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Executive Summary

Designing Blue Green Infrastructure (BGI) for water management, human health, and wellbeing: summary of evidence and principles for design

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1. Introduction and purpose

The aim of the report is to select, collate, and present evidence about the ways in which enhancing green features of the local environment to improve water management (and thus creating 'Blue Green Infrastructure', or BGI) can also improve health and wellbeing within a host community. The evidence in this report is expected to support practitioners and policymakers to undertake advocacy for BGI with health benefits, to design BGI considering health and wellbeing, and to support the integration of health-promoting BGI into policy and planning.

Evidence in this report can enable practitioners...

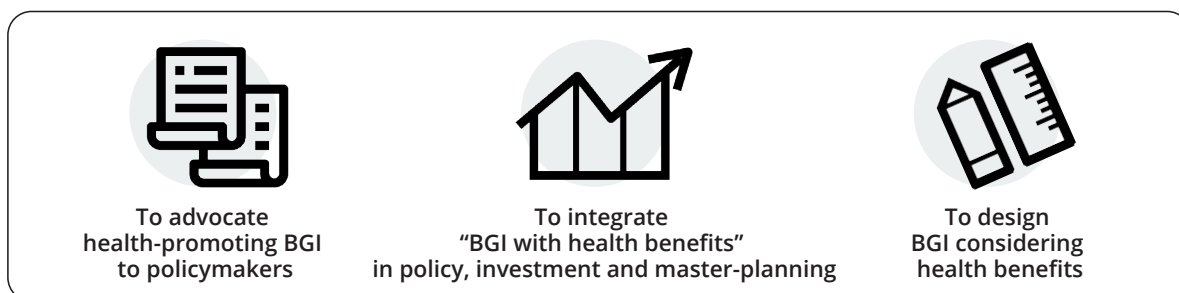


Figure 1: Infographic showing how we expect the report to be used

Blue Green Infrastructure (BGI) examples



2. Concepts and terminology

2.1 The term 'Blue Green Infrastructure' (BGI) in this report is used to describe the green spaces and semi-green built systems (including fields, woods, rivers, lakes, and gardens) that are found between and within our built-up areas.

2.2 We focus on local health and wellbeing: the benefits felt by people in the location where the BGI is sited.

2.3 We investigate the effect of BGI on health across three categories: BGI attributes, health-relevant impacts, and health outcomes (see Figure 2).

- There are 3 main **attributes of BGI** that have health-relevant impacts: greenness, accessibility, and aesthetic and sensory qualities.
- These attributes are connected to **health-relevant impacts** in six main areas, which affect local environments and people.
- These impacts are causally connected to **health outcomes**: reported or self-reported changes to people's physical or mental health and wellbeing.

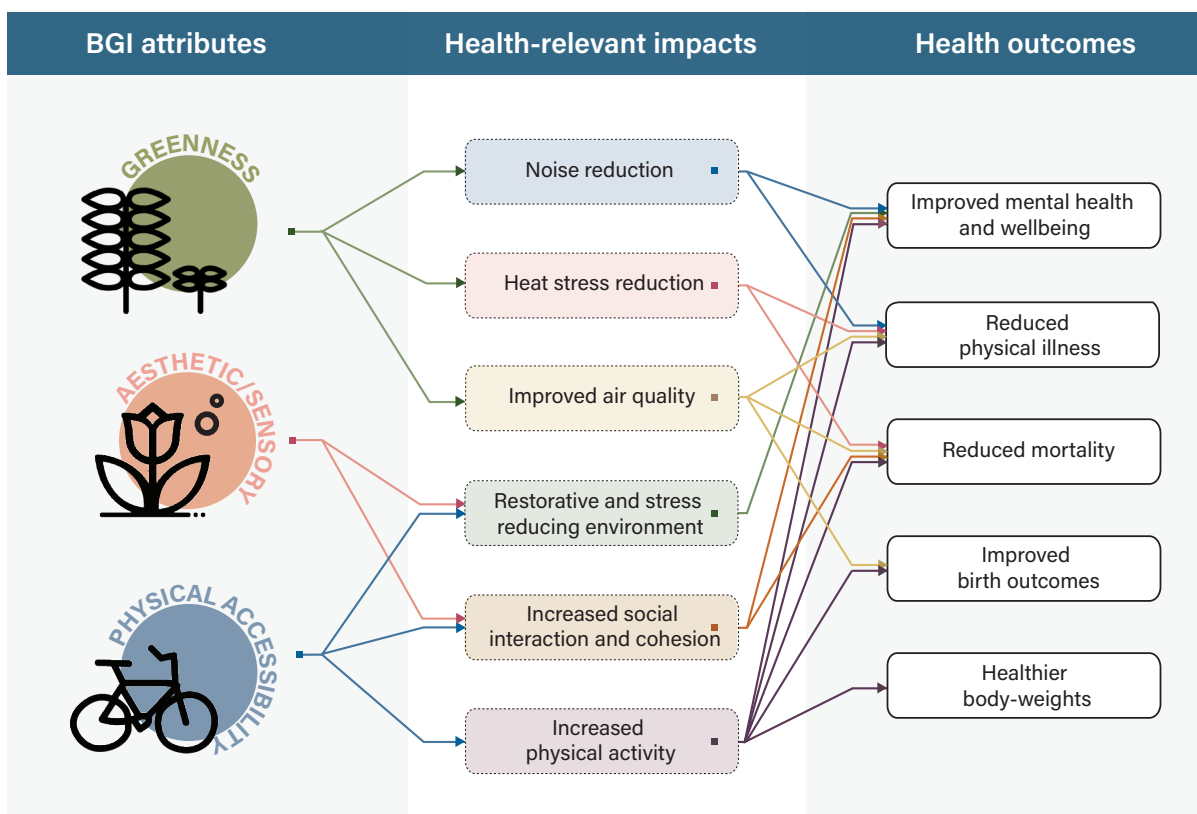


Figure 2: Schematic pathways showing different forms of BGI exposure, with potential for health-relevant impacts and health outcomes. Kenyon, A. & Choe, E. Y.

3. Noise reduction

3.1 Traffic noise is associated with health problems including cardiovascular disease, sleep disturbance, psychological stress-related illness, and poor cognitive performance. In the UK, the annual social costs of noise pollution are estimated at £7 to 10 billion.

3.2 Using wide, high, and dense roadside vegetation can significantly reduce road traffic noise.

3.3 Well-designed BGI can be used to generate natural sounds, which can mask noise or distract attention away from it.

3.4 Neighbourhood green space can reduce people's perception of noise, lessening its harms.

BGI design tips for noise reduction



9-11dB

- Design '5m depth of vegetation belt' next to a highway for effective traffic noise reduction.
- Use green walls to absorb sound of human voice (60dB) in public spaces.
- Add natural sounds (e.g. bird song, stream/fountain sound) to mask urban noises.

Figure 3: BGI design tips for noise reduction

4. Heat stress reduction

4.1 UK summers are expected to become longer and hotter. The 2003 heatwave led to 2,091 excess deaths, and experts estimate that by 2080 the mortality rate associated with a typical heatwave could be three times as high. The increased temperatures and higher air pollution associated with urban heat islands (UHI) can contribute to heat-related illness and mortality. A significant proportion of low income households already find their housing too warm in summer.

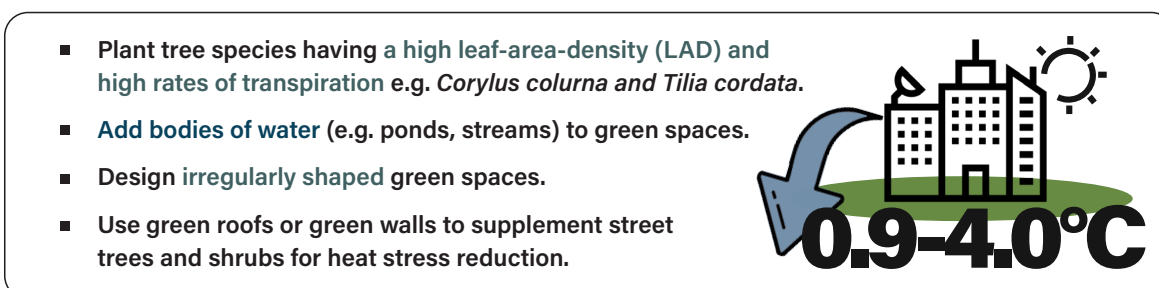
4.2 A green space with a body of water can lower the temperature in the surrounding area by between 0.9°C and 4.0°C.

4.3 Tree species with high leaf-area-density (LAD) and high rates of transpiration are effective at cooling air temperatures during summer days.

4.4 Green space with a large area or an irregular shape can have a greater cooling effect.

4.5 Green roofs and green walls regulate temperatures inside buildings by providing a layer of insulation that prevents heat absorption.

BGI design tips for heat stress reduction



- Plant tree species having a high leaf-area-density (LAD) and high rates of transpiration e.g. *Corylus colurna* and *Tilia cordata*.
- Add bodies of water (e.g. ponds, streams) to green spaces.
- Design irregularly shaped green spaces.
- Use green roofs or green walls to supplement street trees and shrubs for heat stress reduction.

0.9-4.0°C

Figure 4: BGI design tips for heat stress reduction

5. Improved air quality

5.1 Long-term exposure to air pollution reduces average life expectancy in the UK by around 6 months per person, an impact valued at £16 billion per year.

5.2 Using BGI in strategic locations can prevent the spread of pollution or dilute it before it reaches pedestrians or housing. Evergreen shrubs and tree species intercept more pollutants than deciduous species.

5.3 However, care needs to be taken because street trees and vegetation can also increase local concentrations of air pollution by preventing air movement and lowering wind speeds. Some tree types also release large amounts of allergenic pollen.

5.4 Green roofs and green walls can improve air quality, though they are generally less effective than trees and shrubs.

BGI design tips for improved air quality

- Plant evergreen shrubs, evergreen tree species with smaller leaves, hairs or more complex shoot structures to capture particulate matter.
- Guidelines for low allergy impact: Increase plant biodiversity, control invasive species and select species with low-to-moderate pollen production.
- Use urban trees for air pollution control supplemented by green roofs or green walls.

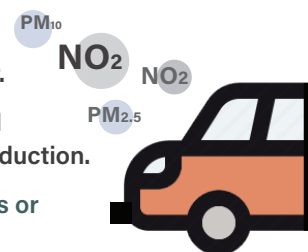


Figure 5: BGI design tips for improved air quality

6. Restorative and stress-reducing environments

6.1 In the UK, 70 million working days are lost each year due to mental ill health, making it the leading cause of long-term sickness leave. This costs an estimated £105 billion per year.

6.2 Many studies link access to green space and improved mental health. Exposure to natural environments can bring about positive emotional states, give people an escape from their daily routine, and mitigate mental stress and cognitive fatigue.

6.3 Evidence suggests that more biodiverse green spaces have a stronger restorative benefit. Varied environments and those with water features particularly boost mental health and wellbeing.

BGI design tips for restorative and stress reducing environments

- Increase biodiversity (e.g. colour, floral diversity, high vegetation cover, plant richness, bird richness, and habitat diversity) in urban green spaces.
- Offer a variety of spaces and vegetation types e.g. balance enclosed dense growth with more open views
- Add water features to create spaces for restoration and relaxation.



Figure 6: BGI design tips for restorative and stress reducing environment

7. Increased social interaction and cohesion


7.1 Over 9 million people in the UK, almost a fifth of the population, report that they always or often feel lonely. The health impacts of this can be severe: studies suggest that loneliness may be as harmful to health as smoking 15 cigarettes a day.

7.2 Local BGI can provide attractive places for social contact and interaction and can promote a sense of community. Designing community-oriented spaces, with seating and play areas, can increase this effect.

7.3 Community engagement and volunteering can help to maintain BGI and generate a sense of ownership by local people, as well as providing an opportunity for social contact.

7.4 Involving communities in the design and planning of BGI ensures that green space meets their needs and priorities, increasing the likelihood that they will use it long term.

BGI design tips for increased social interaction and cohesion



- Create community space, such as a resting point for people, a play area for children, alongside green planting.
- More community engagement for co-development and maintenance of BGI.
- Provide a range of environmental volunteer opportunities to suit participants' age, interests and ability.




Figure 7: BGI design tips for increased social interaction and cohesion

8. Increased physical activity

8.1 Lack of physical activity is responsible for 3% of the disability-adjusted life years (DALY) lost annually in the UK, at a direct cost to the NHS of £1.06 billion per year.

8.2 Accessible and amenity-rich BGI can provide a pleasant environment for outdoor exercise: there is a connection between the greenness of a neighbourhood and the amount of physical activity its inhabitants take.

8.3 The findings of research into the relationship between availability of green space and increased physical activity are inconsistent. This may reflect differences in the quality of the natural environments assessed.

8.4 Levels of physical activity in green space are positively associated with provision of public facilities such as a walking and/or cycling route, seating areas, toilets, the presence of a water feature (i.e. pond, stream), lights along trails, a pleasant view, a bike rack, and a car park.

8.5 Being physically active in an outdoor setting may be more beneficial than exercising in an urban or indoor environment. BGI can be a focus for local programmes that involve physical activity e.g. gardening and maintenance.

BGI design tips for increased physical activity

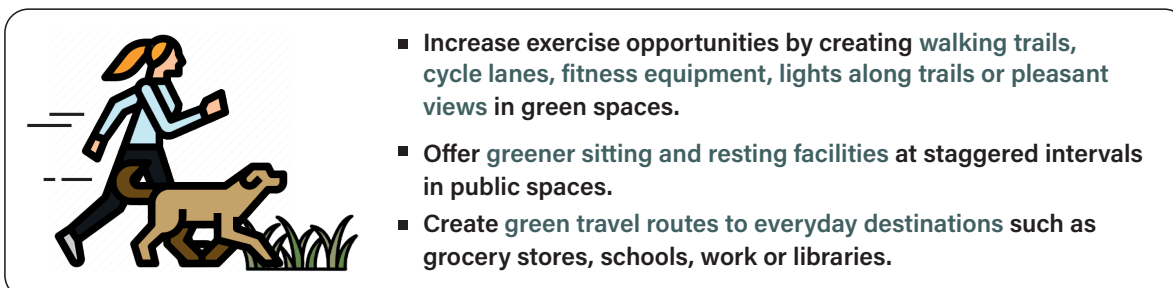


Figure 8: BGI design tips for increased physical activity

9. Health inequalities and health supporting blue and green environments

9.1 People living in more deprived areas tend to be more exposed to noise, heat, and air pollution, and tend to suffer greater negative impacts from this exposure. They also tend to have lower levels of green space in their local area.

9.2 It is important to design green spaces that take the needs of the local community into account, because satisfaction with the quality of green space may be of a critical factor in its use, particularly in poorer areas.

9.3 Improving blue and green spaces can improve quality of life and confer physical and mental health benefits on people in deprived neighbourhoods, mitigating inequality.

9.4 It is important to ensure equitable access to health-promoting BGI across different groups of people. Factors like ethnicity, gender, age, disability, and socioeconomic status need to be considered.

10. Health outcomes

10.1 Access to blue and green space is associated with improved mental health and wellbeing, such as reduced stress, anxiety and depression, enhanced self-esteem and life satisfaction, and increased attention and memory.

10.2 It is also linked to reduced physical illness, such as lowered risks of cardiovascular morbidity, coronary heart disease and stroke, and type 2 diabetes.

10.3 The more green space a neighbourhood has, the lower all-cause mortality is for residents.

10.4 Babies born to mothers living in places with more green space have higher birthweights (an indicator of good health) and are less likely to be born early.

10.5 Greener areas may encourage more physical activity, though a direct association between green space and lower Body Mass Index (BMI) is not always observable.

10.6 People from socially disadvantaged backgrounds, those with disabilities, and those from minority ethnic backgrounds are more likely to experience place-based inequality, mental illness, and poor physical health. BGI has the potential to be 'equigenic', which means that it can disrupt the usual conversion of social inequality to health inequality.

11. Implications for BGI design

This section presents detailed design guidance for different types of small-scale, large-scale, and linear BGI. In each case, we show how different design elements can be used to mitigate each of the health impacts outlined in the report, thus improving health outcomes.

12. Conclusion

To develop a form of BGI that reduces inequality, promotes health and wellbeing, and delivers environmental and water-management benefits, it will be necessary for professionals in the fields of water, public health, and the built environment to work together closely.

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