and on-site stormwater management, by using solar panels, wind turbines, public transport, and green roofs. Stormwater runoff is managed through green roofs, which is collected by open paving channels and canals. This stormwater strategy reduced the development's pressure on the city's water treatment system while creating natural environment in the area.

The success and experience of the project were shared within the community, and knowledge was transferred to key stakeholder groups and the wider community. In particular, the innovative strategies used in the development's design (including the green public transport system, the waste management strategy, energy efficiency, ecological design, and water management) were documented for this purpose. The development now attracts many study tours annually. The organizations and agencies involved in the project benefitted from a significant increase in reputation as visible drivers of BGI. Internationally, Malmö served as a model for Chinese eco-cities like Tangshan[2] and Caofeidian[3].

FREIBURG, GERMANY

There are a number of cities that have demonstrated similar transformations in their reputation. For example Freiburg in Germany is now known for being a pioneer in ecological policy and urban planning. In the 1990s a sustainable model district for 5500 residents was constructed in the Vauban area of Freiburg, which today serves as a flagship for sustainable urban design. Vauban is internationally known for its rainwater infiltration system, as well as other innovative technologies for sustainable architecture and urban design. On the whole site no rainwater drains exist; all stormwater runs to two rigole-trench infiltration ditches. Nearly all the rainwater is managed on-site[4]. Vauban was presented as "German Best Practice" at the Habitat II Conference 1996 in Istanbul and won the title "Sustainable Capital"[5]. Meanwhile Vauban became a highlight in green urban design tourism as it "attracts busloads of energy experts, who regularly walk through the neighborhood firing away with cameras"[6].

1 See Ekostaden Augustenborg Homepage. http://www.malmo.se/English/Sustainable-City-Development/Augustenborg-Eco-City.html
2 Senthilingam, M. (2014): How one eco-project in Malmo changed the future of industrial wastelands. CNN, September 25, 2014. http://edition.cnn.com/2014/09/25/living/ecofriendly-shipwards-in-malmo/
3 Swedish Cleantech: http://www.swedishcleantech.se/english/cleantechsectors/sustainableconstruction/exportingsustainablecities.4.5fc5e021144967050481899.html
4 Energie-Cités (2008): Sustainable neighbourhood - Vauban (Freiburg im Breisgau - DE). http://www.energy-cities.eu/db/freiburg2_579_en.pdf
5 Further information about living in Freiburg -Vauban see: Bichard, E. (2013): The coming of age of the green community: My neighbourhood, my planet. Routledge.
6 Morris, C. (2013): Vauban: Germany's renewable tourist attraction. Renewables international, October 17, 2013. http://www.renewablesinternational.net/vauban-germanys-renewable-tourist-attraction/150/537/73974/

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BGI´S IMPACT ON ICONIC VALUE AND TOURISM

City tourism increases and urban green plays an important role in attracting a share of it. Although BGI is more about harmonic integration between its blue and green components than spectacular ornamentals, there are many outstanding examples that have proven to be very appealing for tourists because of their iconic value as sustainable design and their natural beauty. Examples of the benefits to BGI on the iconic value and value for tourism include well-known city parks like Central Park in New York and Boston Necklace. These urban parks are now elements of these cities that are iconic stops in tourism. These parks not only enhance a city's beauty, but are also well used by residents and can help tourists feel more connection to the local urban community. Green roofs, green walls, and green skyscrapers - these architectural elements can all be icons of future-oriented urban design and will therefore attract a specific type of urban tourist. Urban farming and gardening are also recognized as innovative and inspiring civic movements. However, by far the most important benefit to the city in terms of enhancing its iconic value is the overall appearance and image of a city – of which BGI obviously is of significant importance.

The case studies demonstrated that the particular benefits to iconic value and attractiveness to tourists fostered by BGI were:

- Modern elements in traditional parks combining functionality with aesthetics and beauty.
- Iconic manifestation of future-oriented urban design.
- And in highlighting the perception of a city's overall attractiveness and liveability.

GREEN INFRASTRUCTURE AND TOURISM IN SINGAPORE

The tourism sector contributed 4% to Singapore's gross domestic product (GDP) and supports some 160,000 jobs based on 15 million visitors spending 56 million days in Singapore in 2014 (STB, 2015, p.2). Since the first tree planting day in 1968 by the then Prime Minister Lee Kuan Yew, urban green infrastructure has been an instrument to attract tourists and in shaping the city's image. Meanwhile Singapore has been promoting a "City in a Garden" concept that is stated on nearly every site in Singapore. An example of iconic green infrastructure is Singapore's Botanic Garden, which is a UNESCO World Heritage site and hosts some 4.2 million visitors a year (300,000 visitors at the Singapore Garden Festival in July 2015)[1]. Other parks, like Gardens by the Bay, are frequently marketed as a picturesque tourist attraction.

BGI might not be the primary attraction for international tourists to a particular city. Nevertheless, they can significantly enhance the experience of a city for a tourist. That many famous and popular tourist sites are BGI, such as NYC Central Park, the swimming facilities at Islands Brygge in Copenhagen, and the Skyrise Greenery in Singapore demonstrate this. Furthermore, when tourists have a positive experience with BGI they may return home with an increased awareness of and demand for it. BGI as a tourist attraction can be directly connected to a further increase in BGI when tourists get conscious about it.

1 UNESCO World Heritage Sites (WHS) See http://www.worldheritagesite.org/sites/singaporebotanic.html; furthermore see NParks Singapore Botanic Gardens: Singapore Garden Festival. https://www.singaporegardenfestival.com/

FINANCIAL CAPITAL

Financial capital includes relevant direct as well as indirect costs and benefits resulting from financial impacts or from impacts that are frictionless and transferable in monetary terms.

Very often a financial cost-benefit analysis is decisive in infrastructural decision-making. Both costs and benefits depend to a great extent on the local conditions and the opportunity costs taken into account. Despite the limitations in collecting and analyzing quantitative data on the socio-economic benefits of BGI-projects, the case studies demonstrate that the overall costs of BGI are often more than compensated for by the added values generated through BGI. Compared to grey infrastructure options, BGI is a competitive solution that often bears the chance for significant financial revenue[1].

In our research we found clear evidence that BGI has direct benefits for financial capacity in the following way, through[2]:

(1) Increased property value,

(2) Economic benefits of improved physical and mental health, and

(3) Economic benefits of improved water management and resilience of the city.

INCREASED PROPERTY VALUES

It is a well-studied phenomenon – starting in the 19th century with Frederick Olmsted's research work[3] – that well-maintained and well-designed parks have a significant impact on the value of surrounding property by improving the social and aesthetic attractiveness of the surrounding land and buildings and therefore its real estate value. In a meta-study of 30 research projects about hedonic price changes due to park access, John L. Cropton found an average increase of 20%.[4]

Because of methodological problems associated with isolating BGI-related value from benefits associated with green infrastructure, the particular impact of BGI integration is less well understood. However, some studies do exist. For instance, the Bishan-Ang Mo Kio Park Cost-Benefit Analysis affiliated to this research project focused on the isolated BGI integration effect[5]. Due to intelligent research design and extensive data collection, it was possible to compare status ex ante and ex post of BGI implementation, based on separating BGI effects. This study found that the most significant financial benefits of the BGI integration were to increased property values, particularly in high-density urban areas. While increased property value in the course of park access is accepted as being remarkably high, it is important to pay regard to the role of BGI integration as a powerful lever in this context.

Increase in property value is by nature a benefit for property owners, while costs of development and maintenance are very often taken by the public utilities. That means cities need to consider ways, regulations, and opportunities to socialize the benefits. One way to reap some of the economic benefits of BGI and increase municipal revenues is through taxation of the market value of properties, which many cities around the world rely on as an important funding source for infrastructure.

Even more important is to realize that BGI is also a matter in the issue of social equity of urban residents. While BGI does provide important benefits for health and well-being to all residents, it is also related to increased property value in its immediate neighborhood. Accessibility to parks often shows remarkable correlation to socio-economic inequity of citizens i.e. the improvement of parks might be directly connected to gentrification. It is important to notice that the restoration of parks might contribute to gentrification and can have a negative effect on the overall liveability of a city unless active measures are taken for its prevention. Suchlike threats for urban social equity need to be counteracted by long-term urban planning. For example Singapore and New York City integrated aims for equal access to green recreational space within walking distance to the next park[6], and Vienna has long tradition in positioning social housing also in those areas, where the richer people are living.

1 As a matter of analytical correctness it is to mention, that issues of double accounting in the different fields of financial impact were not explicitly taken into consideration. E.g. it might be realized that increased property value is at least partly depending on a better access to the park and its opportunities. Therefore acidity related benefits are partly included in an observed increased property value.
2 Again, this should be considered a representative, not an exhaustive list.
3 Olmsted, F. L. (1881): A consideration of the justifying value of a public park. Tolman & White.
4 Crompton, J. L. (2001): The impact of parks on property values: A review of the empirical evidence. Journal of Leisure Research 33.1: 1-31.

5 Dreiseitl, H., Leonardsen, A., L., Wanschura, B. (2015): Cost-benefit analysis of Bishan Ang-Mo Kio Park. National University of Singapore, School of Environment and Design, Department of Architecture.
6 Singapore gave a specific target: 100% of all citizens with distance of 400 meter or less to the next park till 2030. New York was a little more modest setting a walkable distance for 85% of all citizens as a target for 2030. For Singapore See: National Population and Talent Division, Prime Minister's Office, Government of Singapore: Issues Paper 2012 – A Good Quality Living Environment; http://population.sg/vision/environment/#.Vk4BtkZFoZM; For NYC see: NYC Parks: Framework for an Equitable Future; http://www.nycgovparks.org/downloads/nyc-parks-framework.pdf

INCREASING PROPERTY VALUES

COPENHAGEN, DENMARK

The Municipality of Copenhagen was hit by a high intensity precipitation event in 2011. The resulting damages from flooding generated an estimated EUR 800 million in insurance claims, which is about 1,040 billion USD at exchange rate of that time. As a response, the municipality created a flood adaptation plan, with the focus on identifying critical and high risk areas and designing solutions for adapting to these events in the future. Rambøll has driven design of a detailed flood adaptation plan for two high-risk areas: Vesterbro and Ladegårdså. During a flood event, the water can either be transported or stored in traditional subterranean structures such as drainage pipes, sewers, storage chambers, etc. Alternatively the water can be handled by terrain-based solutions, where blue and green elements disperse the water. The alternative solutions have a large impact on the design and feel of the city. Green and blue elements act as urban lungs and also provide recreational areas. Trees and bushes assist in capturing and filtering air pollution, augment biodiversity, increase property values, and create a pleasant-looking urban area. In contrast, blue and green elements can obstruct traffic patterns and reduce road capacity. It is therefore necessary to plan according to local needs. Besides design of the master planning and of the Flood Adaptation Plan, a socio-economic cost benefit analysis was conducted by Rambøll.

BISHAN-ANG MO KIO PARK (BAMK), SINGAPORE

Similar effects to property values were observed in Singapore in the course of the BAMK renovation. In 2014 and in 2015 the Ministry for Environment and Water Resources used a hedonic price model to analyse the effect of BAMK on the nearby real estate. The research showed that implementing BGI in the park resulted in an average increase of 2-4% and that the overall value of the park could be calculated to be SGD 100-200 million, which is USD 75-150 million.[1]

1 Information given by Ministry of Environment and Water Resources of Singapore.

Img.75a

ECONOMIC BENEFITS OF BGI FOR PHYSICAL AND MENTAL HEALTH

Even though the effects of BGI on health are still relatively unexplored, there is extensive literature suggesting a positive correlation between green spaces and physical and mental health benefits. The global engineering consultancy ARUP found that green spaces deliver social and health benefits of up to GBP 1.44 billion per year (USD 2.4 billion at exchange rate of 2014) for the United Kingdom economy. Furthermore, it has been calculated that the National Health Service in the UK could save GBP 2.1 billion (USD 3.5 billion at exchange rate of 2014) a year if everyone had access to green spaces.[1]

Blue-green spaces not only help to reduce mental stress and increase life satisfaction, they also provide attractive open spaces for physical activity. According to WHO, adults are recommended to engage in at least 150 minutes of moderate physical activity or a minimum of 75 minutes of intensive physical activity per week, a minimum standard met by only 30% of the population of the European Union.[2]

The case studies show that BGI can have a strong effect on people's propensity to use public spaces for exercise and recreation, which generates economic value to society in terms of lower health care expenditures.

- BGI can help improve human physical and mental health by means of upgraded space for recreation, exercise and social activities. These amenities reduce individual and public health costs.

- BGI supports social interaction and social integration as it increases the tendency to use open spaces for activities in groups and the commitment to spend time with families, neighbors, and communities.

1 Arup, (2014): Cities Alive. http://publications.arup.com/Publications/C/Cities_Alive.aspx; BBC (2013): Green spaces boosts wellbeing of urban dwellers. http://www.bbc.com/news/health-22214070; BBC (2013): Green spaces can save NHS billions. http://www.bbc.com/news/science-environment-24806994
2 Sjöström, M., et al. (2006). Health-enhancing physical activity across European Union countries: the Eurobarometer study. Journal of Public Health 14.5: 291-300.

THE INFLUENCE OF BGI ON PUBLIC HEALTH

From a financial capital perspective, Bishan-Ang Mo Kio Park (BAMK) provides an interesting case. BAMK provides a good view of return on BGI construction investments including opportunity costs for avoided restoration of grey infrastructure.

The BGI construction cost of the naturalized river in BAMK was 19,000 SGD (USD 16 thousands at exchange rate of 2013) per meter, which should be compared with the SGD 28,000 (USD 23 thousands at exchange rate of 2013) per meter for a conventional concrete canal. While the normal life cycle for a concrete canal is about 30 years, BGI is expected to last for at least 50 years. This difference in project life span reduces the lifecycle costs further. The higher maintenance costs for BGI are more than compensated for by the significantly lower construction and reconstruction costs and the life period.

The redevelopment of the park has attracted an increased number of visitors. Upgrading the old park with BGI increased the estimated annual park users by more than 100%, from 3 to 7 million. The benefits from the time spent exercising in the park have been estimated to be an annual benefit of SGD 8 million in the baseline scenario, 16,2 million in the conservative scenario and SGD 43 million in the probable scenario (USD 6 / 13 / 35 million at exchange rate of 2015). Computing these annual benefits over the lifetime of the business case results in a Net Present Value (NPV) of SGD 188,3 million for the baseline scenario, SGD 376,6 million for the conservative scenario and SGD 1.004 million for the probable scenario (USD 150 / 301 / 903 million at exchange rate of 2015).[1]

1 Dreiseitl, H., Leonardsen, A., L., Wanschura, B. (2015): Cost-benefit analysis of Bishan Ang-Mo Kio Park. National University of Singapore, School of Environment and Design, Department of Architecture.

ECONOMIC BENEFITS OF IMPROVED WATER MANAGEMENT AND RESILIENCE AND BGI

The ongoing challenge of climate change is likely to lead to more frequent, more intense, and longer duration weather events. The cost of the damage inflicted on buildings and infrastructure by such events is already a huge burden to local governments, and is expected to increase substantially with climate change.

A considerable part of the flooding risk can be linked to stormwater events. According to Jan Rasmussen from the City of Copenhagen's Parks and Nature Department, the high intensity precipitation event in 2011 caused damage of more than USD 1 billion.

Through on-site infiltration and retention, BGI efficiently reduces the amount of water flowing into the sewer systems, thereby reducing the flood risk as well as the energy costs associated with pumping or treating the water. Compared to more mono-functional infrastructure approaches, the stormwater management costs are significantly reduced with this long-term holistic perspective.

Increasing the infiltration in the city also helps to replenish groundwater reserves, which, when these are used as a water source, reduces stress on local water supply as well as the need for importing water.

The benefits of BGI on water quality can also become an important factor in situations where water is scarce and/or polluted. With appropriate application of ecological and biological cleansing, BGI can clean water so that in many cases only an ultraviolet treatment is then required for it to be classified as drinking water (Studio Dreiseitl, 2014).

Several examples around the world have identified water management as a strategic field for a city's future economic status. The city of New York decided to make substantial investments in land management upstream to protect the quality of its freshwater sources. The costs for these changes came in at USD 1 billion; the same improvement in water quality through construction of a water treatment plant was estimated at a much higher cost of USD 6-8 billion. An increase of 9% was added to the unit cost of water to the user in order to finance the investment. In contrast, financing the water treatment plant through an increase in the unit cost would have required more than a 100% – a change that would certainly have been unpopular with residents.[1]

Similar conclusions can be made based on the other case studies in this report. In other words, these case studies demonstrate generally that decentralized stormwater systems based on BGI are cost-effective relative to conventional grey infrastructure.

1 Juniper, T. (2013): What Has Nature Ever Done for Us? How Money Really Does Grow on Trees. Santa Fe, N.M.: Synergetic Press.

COST EFFECTIVENESS OF BGI IN NEW HOUSING DEVELOPMENT PROJECT AT HANNOVER-KRONSBERG

In the newly built residential area of Hannover-Kronsberg, BGI is used as functional and cost-effective stormwater runoff drainage infrastructure. The intention was to introduce BGI as a supplement to conventional grey infrastructure, which would have required a need for an upgrade of the already constructed drain capacity in the wider area.

Given the topographical conditions, a conventional grey drainage system would have had large impact on the urban water balance, as the flow of stormwater is subject to a large fluctuation – normally storage levels are quite low but come close to overflow in times of heavy rain. At the same time, increases to impervious surfaces would have reduced groundwater refill, which sooner or later would lead to a dehydration of a nearby wetland and adjacent forest.

Consequently, on-site retention and infiltration by BGI was chosen as best option, even though soil had comparably low permeability and did not allow for complete on-site infiltration For this reason, an expansive concept with combined outflow, storage, and delayed drainage was implemented with the aim to optimize groundwater refill. BGI was implemented with a Swale-French drain infiltration design to increase on-site retention and groundwater refill and guarantee a high level of flood protection to Kronsberg and the downstream areas.

According to a cost comparison carried out after the development was completed, decentralized rainwater management for public spaces is more economical for the City Water Treatment Services than conventional drainage systems. Minimizing the areas sealed by paving and buildings reduces the need for rainwater retention facilities. Removing the need for street drains and environmental compensation measures according to nature conservation law also saves money.

Looking at the capital investment cost, the decentralized BGI approach to stormwater management was around 8% more economical than a conventional drainage system. The construction costs were EUR 11,599,167 (USD 10.9 million at exchange rate of 2001) while the costs for a conventional drain construction were estimated at EUR 12,606,412 (USD 11.8 million at exchange rate of 2001). The specific investment costs worked out at around EUR 34/m2 of built area.

The viability studies performed by private-sector property developers showed that 'the investment costs of decentralized rainwater management are to be assessed as on average about 25% higher than conventional drainage.' However, according to the water table of charges, 70% reductions in rainwater disposal charges more than compensates for this difference.[1]

1 Rumming, Karin (ed.) (2004): Hannover-Kronsberg handbook: planning and realisation. Landeshauptstadt Hannover, Umweltdezernat, Baudezernat.

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CHAPTER 6

RECOMMENDATIONS

RECOMMENDATIONS

The recommendations outlined here are based on lessons learned in the case studies and shall support urban decision-makers, practitioners and the interested public to consider and be aware of challenges, constraining as well as enabling factors in the process of planning and implementing blue-green infrastructure. Hence, these recommendations present a guideline to avoid potential pitfalls and to build the capacity needed within and outside the team to be successful.

Today we have all technology and knowledge available to carry blue-green infrastructure into effect and create robust and resilient urban environments while at the same time building vivid, liveable, and playful open spaces for recreation and social life. However, there are both practical and mental barriers that may obstruct or delay the realization of BGI. The intention of this research was to clearly enlighten the discrepancy between what designers and engineers are able to design and create and what reality looks like; and to show ways to overcome these challenges.

Of course this is not the place to develop customized solutions. Finally every city and every place has its unique conditions and challenges. Hence, there is a need for a variety of partial solutions at different scales that can be assembled for each new situation when planning, financing, processing and maintaining BGI.

Img.77

STRONG VISION AND INNOVATION

STRONG VISION TO PROCURE LEGITIMACY, REPUTATION AND CIVIC SUPPORT

From a political perspective, investments in BGI projects promise a profitable rate of return: BGI is an excellent measure to prove innovativeness and performance as BGI has high visibility in both directions – inwards as BGI strongly and significantly effects the quality of citizens' life, like public health, and outwards as it has evolved to be an important factor in inter-city competition and ranking of prosperity, sustainability and liveability. Therefore the motivation of policy-makers to gain reputation is a very relevant driver for BGI in urban design in our cases.

Political and social support turned out to be bottleneck resources for a shift towards BGI in urban planning and design. It is therefore very necessary to make efforts in public relations and to communicate the benefits of BGI convincingly.

In the cases the drivers of BGI projects often made effective use of certain visions of liveability and prosperity to bring the advantages of BGI into play (Green city vision, Biophilia, Sustainable Urban Design, Garden City, Water Sensitive City). This is important, as all involved parties have to understand the techniques, motives and the positive impacts of the projects (see Chapter 5).

Innovative design with high functional and aesthetic values helps to attract and generate support. But still it might be time-consuming to gain all attention and support that is needed. Integrating the overall benefits of a BGI project in an extensive story has proven to be effective. For success it is most beneficial if a BGI project can contribute to other challenges and support win-win situations to modernize and upgrade the quality of a city.

Civic support can be established right from the start of the planning phase, if people of the neighborhood get involved. This will also foster broader public awareness. The identification with a spot – as it is the case in Tanner Springs Park in Portland – will elicit volunteerism and sustained BGI advocacy.

Img.78

USE BGI TO ENHANCE YOUR INNOVATIVENESS

BGI projects tend to be wicked challenges as they rely on cultures of collaborations and on mindsets of liveability that often have to be newly introduced in a city's institutional body. Quite a few observations point in this direction and stress the amount of institutional engagement needed for BGI innovations. It is therefore wise to regard this engagement as an investment in innovative urban planning.

The cases prove that learning effects in the field of BGI often were transferred to other planning fields and networks created in BGI projects serve as a resource in other projects. This is true on the operative level as well as on the top level, as positive side effects of strong institutional capacity with effective leadership will tend to spill over to other policy areas, and thereby improve urban governance performance in general.

By introducing new techniques like BGI, the innovativeness of a city will be enhanced.

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CULTURAL CAPACITY

SHARE PROBLEM PERCEPTION AND VALUE PATTERNS WITH INVOLVED ACTORS

This dimension is primarily concerned with the cultural fit between organizations and their (leading) staff members and further stakeholders involved. In an optimal case, the understanding, problem perception and value patterns of involved actors correspond with one another.

Culturally based structures of institutional bodies, professional groups and whole societies are some of the most basic drivers of social and economic evolution of a city. Although often termed as soft factor, culture is also most difficult to change. Nowhere is this more true than in the field of BGI: Decision-making in urban infrastructural planning is based very much on cultural frames and meaning structures of the political, civic and corporative actors involved. A joint understanding about relevant goals and appropriate measures can function as a source for high productivity of infrastructural projects.

The relative cost of coordinating and cooperating depends on the prevailing cultural patterns of work-related attitudes and professional role understandings of relevant stakeholders and key players ("planning cultures"). In some institutional settings, cooperation tends to be facilitated by a shared professional socialization, similar educational or social backgrounds. In other settings, values professional "worldviews" or "belief systems" might clash with one another (e.g. legalist perspectives with managerial notions of policy-making, aesthetic or technical considerations with political or economic rationales).

In a similar vein, relevant stakeholders and key actors in policy-making and implementation may adopt a variety of role understandings for themselves that can facilitate or hinder effective cooperation across organizational boundaries (e.g. a more re-active role of a classical bureaucrat or expert-driven and technocratic role understandings, while others pursue pro-active policy advocacy or classify as political activists or 'policy entrepreneurs').

Surprisingly the cornerstones for BGI-oriented planning cultures can differ significantly from city to city. For example cultural capacity for BGI projects can rest on a more managerial and technocratic planning conception when BGI is realized as an innovative and suitable technology to handle critical infrastructural demands (Copenhagen). Or, cultural capacity for BGI projects might be based on 'grassroots politics', 'bottom-up policy-making' and – more generally – an eco-friendly approach shared by all involved stakeholders (Portland).

If cultural capacity in an urban institutional setting is low or the established urban planning culture is not BGI-oriented, we recommend investing in a change of the collective mindset. It takes a long breath, but in the end it pays for all. Some tools seem to be very effective:

- **Commit "boundary spanners"** in decision-making and implementation processes across the involved (central and local) government offices, public enterprises and private-sector contractors. This might be external experts with good networks or even central senior executives in municipal administration and public utilities, who serve as interfaces between different professional and organizational cultures. But also interdisciplinary staff units endowed with extensive responsibilities for the coordination of project management partners might strengthen the "work relationships" between public utilities, private consulting engineers and municipal administration.

- **Invest in BGI capacities:** Professional socialisation is a very strong source for a planning culture, and professional education is its main driver. Following a long-term BGI agenda, it pays to invest money and time in specialized programs for BGI planning and construction. This helps to change role understandings of young professionals who sooner or later will support innovative projects as members of an epistemic community spread over different agencies and companies.

- Create newly-established **professional networks and associations** related to blue-green infrastructure e.g. by sponsoring research projects, hosting professional meetings, initiating training and education programs or forming networks focused on blue-green infrastructure.

- **Participatory approaches** in public policy analysis is also an important vehicle to carry projects of blue-green infrastructure through the policy-making process: town hall meetings, hearings, focus groups and elements of mediation can support the cause of blue-green infrastructure by developing a common ground for meaningful policy discourses.

- **International / national competition as driver**: Copenhagen's blue-green infrastructure projects are also energized and propelled forward by a strong sense of international competitiveness. Most key actors and their agencies have been an integral part of an international epistemic community of planning experts and political protagonists of blue-green infrastructure for a considerable period of time. Being part of this community not only incentivizes key players in Copenhagen on their ways to top positions in international rankings and indices, it primarily provides much needed access to expertise and is, perhaps even more importantly, a rich source of visibility and legitimacy.

STRUCTURAL CAPACITY

INTEGRATED OWNERSHIP AND STRONG LEADERSHIP

Structural capacity of a governmental body to implement BGI refers very much to the extent to which “policy ownership” for BGI is concentrated or diffused and fragmented. For effective and efficient policy-making and implementation, various levels of government are needed.

In many cases, responsibility for BGI though is fragmented vertically and horizontally respectively. BGI implementation is a near-perfect example for a complex policy area that cuts across many traditionally established functional lines of responsibility. Designating a specific permanent function, like a “BGI-commissioner”, planning units or joint working groups with responsibilities for strategic thinking and coordination is highly important in order to counteract fragmentation and increase structural capacity. This strengthens the ability to solve general problems and effectively achieve the BGI goals.

Success in BGI projects often relies on singular skillful political entrepreneurs. As such projects in the first run tend to be more a question of BGI-oriented planning culture and political relevance setting than of technical capability, it is most helpful to have a convincing and powerful person in charge (“BGI-Ambassadors”) to speak out for BGI topics.

At agency level, water agencies are most likely to take charge for the process of implementation successfully. As experts often hang on to standard grey model of rainwater management, they have to be convinced to take a leading role and to be a driving force.

Additionally a permanent BGI function helps to institutionalize BGI goals. A BGI-commissioner, planning units or joint working groups with responsibilities for strategic thinking and coordination are highly important in order to counteract fragmentation and increase structural capacity. This strengthens the ability to solve general problems. In consequence BGI goals should no longer be subject to abrupt change and modification with each change in local government.

Img.81

OVERCOME SILO MENTALITY

Unfortunately a state of silo-thinking is a common attitude that occurs when several departments or groups do not (want to) share information or knowledge with other individuals in the same organization. This behavior is common all over and related to traditional beliefs in power structures with an enormous impact on the expertise of organizations.

It can happen in all scales in small organizations, in cities and regions but also in large governments. Silo mentality often creates a destructive culture based on competition and e.g. reduces the ability to implement BGI effectively. It is the nature of water and greenery to be connected and in permanent exchange with the environment. BGI projects require holistic thinking to overcome silo mentality, governance bottlenecks and fragmented operations.

We recommend city leaders to promote policy integration and inter-agency coordination to ensure knowledge exchange and a structure and framework that help to ensure mutual support, understanding and cooperation. Planning cultures are likely to benefit from (interdisciplinary) professionals who can transcend institutional boundaries to avoid structural fragmentation.

Institutionalizing inter-departmental cooperation, inter-disciplinary coordination and day-to-day work alignment might require both system and behavioral changes. Urban management can help and facilitate these necessary changes by special interdisciplinary training programs and workshops, staff rotation and generalist career programs. Often workshops help to acquire such skills. By recognizing the topics and problems of other disciplines, the notion to help and the desire for cooperation occurs. The cases too prove that professional workshops can be most relevant and helpful to open up silo-thinking and create win-win situations.

Additionally more permanent measures are recommended, such as creating new BGI-related professional networks and associations across departments.

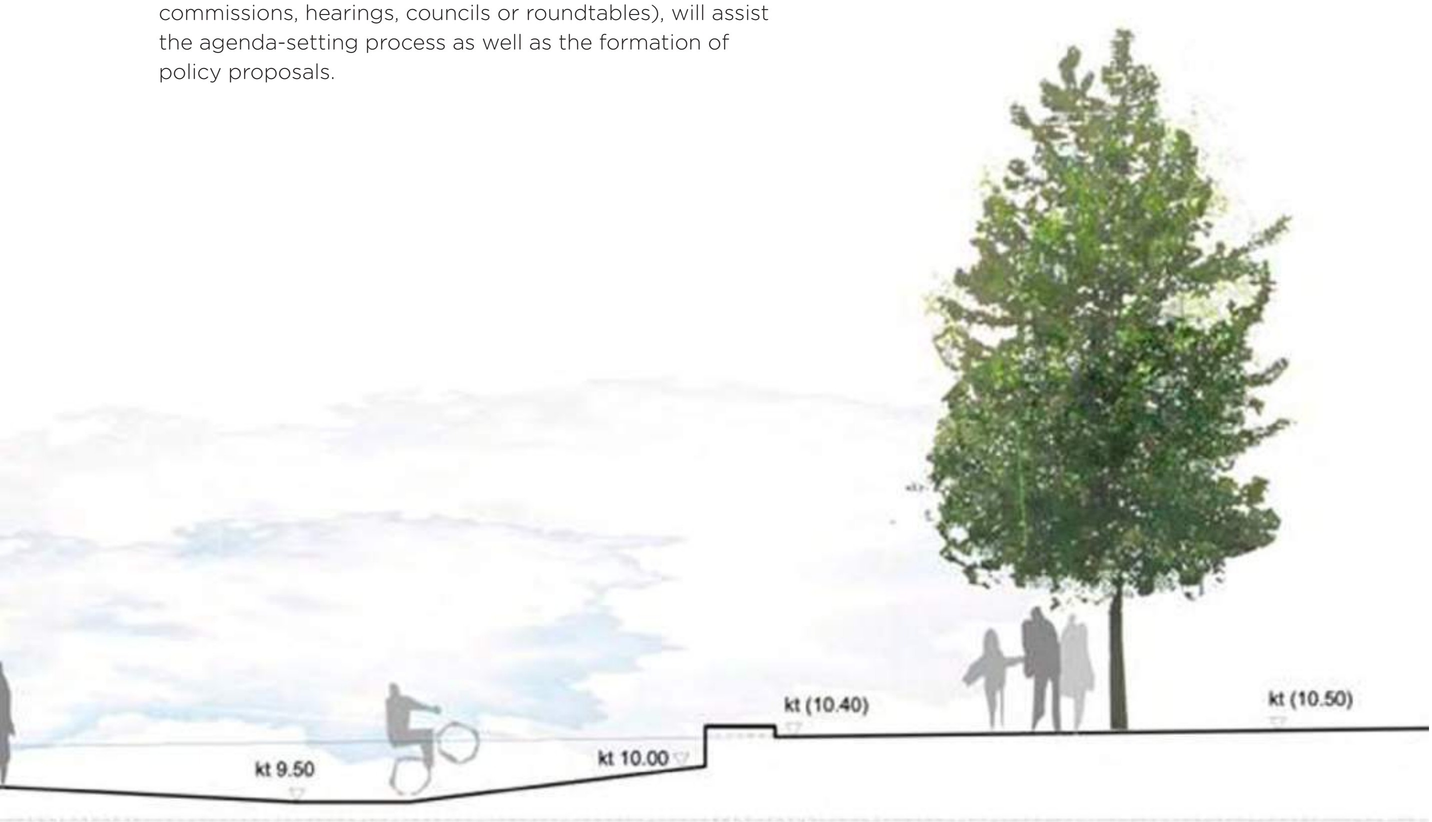
CREATE PARTNERSHIPS

Forming partnerships and collaborations ("collaborative administration") and aiming at the improved inter-agency cooperation is a further vehicle to enhance capacity for complex and innovative policy proposals across established department boundaries. Most importantly, local and state government authorities will enhance their strategic capacity if they build effective collaborative working relationships with external actors.

These networks of mutual exchange and support might include private stakeholders like NGOs and private companies, who can span different vertical political levels and they might contain representatives of different public agencies. These networks function as crucial resources (Social Capital) in political and administrative decision-making. Ideally they exist independently from single projects and get activated for political opinion making when two or more network partners have complementary interests. The interface between public authorities, external (organized) interests and stakeholders (such as boards, commissions, hearings, councils or roundtables), will assist the agenda-setting process as well as the formation of policy proposals.

Networks that have a specific BGI focus best support BGI projects. Sometimes informal BGI exchange groups might be the most important drivers in this context. But these groups are hard to govern as they depend on a critical mass of experts and interested persons that participate individually. Networking might also be pushed forward on a more institutional level. Here platforms or 'clearing houses' that may help to initiate debates, provide and disseminate expertise and information, are also options for improved cooperation.

Effective partnerships also contribute to enhanced knowledge and skills as well as to legitimacy.



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OPPORTUNITIES

LOOK FOR WINDOWS OF OPPORTUNITY TO INITIATE BGI

Urban areas experience a permanent process of change and adaptation. These occasions are THE chance for innovation.

In the case studies, however, urban challenges have proven to be an efficient lever for BGI thinking in an urban planning culture: catastrophic floods, water-related health problems, climate change, biodiversity loss and heat island effects foster political and social support for BGI implementation.

As windows of opportunities like floods may occur spontaneously, it is highly valuable to be prepared for starting a BGI project immediately and to have the courage to avoid old habits when urgent action is needed.

In order to overcome barriers, it is essential to gain acceptance and support for BGI ideas before executing projects. Therefore you need to point at advantages and relevance of BGI comprehensively and to find initial projects where BGI is very obviously the best solution. The comparative cost advantage of a newly built BGI instead of renovation is usually very significant.

For choosing adequate initial project, take different criteria into account. Two criteria are of special importance:

1. Scale: As BGI heavily relies on the idea of onsite water retention, the project scale has to fit to the volumes of water that need to be treated and stored.

2. Need for renovation or upgrading: When old, grey infrastructure needs renovation or upgrading, the comparative cost advantage of a newly built BGI instead of renovation is usually very significant.

In summary, it is wise to gain as much know-how as possible and be aware of the right moment to act.

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SKILLS AND KNOWLEDGE

BUILD UP AN INTERNAL STOCK OF KNOWLEDGE

BGI is in many cases a relatively new practice, and integrating blue, green and social elements in the urban landscape requires experience, detailed expertise and the generalist's ability to coordinate all parts of the complex implementation. However, local governments often face insufficient human resources or general knowledge required to implement BGI.

One way to improve general knowledge within the local office or department is to use external expertise in an early stage and from that build up an internal stock of knowledge. This external expertise could be provided in form of consultants to develop guidelines, best practice examples and handbooks of relevant recommendations and toolboxes.

To ensure a good outcome in terms of both water management and biodiversity enhancement, a combination of hydraulic and ecological risk assessment needs to be incorporated in the final implementation plan of BGI. This may require expertise beyond traditional engineering techniques.

Apart from technological knowledge, it might be required to have support from interdisciplinary professionals who can transcend institutional boundaries to create an integrative planning culture addressing all different disciplines that have to be involved (see Chapter Cultural Capacity).

LEARNING FROM PILOT PROJECTS IS DECISIVE

Pilot projects used to be a first resort measure in nearly every field of socio-technological innovation. Well-designed and constructed BGI projects easily serve as long-term references and are highly effective to establish first steps of a BGI planning culture. As permanent exhibition for BGI technology, they unfold their long-term financial, social and ecological benefits. Another plus is that pilots offer some degree of freedom for innovation and collaboration, which is an important resource for later planning routines. Experiments that deepen the understanding of opportunities and necessary preconditions of BGI can be executed under local conditions.

Technological expertise needs to be built on the local scale and important key officials as well as the wider public have to be convinced of the feasibility of BGI solutions to turn into a future BGI path in urban development. Pilot projects offer the chance to conduct experiments that deepen the understanding of opportunities and needs of BGI under local conditions.

However, they can also be some sort of obstacle as they seem to be exceptional and cannot be achieved under normal conditions. Therefore it is of most importance that pilot projects are able to become paradigm examples with a high relevance to other cases.

To have a positive learning effect and understanding of the multiple long-term benefits from such pilot projects, it is important to document all relevant steps towards its success and to demonstrate the performance after completion by an in-depth evaluation.

BASIC CONDITIONS

THINK HOLISTICALLY AND RIVER CATCHMENT-WISE

For BGI implementation one of the preconditions is to take the whole river catchment area with all its resulting requirements into account.

Most cities have been evolving slowly by implementing mono-functional solutions for problems that occur in the process of growing. Providing drinking water and sanitation is very typical in that aspect: Cities used to construct separate structures for water inflows and outflows without paying any regard to the urban body as a socio-ecological system of its own. The way cities were and often still are built induces disturbing effects for the natural conditions in the urban area and beyond. With sustained growth and rising density, these disturbing effects tend to endanger urban living conditions and capital resources. Increasing population leads to a growing demand for water and energy; more settlements means an increased share of impervious surface on urban area and thus a higher risk of flooding, increasing drought, more climatic stress and less biodiversity.

At latest with the introduction of the European Water Framework Directive in the year 2000, European cities, agencies and planners started to look onto their city as being part of one water catchment area. From there it follows that all planning and construction work of urban infrastructure should have minimal impact on the natural water balance. Future BGI should pursue increased connectivity with upstream and downstream socio-environmental systems. Cities in other parts of the world are experiencing similar movements.

DISPOSAL OF LAND AND PRECAUTIONARY LAND USE PLANNING

The disposition of land to build BGI projects is fundamental. The process of acquiring land becomes increasingly complex under conditions of high urban density.

This is true for all infrastructural projects (housing, traffic and commerce), but of particular relevance to BGI. One of the main goals of BGI is to enhance the regional hydrology. Since water obeys the law of gravity and ignores zoning plans and property rights, an optimal BGI design does not necessarily follow the local logic of private, semi-private, and public spaces. However, the pattern of land ownership and zoning affects the acquisition of land for project implementation.

Several measures like expropriation, reallocation of property rights, and application of pre-emption rights are known to be more or less effective depending on the institutional capacity of the governmental body.

However, in the long run, it is more effective to develop proactive land use policies to support the acquisition of land for BGI projects, which are sensitive to the needs of a water catchment in their design. Such land use policies may be introduced in a variety of forms, e.g. as master plans, and should aim to reserve urban corridors and contiguous catchment areas for BGI.

Precautionary land use planning is also essential for urban equity – an equitable provision of citizens with the benefits of urban green. As BGI is connected to healthy and socially embedded living citizens there is legitimate claim to profit equally from the overall BGI activities of an urban government.

INSTITUTIONALIZE BGI AS A STANDARD TECHNOLOGY IN URBAN PLANNING

BGI´s integrative and interdisciplinary approach to water management requires collaboration and cooperation across agencies: for instance, between urban designers, landscape architects, and water engineers. The need for cross-agency cooperation adds complexity to the process of BGI planning and implementation and can lead to delays and increase project costs. However, BGI projects are not inherently more complex than more conventional infrastructure projects. Support from an appropriate regulatory framework can go a long way towards simplifying the process for BGI. Once necessary local knowledge and experience is built up through a handful of pilot BGI projects, local decision-makers and experts should create a set of standards to facilitate future BGI implementation.

In short, once routines and standards for BGI have been defined, the planning process for BGI is not more demanding than it is for conventional grey infrastructure. Institutionalization of appropriate regulations and standards reduce transaction costs and support the creation of new paths of development.

The need for institutionalized standards for BGI becomes even more crucial for project success if the inter- and intra-agency dynamics are dominated by individual personalities. Whether a city supports or hinders adoption of BGI is highly dependent on the particular individuals in positions of power, and how they feel about BGI. Long-term development of BGI should not be allowed to remain at the whim of those in top political positions. Where support for BGI remains closely tied to particular people, its success is vulnerable to abrupt changes with shifts in local governance (see also Chapter “Structural capacity”).

Establishing a formal institutional framework for BGI projects not only liberates the success of the project from personal and agency politics, it can actually help to initiate changes in well-established habits. The pace of innovation has been found to increase when first pieces have already been put in place.

To support the development and adoption of an institutional framework for BGI, an effective first step is to document acquired knowledge and experience in handbooks and guidelines. This documentation supports the transfer of experience from a single project to future projects and enhances the efficiency and effectiveness of BGI implementation. Where possible, lessons learned should be communicated so as to be applicable to different project scales. Once this documentation is in place, it should be followed by implementation of effective, enforceable, and sanctionable BGI guidelines and regulations in the urban planning processes like e.g. drainage regulations; policies for land ownership and land use; requirements for rainwater inflows and outflows; etc.

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ANTICIPATE LONG-TERM OPERATION AND MAINTENANCE

BGI often has lower initial capital and construction costs than comparable grey solutions. However, since it consists of living organisms and habitats, and provides spaces that are actively used by residents, the blue-green open spaces require commitment of time and resources to retain its function as effective infrastructure.

No one wants a poorly maintained park. In the long run, professional maintenance and monitoring of BGI ensures that it remains beautiful and attractive to the public, and retains its capacity to impart the positive social and environmental benefits that set this infrastructure apart from conventional solutions. However, the findings of this research indicate that long-term costs that are associated with operation and maintenance of BGI are often not anticipated. One of the reasons for this lack of foresight appears to be that grey infrastructure can continue to function without maintenance for a much longer period, after which a substantial investment is required. In contrast, the living organisms of BGI require a permanent level of attention; if BGI receives regular maintenance, major investments down the road can be avoided.

A clear and realistic picture of the life cycle costs of BGI should be transparent and every attempt should be made to communicate these requirements to decision-makers throughout the process. Securing long-term funding for maintenance of BGI is crucial to the success of a project and should be considered a critical part of BGI planning. Furthermore it is also of major importance to clarify the financial and human resource responsibilities for maintenance in advance and to allocate and secure commitment to these responsibilities from the relevant municipal agencies.

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FINANCES

LOOK FOR INNOVATIVE APPROACHES TO FINANCING

BGI has certain features that enable and sometimes even call for new solutions of financing.

Well-designed BGI has multiple uses and thus provides benefits for many different stakeholders. To acquire financial support from the different beneficiaries should be high priority in project planning. Opportunities to bring these partners into joint financing arrangements can be crucial for the success of a BGI project: first, since BGI is still a relatively new technology more traditional funding sources are not always available; second, bringing these partners into financing arrangements increases their commitment to the success of the project and supports innovation.

A number of successful, well-managed models for public-private partnerships exist in the field of BGI: an example is real estate financing. Real estate owners and insurance companies, for example, as partners of flood prevention improvements in dense urban areas typically are in privileged financial positions.

However, it is still an open question to find a model for financing that attracts insurance companies as financial partners for BGI. However, since BGI mitigates the risk of flooding and therefore flood-related damages, BGI provides an insurance-related service. Potentially there is a large opportunity to include insurance companies into BGI financing in advance. We expect inspiring and innovative solutions in this field to come soon.

Currently, BGI implementation is heavily dependent on private contributions, as effective rainwater management has to regulate stormwater inflows to the public system already on the private ground. Split water charges and tax cuts seem to be an effective way to reimburse private property owners for investment in BGI. Other measures include the reduction in water charges where property owners invest in on-site stormwater retention.

Normally building BGI relies on the engagement of a number of different public agencies. These agencies include not only water and environment, but also public housing and transportation. When these agencies decide to invest in BGI they usually have to reallocate budgets from their core responsibilities to another category. In practice, this can be a complex and complicated accounting maneuver. There are intelligent tools, however, to rebalance this budgetary shift.

Wherever possible, financing for BGI should identify arrangements that coordinate budgets across agencies: for instance, program budget that merge budgets across departmental lines. Cross-agency budgeting can be highly effective because it increases inter-agency involvement and can therefore enhance cooperation. When multiple agencies have financially invested in funding the BGI project, it can help in securing funding from external investors.

Agencies who plan BGI investments can also look to apply for funding that is earmarked for that specific purpose by the city government or other funding agencies. Alternatively water agencies themselves might fund money through financers that provide seed money for BGI projects, whether the projects are driven by public or private developers. Ultimately, it is important to find an arrangement so that a single agency does not have to bear the full burden for BGI investment. Instead the benefits are concentrated and the costs are diffused – so called distributive policies.

The combination of city-administrated BGI funding, BGI commissions, and BGI reports can be an effective, three-pronged approach to institutionalizing BGI in an urban planning process.

FINAL THOUGHTS

The combination of water and vegetation makes cities more vibrant, lively and attractive for community life. And this in turn helps people avoid depression, burnout and diseases like diabetes. Blue-Green cities have a higher reputation, attract young families and give companies strong arguments to locate their headquarters there.

It all adds up to greater economic stability, more dependable tax revenues, increased prosperity and greater long-term welfare. With a strong vision and focused leadership, let us reconnect blue and green within our cities.

Blue-Green infrastructure will help us adapt to climate change! But its implementation requires a new mindset – which we can only bring about by working stronger together. This research shall support urban decision-makers on their path towards a future, where we intelligently use what nature is teaching us for the sake of environmental protection and societal benefits. ■

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Common acronyms and abbreviations

ABC – Active, Beautiful, Clean

AH – Alexandra Hospital

B-AMK – Bishan-Ang Mo Kio Park

BCA – Building Construction Authority

BD – Biophilic Design

BGI – Blue Green Infrastructure

CGH – Changi General Hospital

CLC – Centre for Liveable Cities

HDB – Housing Development Board

KTPH – Khoo Teck Puat Hospital

MOH – Ministry of Health

NParks – National Parks Board, Singapore

NUH – National University Hospital

PCN – Park Connector Network

PUB – Public Utilities Board

UPPC – Ulu Pandan Park Connector

URA – Urban Redevelopment Authority

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Public Utility Board, Singapore (PUB)

CREDITS

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This research is based on case studies of projects and cities, extended literature reviews, and numerous interviews with different stakeholders including governmental officials, developers, planners, construction and providing companies, NGO groups and citizens. The study extends across several continents, America, Europe, and Asia, and by doing so it includes different climate zones – the monsoon climate in Asia (Singapore, Jakarta, Mumbai), the humid continental climate in Central Europe (Germany, Denmark, etc.) and continental and coastal climates of North America (Boston, New York, Portland). In addition to case study projects, programs at the city scale were studied to learn more about relevant citywide agendas.

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