

# Delivering multiple co-benefits in Blue-Green Cities

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# Introduction

Transformative change is needed in how flood risk and water security are managed in urban environments, in the UK and globally.

Increasingly, cities are rethinking their approaches to flood risk and water management, transitioning from flood defence to flood resilience by implementing water sensitive urban design such as Sustainable Drainage Systems (SuDS), Nature-Based Solutions (NBS) and Blue-Green Infrastructure (BGI, swales, rain gardens, green roofs and wetlands) alongside the more traditional 'grey' infrastructure (flood walls, barriers, pipes and tanks). Despite acknowledgement of the environmental, economic and social benefits of BGI a range of barriers hamper widespread implementation.

In April 2021, the Royal Geographical Society (with IBG) hosted an online knowledge exchange event to explore the multiple co-benefits of Blue-Green Cities, and how these can overcome the biophysical, socio-political and societal barriers to innovation in urban flood and water management. The event was chaired by Oliver Harmer (Yorkshire Area Director, Environment Agency) and contributors included:

- Emily O'Donnell (Research Fellow in Urban Flood Resilience, University of Nottingham)
- Ana Mijic (Senior Lecturer in Water Systems Integration, Imperial College London, and a Co-Director of the Centre for Systems Engineering and Innovation (CSEI))
- David Singleton (Director, DSA Environment and Design)
- Mark Fletcher (Global Water Lead, Arup)

This briefing paper draws together discussion from that event, framed by geographical research in the Blue-Green Cities ([www.bluegreencities.ac.uk](http://www.bluegreencities.ac.uk)) and Urban Flood Resilience ([www.urbanfloodresilience.ac.uk](http://www.urbanfloodresilience.ac.uk)) projects, to give recommendations to enable greater implementation of BGI in policy and practice.

The Blue-Green Cities project was led by Professor Colin Thorne (University of Nottingham), and ran from 2013-2016. The project was funded by the Engineering and Physical Science Research Council (EPSRC) and involved nine UK Universities in addition to numerous academic, industry and local government partners. The Urban Flood Resilience project followed in 2016, again funded by the EPSRC, and continues exploring how urban water systems might be transformed to deliver multiple benefits to the environment and society while creating flood resilient places.

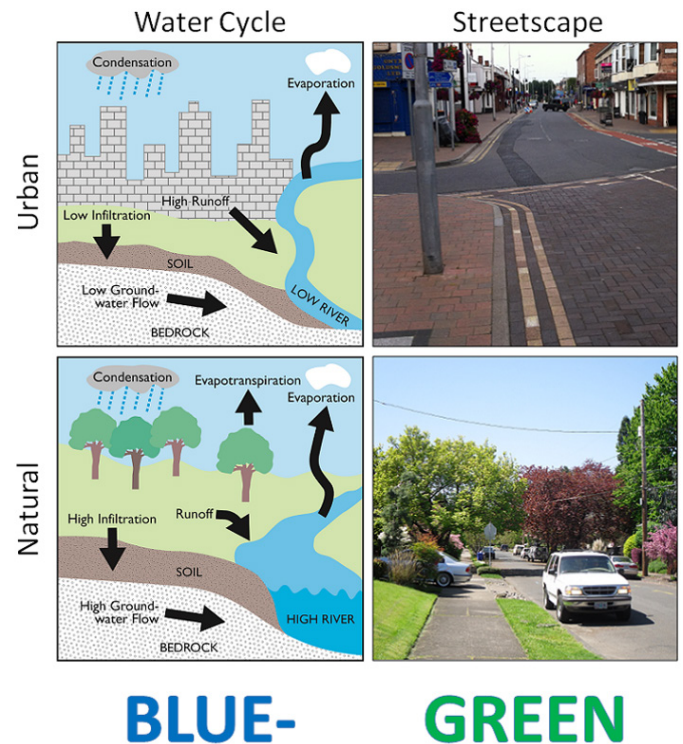


# Blue-Green Cities

Global cities face a range of water challenges, driven by increasingly frequent and extreme storm events, drier summers, accelerating urbanisation and reductions in public green space. Blue-Green Infrastructure (BGI) and Nature-Based Solutions (NBS) are increasingly being used to address challenges across the full water spectrum while tackling social, economic and environmental issues. At the largest scale, a Blue-Green City aims to recreate a more natural water cycle by bringing water management and green infrastructure together. In Blue-Green Cities, natural drainage channels are restored, imperviousness is reduced, and infiltration, evapotranspiration and surface storage are enhanced. By delivering multiple co-benefits to the environment and society, a Blue-Green City moves beyond sole consideration of flood and water infrastructure, and champions equitable distribution of infrastructure that is valued by actors at all levels, from citizens and communities to policy and decision makers (O'Donnell and Thorne, 2020).

**BGI:** interlinked networks of natural and designed landscape components, including green spaces and water bodies, that provide multiple functions. They are specifically designed to turn 'blue' (or 'bluer') during rainfall events to manage stormwater and reduce flood risk (O'Donnell and Thorne, 2020).

**NBS:** using nature to manage societal disruptions, (e.g. climate change, urbanisation, water availability and hazard management), preserve biodiversity, maintain and enhance ecosystems and deliver multiple benefits to the environment and society while enhancing resilience (Debele et al., 2019).



*"The ultimate aim is to try to recreate, or mimic, pre-development hydrology"*  
(Emily O'Donnell)

Blue-Green Cities are fundamental in addressing global environmental and climate emergencies, offering solutions that can meet climate change mitigation and adaption objectives and help cities move towards Net Zero Carbon. The importance of high-quality, local blue-green space has never been more apparent than during lockdowns imposed by the COVID-19 pandemic.

*"The vast majority of local authorities have not only declared a climate emergency, they've set really ambitious goals around net zero - the challenge is positioning blue-green as a solution to that"*  
(Oliver Harmer)

# Benefits of Blue-Green infrastructure

The benefits of BGI are well known, and include:

- **Environmental:** reduced flood risk, enhanced biodiversity and ecology, improvements to air, soil and water quality, mitigation of urban heat islands, carbon sequestration and enhanced performance of urban water systems
- **Social:** improved health and wellbeing, amenity and recreation, reduction of crime, educational opportunities, noise attenuation, and building temperature regulation (cooling and/or insulation)
- **Economic:** reduced damage costs from flood events, opportunities for economic growth and development, reduced pressure on existing grey infrastructure, lower maintenance costs and increased land value

*“Increasing health benefits go hand in hand with creating engaging places”  
(Mark Fletcher)*

Benefits can accrue at different scales. At the site scale, green roofs and rain gardens have been proven to reduce runoff and retain surface water, helping mitigate flood risk from small magnitude events (e.g. one chance in every three years of occurring). At the local/development scale, BGI interlinks with other infrastructure systems (e.g. transport, energy, communications) and helps protect this critical infrastructure from flooding. At the city/catchment scale, BGI benefits the water sector by improving water quality and managing stormwater through rainwater harvesting and storage, reducing the quantities travelling into the sewer system. At all scales, the wider environmental and social benefits outweigh the flood only benefits, and can accrue to a greater range of stakeholders.

*“If we combine the data and models we have, there is probably enough evidence that there are significant benefits for water management across multiple stakeholders and scales”  
(Ana Mijic)*

Changes in landscape management practices towards greater sustainability often include BGI, particularly when biodiversity net gain is a key objective. Engaging local students and pupils, and using BGI as a ‘living lab’ will increase enjoyment of blue-green spaces in addition to creating opportunities to learn about the processes and become more actively involved in management.



## Optimising benefits

When designing BGI in place, and recognising that places are different, it can be difficult to optimise all of the benefits. The question then is how do we know which benefits to optimise? One approach is to look at the key challenges in each area and prioritise them, recognising that trade-offs between benefits will need to be made. Discussions of the challenges will require a range of viewpoints from different stakeholders to capture different perceptions of benefits and their importance to the area – what are benefits to some people may not be to others. Greater guidance on designing multifunctional infrastructure would help with these discussions and ensure that BGI does not simply tick a box as part of the planning process. However, a balance between discussing benefit optimisation and delivering BGI on the ground needs to be achieved to ensure that implementation is not overly delayed, as benefits only start to accrue after delivery of the infrastructure.



# Overcoming barriers to delivering Blue-Green infrastructure

Despite compelling evidence of the benefits of BGI, many barriers hamper progress and are particularly related to socio-political and governance challenges. While there is generally high confidence in the hydrological and engineering performance of BGI, owing to the wealth of evidence in academia and industry on the functionality and positive impacts of BGI, developing governance mechanisms, determining public acceptability and developing future funding streams are more uncertain and challenging. However, barriers to BGI can be overcome and there are many exemplar schemes in the UK and internationally that can inspire change in national and local practices and policy. The table on page 7 gives examples of how stakeholders at different levels, and within different types of organisations, might act to help overcome some of the barriers to implementation of BGI.

*"It can't just be about national change - there needs to be acceptance at the local level and passion for delivering this locally, to work within the national guidelines"*  
(Emily O'Donnell)



## What needs to be done?

Overcoming barriers to enable widespread delivery of BGI requires a variety of changes in governance, planning, design and assessment of benefits. In many ways this relates to changing hearts and minds and working with stakeholders to highlight the value of BGI as a new way of working with water. Without a legal framework specifically devoted to delivery of BGI, the challenge around implementation becomes more of a political one, with senior and political buy-in essential for new policy, practice and funding allocations to be developed.

*"Governance across the water system is absolutely fundamental. Sometimes there's a preoccupation with blue and green and missing the governance"*  
(Mark Fletcher)

**Collaboration** is essential in delivering high quality BGI. No one organisation is responsible or able to comprehensively deliver Blue-Green City aspirations. Siloed working is ineffective and leads to missed opportunities. There needs to be a common objective in what BGI is being used to deliver and having enlightened players who can create a vision of what is to be achieved is essential in gaining support from other parties. National agencies, like the Environment Agency, have a key role to play in brokering discussions and facilitating joined-up thinking.

Collaboration must include local residents and communities, whereby active involvement in BGI projects creates a greater sense of ownership of the BGI and increased willingness to maintain the infrastructure, in addition to improving understanding of the functions and benefits and creating local environments that people desire and will utilise. Successful engagement may also inspire inclusion of BGI in other projects and encourage people to go out and enjoy blue-green landscapes – what makes places is people's interaction with them.

*"National policies frame behaviour but unless you're getting action and demand at the local level, that won't play out into tangible benefits over time"*  
(David Singleton)





**BGI design** should be regarded as a process, not an end point. Design does not have to be elaborate or expensive but must deliver BGI that is functional and desired by intended beneficiaries. The local context is fundamental in effective BGI design as no one solution will deliver the desired benefits to all people. There is a wealth of guidance on how to design BGI to perform well, including Building for a Healthy Life, a recent Homes England design code for delivering BGI in neighbourhoods, streets, homes and public spaces. Interactive blue-green landscapes, with opportunities for informal, natural play, can enrich developments and get more people involved in BGI. However, adequate funding and a progressive local authority is needed to enable design ideas to come to fruition.

*“Blue-green in itself is not the end goal, it should be the benefits that are the end goal, and that takes design”  
(David Singleton)*

Long term management and maintenance of BGI to ensure delivery of the multiple benefits over the lifetime of the infrastructure needs to be included as part of the initial planning and design process. This includes who pays for management after the initial capital outlay to construct the scheme.

From a planning perspective, the legal framework to deliver BGI exists however, interpretation of how this is applied can impact on BGI delivery. Engagement with planners around the benefits of BGI is essential. Local



planners determine how much BGI must be delivered in new developments, but the value of land needs to be captured better to reflect the potential benefits that BGI can deliver. Supplementary Planning Documents and design codes are one way of building upon and providing more detailed guidance about policies in the local plans, and can be used to support the case for quality BGI that delivers specific benefits.

*“Policy has to have teeth - supplementary planning documents could be provided to give policy teeth. Whether it’s resourced adequately is a good question”  
(David Singleton)*

**Exemplars** are key to reinforcing and articulating the benefits of BGI in addition to sharing best practice and strategies for overcoming barriers in different geographical, social and political contexts. Places with high quality BGI should be celebrated and shared more widely across government, industry and academia as part of a multi-directional exchange of knowledge and expertise.

*“People don’t necessarily want to see an international example - we need to publicise UK examples more widely. It’s easier to relate to for some cities and areas”  
(Emily O’Donnell)*

# Overcoming barriers to Blue-Green infrastructure at different stakeholder levels

| Stakeholder level  | Strategy to overcome barriers to BGI  |
|--|---|
| National Government policy makers  | <ul style="list-style-type: none"> <li>Acknowledge the benefits of BGI and champion approach nationally</li> <li>Change legislation (e.g. implementation of Schedule 3 of the Flood and Water Management Act 2010, as per Wales in January 2019), establish SuDS Approval Bodies (SABs)</li> <li>Develop statutory technical standards or guidance for BGI</li> <li>Remove the automatic right to connect to public sewers</li> <li>Devolve power to regional and local entities to create their own policies and standards</li> <li>Clear policy on maintenance and adoption</li> <li>Change remit of Lead Local Flood Authority (LLFA) to emphasise the importance of multi-functional BGI and SuDS</li> <li>Align BGI with other national objectives, e.g. Net Zero, 25 Year Environment Plan</li> </ul> |
| Local Government policy makers   | <ul style="list-style-type: none"> <li>Acknowledge the benefits of BGI and champion approach locally</li> <li>Invest in outreach, education and knowledge exchange between local Government and communities</li> <li>Investigate alternative, sustainable and longer-term funding mechanisms for BGI</li> <li>Place more emphasis on Blue-Green SuDS and those that deliver multiple benefits</li> <li>Implement community engagement programmes to raise awareness of BGI function and benefits</li> <li>Clear policy on maintenance and adoption</li> <li>Work with developers to increase their awareness of the range of SuDS and BGI options</li> <li>Identification and reconciliation of inter-agency goals</li> </ul>   |
| Practitioners: public and private sector (e.g. planners, designers, engineers, ecologists) | <ul style="list-style-type: none"> <li>Design BGI to be low maintenance and appropriate to the local environment</li> <li>Engage local residents in designing BGI schemes to increase local acceptance and ownership/stewardship</li> <li>Showcase best practice exemplars for other practitioners</li> <li>Work towards changing industry standards</li> <li>Develop open-source toolkits to identify, evaluate and monetise the multiple benefits of BGI</li> <li>Work with developers to increase their awareness of the range of SuDS and BGI options</li> <li>Implement community engagement programmes to raise awareness BGI function and benefits</li> </ul>  |
| Academia   | <ul style="list-style-type: none"> <li>Improve scientific understanding of BGI systems</li> <li>Disseminate research findings with policy makers, practitioners and public</li> <li>Disseminate (international) best practice exemplars</li> <li>Develop open-source toolkits to identify, evaluate and monetise the multiple benefits of BGI, potentially linking with Natural Capital Accounting and/or Biodiversity Net Gain</li> <li>Work with developers to increase their awareness of the range of SuDS and BGI options</li> <li>Incorporate BGI into teaching programmes</li> </ul>   |
| Developers   | <ul style="list-style-type: none"> <li>Discuss BGI and SuDS with LLFA and LPA (Local Planning Authority) at early stages in the planning process</li> <li>Investigate the viability of a range of BGI solutions</li> <li>Work towards changing developer industry standards</li> <li>Implement community engagement programmes to raise awareness of BGI functions and benefits</li> <li>Develop options for sharing short-term building costs (to developers) with long-term owner savings</li> </ul>  |
| Communities and individuals  | <ul style="list-style-type: none"> <li>Support and engage with new BGI initiatives</li> <li>Get involved in local BGI volunteering and/or stewardship schemes (or petition for such schemes)</li> </ul>   |
| All  | <ul style="list-style-type: none"> <li>Improve communication</li> <li>Become a champion for BGI</li> <li>Work towards changing cultures and behaviours around BGI</li> <li>Monetary investment in BGI schemes (on public and private land, where appropriate)*</li> <li>Acknowledge and promote BGI as multifunctional space</li> </ul>   |



## Recommendations for action

To enable a significant step-change in delivery of multiple co-benefits of BGI requires action from a range of stakeholders at a range of different scales, from decisions around policy and practice made on a national level by the national government, to individual championing of BGI in new and retrofit local developments (see also the table on page 7). This requires strong collaboration between actors at all scales. Champions and leaders who are passionate about BGI are needed at all scales to help barriers be overcome and progress blue-green visions.

*“Leadership can come from local people, from local authority/environment agency level, and it can come from multiple stakeholders locally in a national framework”*  
(Oliver Harmer)

Delivery of BGI needs to be regarded as an urgent priority, and an essential component of the UK’s strategy to address the climate and environmental emergencies, and improve quality of life of communities and individuals. This may be facilitated by a national champion who has the power and influence to spearhead BGI campaigns and make rapid change in policy and practice.

We also need to focus on both new developments and retrofitting existing neighbourhoods, towns and cities to ensure equitable delivery of BGI rather than limiting benefits to those who can afford to live in expensive BGI developments. In a just transition, blue-green should be everywhere and for everyone.

*“To live in high-quality blue-green infrastructure developments might be costly. We need to be looking at retrofit for equitable delivery of blue and green infrastructure. The vast majority of our housing stock has already been built”*  
(Emily O’Donnell)





## National scale

BGI needs to be aligned to the current objectives and agendas of National Government, such as Net Zero, climate resilience (e.g. rallying around international events such as COP26), The Ten Point Plan for a Green Industrial Revolution, and post-COVID-19 recovery, and positioned as a major part of the respective solutions. This will help strengthen the case for BGI and enable BGI projects to access the funding that comes with these national programmes in addition to raising awareness of the Blue-Green Cities concept. The ambitious targets set by many UK local authorities around Net Zero shows that this recommendation is also applicable at the local scale.

*“Using governmental pledges such as zero carbon by 2050 will strengthen the case for nature-based solutions. It can be used as a replacement for carbon-intensive grey infrastructure”*  
(Ana Mijic)

There is a huge role for national (and local) government in budgeting, setting limits to development, incentivising development and retrofit in areas where resilience to climate change is currently low, and transforming policy to embed the Blue-Green Cities concept. They also play a key role in developing **collaborative funding streams** that are needed to acknowledge the multifunctional role of BGI and multitude of actors and organisations involved.

## City/catchment scale

In addition to being designed to tackle local issues, **BGI also needs to be planned and developed at the catchment scale**, looking at how it can be used to both restore and regenerate blue and green spaces such as rivers, agricultural land, open green spaces and other water bodies that connect rural and urban BGI. Incentives for landowners to deliver BGI at scale are of paramount importance, and there needs to be better integration of rural and urban policy around BGI.

**Systems level models** should be used to illustrate the benefits of BGI at all scales, going beyond hydrological benefits and determining a range of ecosystem services to capture the full value of BGI. They can also be used to map and assess where the greatest risks and opportunities for BGI are situated, to help with strategic planning of BGI networks.

*“In terms of the just transition, it’s a question of risk. Areas at risk of flooding or overheating are at a social disadvantage as well. We can target blue-green infrastructure to mitigate climate risk, with the secondary effect of improving quality of life”*  
(Emily O'Donnell)

**Local plans for place** should determine how their environmental, social and economic ambitions can be aligned to enable greater delivery of BGI. Supplementary Planning Documents and design codes are encouraged to compliment local plans.





## Neighbourhood scale

**BGI should play a key role in the future of place-making** and local people, who will be the main beneficiaries of BGI, should be involved in decision-making. This should move on from one-way consultations from developers to communities towards co-production of knowledge. On a practical level, BGI in new developments should not be pushed to the edges but should play a key role in the design of the development to ensure that optimal benefits are delivered, rather than just meeting planning requirements and managing water on the site.

*"Blue-green solutions are not just for the wealthy. A sense of local place can change that"*  
(Mark Fletcher)

**Practitioners should actively engage local residents, students and school children** in planning, designing and constructing BGI systems to increase their understanding of the processes and appreciation of the benefits. Local support and buy-in is key to delivering BGI that is supported and valued by the local people who are the primary beneficiaries. Clear incentives for involvement should also be developed to bring on board under-engaged groups.

Citizens and communities can also act as BGI advocates, actively influencing local and national governments and pushing BGI higher up political agendas.





## How to cite

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## Image credits

### Front cover

Rain gardens at a school in Portland, Oregon USA. Credit: Emily O'Donnell

### Page 3

Comparing the hydrological (water cycle) and environmental (streetscape) attributes in conventional and Blue-Green Cities. Source: O'Donnell and Thorne, 2020.

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Rain gardens at the Alcester Primary Care Centre, Warwickshire, UK. Credit: David Singleton

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Sustainable drainage pond in the Newcastle Great Park development, Newcastle, UK. Credit: Emily O'Donnell

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Green tram tracks in the central city area of Rotterdam, the Netherlands. Credit: Emily O'Donnell

Sustainable drainage ponds in the Hanham Hall Eco Village, Bristol, UK. Credit: Emily O'Donnell

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Supertrees in Singapore's Gardens by the Bay. Credit: Tamal Mukhopadhyay on Unsplash

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Downspout (drain pipe) disconnection into a garden soakaway in Portland, Oregon USA. Credit: Emily O'Donnell

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Engaging school children with Blue-Green infrastructure at Moor Park, Blackpool, UK. Credit: David Singleton

A bridge across the wetlands within the Ningbo eco-corridor, Ningbo, China. Credit: Emily O'Donnell.

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