Urban Water Journal

ISSN: 1573-062X (Print) 1744-9006 (Online) Journal homepage: http://www.tandfonline.com/loi/nurw20

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URBAN WATER JOURNAL, 2017
http://dx.doi.org/10.1080/1573062X.2017.1279190

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RESEARCH ARTICLE

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Recognising barriers to implementation of Blue-Green Infrastructure: a Newcastle case study

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ABSTRACT

There is a recognised need for a fundamental change in how the UK manages urban water and flood risk in response to increasingly frequent rainfall events coupled with planned urban expansion. Approaches centred on 'living with and making space for water' are increasingly adopted internationally. Nonetheless, widespread implementation of Blue-Green Infrastructure (BGI) is currently hampered by barriers that impede uptake and innovation. We investigate the barriers to implementation of BGI in Newcastle, UK, through a series of semi-structured interviews with professional stakeholders. We identify and categorise 17 types of barrier and identify targeted strategies to overcome the dominant barriers. We recommend promotion of BGI's capacity to meet the objectives of multiple organisations and Local Authority departments, in addition to managing urban water. We conclude that strong business cases, supported by monetised evidence of benefits, and collaborative, inter-agency working could advance implementation of BGI within the current flood risk management legislation.

ARTICLE HISTORY
Received 20 May 2016
Accepted 18 December 2016

KEYWORDS
Flood management; integrated urban water management; SUDS; sustainable urban water management; urban water management; water sensitive urban design

Introduction

Flooding can have devastating impacts on social, economic and environmental systems. It is estimated that 2.4 million properties in England are at risk of fluvial or coastal flooding and 3 million are susceptible to surface water flooding (Environment Agency 2015). The urban environment is particularly vulnerable due to high levels of impermeable surfaces and frequent overloading of drainage networks which is likely to increase with urban expansion. The urban flood damage potential is further increased by the changing climate and greater expected frequency and magnitude of intense precipitation events (Slingo *et al*. 2014). In March 2015 the House of Commons Commission of Inquiry into flood resilience stressed the need for fundamental changes to UK flood management to deal with increasingly frequent and severe floods, coupled with more intense and prolonged droughts. They suggested 'living with and making space for water' in order to get 'more for less' by maximising the multiple benefits provided by all forms of water (House of Commons 2015).

Non-traditional water management approaches such as SuDS (Sustainable Drainage Systems) help meet the challenges of climate change and urban growth. Such approaches are gaining increasing acceptance as mechanisms to better integrate the water cycle with urban design and development needs (Wong and Brown 2009; Ashley *et al*. 2013). A Blue-Green City aims to recreate a naturally-oriented water cycle while contributing to the amenity of the city by bringing water management and green infrastructure together (Hoyer *et al*. 2011). This is achieved by combining and protecting the hydrological and ecological values of the urban landscape while providing resilient and adaptive measures to deal with flooding by mimicking pre-development hydrology, increasing infiltration, surface storage and attenuation (Novotny *et al*. 2010). The Blue-Green approach reduces stress on subsurface piped 'grey' infrastructure by managing water above ground and generates multiple benefits from multifunctional use of Blue-Green spaces and corridors under flood and non-flood conditions (Lawson *et al*. 2014). Despite these known and proven advantages, widespread implementation of Blue-Green Infrastructure (BGI) is hampered by uncertainties regarding hydrological performance and service delivery, and lack of confidence that decision makers and communities will accept, support, and take ownership of such infrastructure (Thorne *et al*. 2015).

A wide range of barriers to sustainable water management, including scientific, technological/technical, institutional, legal, managerial, political, monetary and social, have been classified in the literature. The social-institutional barriers typically pose the greatest hindrance to implementation of sustainable water management schemes and exert a greater influence on the chosen solution when compared with purely hydrological considerations (Niemczynowicz 1999; Brown and Farrelly 2009; Bastien 2013; Ashley *et al*. 2015; Carlet 2015; Thorne *et al*. 2015). Resistance to change represents a particularly relevant socio-institutional barrier for BGI, which can still be regarded as a 'novel' approach despite many successful UK schemes, e.g. Derbyshire

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The supplemental material for this paper is available online at http://dx.doi.org/10.1080/1573062X.2017.1279190

Street Pocket Park in the London Borough of Tower Hamlets and Queen Mary's Walk, Llanelli (Susdrain 2015). There may be a reluctance to invest in the complex process of implementing change, or a (perceived) lack of objective evidence to support the new technology or approaches (Lee 1999). The lack of effective UK legislation, such as UK SuDS Approval Bodies (SABs), as intended in the 2010 Flood and Water Management Act (FWMA 2010), and little regulatory control on SuDS design, construction, operation and maintenance, are also cited as significant barriers that hamper progress (White and Howe 2005; Ashley *et al*. 2015). From a planning perspective, the lack of resources and perceived lack of policy support may create a reluctance for planners to support SuDS (White and Howe 2005).

Many of the barriers are difficult to overcome because they are systemic and embedded within organisational cultures, practices and processes. There is also a paucity of targeted strategies for overcoming socio-institutional barriers (Brown and Farrelly 2009). General strategies such as improving education and raising awareness, while essential to the understanding of BGI among publics, lack specificity and may require greater refinement to overcome the myriad barriers in practice. Recognising this, the objectives of our paper are threefold; 1) identify the barriers to widespread implementation of BGI, 2) investigate strategies to overcome the barriers, and 3) draw recommendations for practitioners. We use the outcomes of semi-structured interviews with a multidisciplinary group of 19 well-informed stakeholders from institutions and industry in Newcastle to identify the biophysical and socio-political barriers. We develop specific strategies to overcome these barriers, highlighting those that have been demonstrated to succeed, and reflect on the wider implications of the case study findings for practice and research.

Case study description

Newcastle is located on the north-western bank of the River Tyne, Tyne and Wear. Newcastle City Council is the Lead Local Flood Authority with responsibilities relating to managing flood risk across the city, in addition to being a statutory consultee for surface water management issues in planning applications. They work in partnership with organisations such as Northumbrian Water and the Environment Agency to manage flood risk from all sources (river and surface water) and encourage residents to contribute to reducing their own flood risk (Newcastle City Council 2016). The joint Newcastle-Gateshead Surface Water Management Plan (SWMP) aims to remove and reduce the amount of surface water entering the combined sewer system that serves the Howdon Sewerage Treatment Works to free up headroom for foul water from new development. SuDS are recognised as a viable approach and '*need to be implemented by developers*' (Gateshead and Newcastle Councils 2012). Recent strategic planning frameworks, such as the Core Strategy and Urban Core Plan for Gateshead and Newcastle upon Tyne 2010–2030, reiterate this point, stating that new developments are expected to prioritise SuDS for surface water management '*given the multifunctional benefits to water quality, green space and habitat enhancement*' (Newcastle City Council and Gateshead Council 2015).

In 2012, Newcastle experienced a severe rainfall event where 50 mm (the expected total for June) fell within a two hour period, causing widespread flash flooding, predominantly due to surface water runoff (Environment Agency - Yorkshire & North East Region Hydrology 2012). This event was estimated as having a 1:131 year return period and affected more than 1200 properties, causing internal flooding to over 500 (Newcastle City Council 2013). Met Office projections suggest that such rainfall events in Newcastle will become more frequent in future winters, with high uncertainty surrounding future changes in summer rainfall (Slingo *et al*. 2014). Since the 2012 events, Newcastle City Council has undertaken work to improve the city's resilience and allocated £3 m for capital works in 2013/14 and 2014/15 (Newcastle City Council 2013). As such, Newcastle represents a city that acknowledges the challenges of realising sustainable urban water management while allowing for economic improvement and new development. Many stakeholders (as discussed subsequently) aspire towards greater implementation of BGI and a change in attitudes and behaviours. There have been some notable successes (e.g. SuDS ponds in Newcastle Great Park, Melbury, and Warkworth Woods), however, greater progress is hampered by challenges and barriers.

Methods

Interviews

Nineteen professionals from a range of organisations in Newcastle were selected for interview, comprising the following professional remits: land/facilities owner/manager (5), investments and development (4), flood risk and water management (2), project management (2), planning (2), communities and households (1), policy and communications (1), environmental consultancy (1), and urban traffic management (1). The study had a small geographical reach as most respondents worked within the Newcastle administrative area (the exception being Northumbrian Water which covers the wider NE region). Respondents were selected based on their knowledge and involvement in water and flood management, urban planning, environmental and land management, and/or other urban infrastructure systems that are interdependent on the water system, such as transport, communications and development. The diverse professional remits of the respondents provided a wide range of perspectives on BGI, however, they can be seen as operating within a set of common local and national constraints. Most have also demonstrated an interest in developing a Blue-Green vision for Newcastle via the Newcastle Learning and Action Alliance (Lawson 2015). Interviews lasting 24–67 min were conducted between 19th March–13th May 2015, either face to face (N = 5) or by telephone (N = 14). The interviews were semi-structured, allowing respondents to talk around a set of open-ended questions designed to elicit understanding of their perspectives on urban flood and water management, and BGI.

Interview analysis

Interviews were recorded and fully transcribed. The analysis was initially inductive, with the meanings of each respondent's statements and paragraphs synthesised into different 'nodes' using

Figure 1. Barriers to the implementation of Blue-Green infrastructure in Newcastle. Red = socio-political barriers, black = biophysical barriers, blue = barriers that are both socio-political and biophysical.

qualitative research software (NVIVO 10). We used a Grounded Theory approach (Glaser and Strauss 1967) that allowed important issues to emerge directly from the data, reducing the impact of preconceptions. Sixteen nodes emerged through coding, summarising the raw data. We focused our analysis on two nodes related to barriers: 'Barriers to BGI' and 'Overcoming barriers'. The other nodes related to topics that are not discussed in this paper. The 'barrier nodes' were then separated into sub-nodes to further investigate and categorise challenges around implementation of BGI and how such issues could be overcome.

Evaluation of the sub-nodes drew out greater nuance and captured additional issues, concerns and suggestions. To supplement this qualitative analysis, quantitative analysis was conducted of excerpt-counts to determine the total number of references for each node. This quantitative coding measured the frequency of mention rather than the respondents' position or interest in the sub-node. To maintain confidentiality, respondents are identified numerically throughout this paper.

Results

Barriers

Statements were regarded as pertaining to barriers if the respondents used words such as 'challenge', 'barrier', 'restriction', 'issue', 'concern', 'trepidation', 'lack of', 'risk' and 'problem'. Respondents found it easy to identify a string of challenges that they and others might face in seeking to support and implement BGI. 184 references capturing the barriers were identified, separated into 17 categories, and defined as *socio-political*, *biophysical* or *both* (Figure 1). The five most prevalent barriers are socio-political. 89% of respondents (accounting for 30 references) stated that they perceive there to be a reluctance to support novel/new approaches to flood and water management and change practices, typically from traditional hard-engineering grey solutions towards more sustainable Blue-Green strategies;

> 'I definitely think that there's still a traditional approach in place, and that people aren't thinking about going towards more blue-green technologies' (Respondent #16).

> 'We're very early on in the process, in general. These, almost changes of mentality, again going back to that leap of faith, take a while to happen' (Respondent #3).

More than half of the respondents commented that a lack of knowledge, education and awareness of BGI is a key barrier to gaining support from local authorities and the public;

> 'Lack of knowledge, it's certainly a concern that's been raised by local authorities, particularly around the adoption of SuDS' (Respondent #13).

> 'For the blue-green infrastructure, I don't think there's an awareness of it at all' (Respondent #8).

Securing funding (including funding for ongoing maintenance) was also mentioned as a significant barrier by more than half of the respondents;

> 'You can come up with all the ideas and wonderful ways of doing things, but at the end of it all we've got to find the money to be able to do that. We've got to find a way of making that income stream sustainable as well. You get lots of things that run for three years and the money runs out and everybody looks at each other and things start to fall into disrepair' (Respondent #11).

These three barriers were mentioned the most frequently and by the majority of the respondents, and are classified as 'major' barriers (Appendix Figure 1). 'Minor barriers' refer to those that are mentioned infrequently and by few respondents, and centred on negative past experiences, competing priorities and future land use and climate. Three biophysical barriers were identified (physical science/engineering uncertainties, lack of available space, and future land use and climate): they received fewer total references and were mentioned by fewer respondents when compared with the socio-political barriers. Two barriers (maintenance and adoption, and identifying and quantifying (monetising) the multiple benefits) that include both biophysical and socio-political factors ranked 6th and 7th.

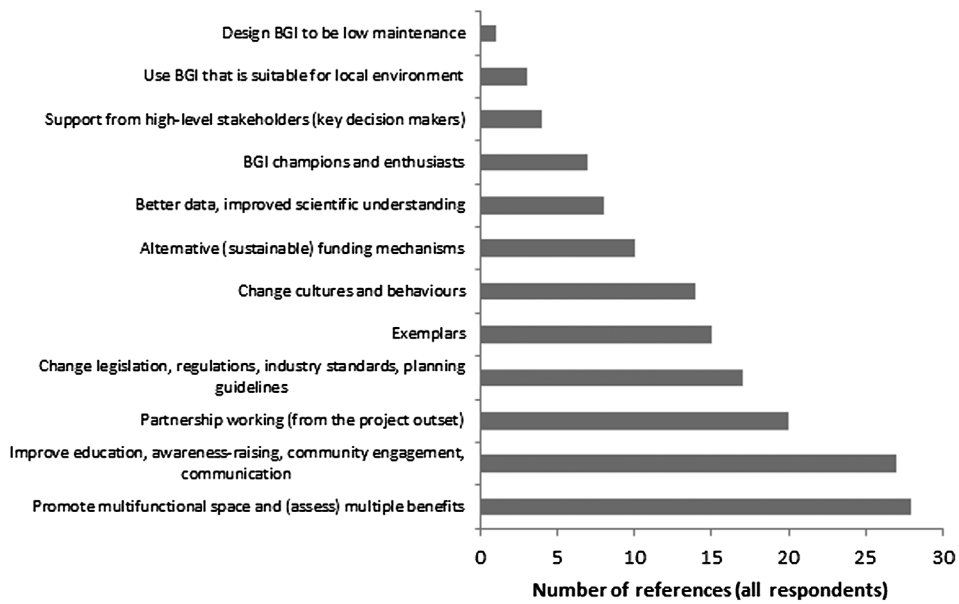

Figure 2. Strategies to overcome barriers to the implementation of Blue-Green infrastructure in Newcastle.

Overcoming barriers

During the interviews, all respondents were asked to outline their ideas on how specific challenges to the implementation of BGI could potentially be overcome. Statements reflecting strategies to overcome the barriers often identified 'a need' and the desire for change ('it just needs', 'I think they need', 'needs to change'). Other statements in this category included words such as 'suggest', 'think about', 'make sure', 'ensuring that', 'we/they could/should', and statements discussing the positive impact of following a new course of action. Respondents found it easy to identify general strategies to overcome the barriers to BGI, e.g. raising awareness and improving education. Others responded in greater depth and highlighted specific courses of action. The strategies to overcome the barriers to BGI were sub-divided into 12 distinct categories (Figure 2). The most prevalent is the promotion of multifunctional space and identification and assessment of the multiple benefits (28 references). This was mentioned by 63% of the respondents and represents a major strategy to overcome the barriers (Appendix Figure 2). Respondents commented that;

> 'Then if it is similar in cost, but you can highlight all these other benefits that link with our sustainability strategy, our air quality improvements, then straight away they would be happy to sign it off as a project' (Respondent #8).

> 'They [SuDS] could potentially be designed to just be functional during a time of floods, so they can perform those sort of dual functions… you need to think about the multifunctional use of space' (Respondent #13).

Further categorisation of the strategies to overcome barriers reveals subsets that either relate specifically to BGI projects or are applicable to general water and environmental management infrastructure projects (Appendix Figure 3). Interestingly, 70% of the strategies within the 'promoting multifunctional space and multiple benefits' sub-node specifically relate to BGI projects. In contrast, ideas relating to improving education, awareness raising, community engagement and communication, another prominent strategy, are more generic, applying to all infrastructure projects that modify the local environment. This suggests that general improvements in education and outreach can tackle specific BGI barriers relating to lack of knowledge and understanding. This strategy places emphasis on decision makers and communities to take action;

> 'I think educating decision makers specifically because it's quite a new concept and none of the policy documentation that is their guide to decision making really pushes that' (Respondent #15).

> 'If the community get together and run the initiative themselves it's got far more power than the council going down wagging our finger at people saying you should have water butts down here' (Respondent #14).

Partnership working (from the project outset) and changing legislation, regulations, industry standards and planning guidelines were the third and fourth highest ranking strategies, respectively, and were both mentioned by just under half of the respondents;

> 'I think the politics has to catch up; the legislation has to catch up. I think it's all right turning round and saying that people should work together. There are some barriers that other people may have in working together, and the legislation should be there to allow us to work together' (Respondent #1).

Partnership working, and the inclusion of partners not typically involved in flood risk management discussions such as Newcastle City Golf Course (the primary land manager) and a golf course designer, were suggested as factors that facilitated the recent river realignment and SuDS scheme at Brunton Park (NWL 2015). For instance, when asked about the involvement of a golf course designer to redesign sections of the course to incorporate the scheme, one respondent commented that;

> 'I think that was the park ranger and project manager; that was his idea [getting a golf course designer to design the Brunton Park scheme]. I've said a number of times: I think that was a masterstroke' (Respondent #1).

Discussion

The barriers derived in this study provide new insight into the challenges and constraints surrounding the implementation of BGI in UK cities. There was a great deal of consistency in the responses; no cases were observed where only one respondent repeatedly mentioned a barrier as an expression of a strong personal opinion. 12 of the 17 barriers were classified as socio-political, supporting earlier literature and the predominance of social, institutional and economic barriers (Niemczynowicz 1999; Brown and Farrelly 2009; Bastien 2013; Carlet 2015; Thorne *et al*. 2015). The barriers generally concur with those in previous studies, however, two potentially new barriers were recognised. The first refers to how negative past experiences with sustainable water management, or with project partners, could exert a strong negative influence on future support for BGI. This barrier is highly personal and was only mentioned by two respondents in relation to specific projects. This barrier may not have been identified in earlier research for several reasons, e.g. the lack of questions and prompts on past BGI schemes owing to the relative infancy of implementation in the case study area. The second barrier that has not been mentioned extensively in the literature until recently (e.g. Ashley *et al*. 2015; Simmons 2015) refers to challenges with identifying and quantifying (and monetising) the multiple benefits of BGI, particularly with respect to the benefits that accrue during the non-flood state (e.g. carbon sequestration, habitat and amenity improvements). This may be due to earlier studies investigating the barriers to sustainable drainage schemes with a specific focus on management of water quality and quantity, or due to the professional remit of interview respondents, e.g. Cettner *et al*. (2013) only interviewed water professionals whereas in this study, a group of multidisciplinary stakeholders was selected.

The lack of biophysical barriers identified in this interview dataset, compared to earlier research (e.g. Lee 1999; Niemczynowicz 1999; Thorne *et al*. 2015), is also noteworthy. This might be related to the highly knowledgeable and experienced profile of the respondents. Ten respondents currently work in flood and water management or have a background in water engineering and five of the nine remaining respondents are part of the Newcastle Learning and Action Alliance and knowledgeable of BGI. Respondents may be comfortable with the level of certainty that current hydrological and engineering science provides based on trusted design guidance, their own engineering expertise and personal experience of successful schemes, as observed in other interviews with water management professionals (Cettner *et al.* 2013; Simmons 2015).

Respondents repeatedly cited reluctance to support new approaches and change practices as a barrier to BGI. This suggests that institutional inertia and a preference for conventional approaches are the largest hurdles. Despite an abundance of international research and case studies, BGI and SuDS are still regarded as a 'novelty' and absent from standard practice. While the interview respondents themselves may not regard BGI as novel, many feel that communities and decision makers perceive that BGI has not been proven in practice. This links with the second most prominent barrier: the lack of knowledge, education and awareness of BGI. This barrier can be interpreted in two ways. First, many respondents felt that communities and professionals working outside of the flood and water management profession are not aware of how BGI can reduce flood risk and manage surface water. In reality, BGI may not necessarily be appreciated for its primary functionality and the other benefits may be valued more highly. For instance, aesthetic improvements and increased greening of urban areas were key advantages of bioswales in Portland, but knowledge of the bioswale hydrological functioning was less widely understood (Everett *et al*. 2015). Second, water management professionals may feel that they lack knowledge and information around future plans for adoption and maintenance of SuDS and BGI. The principal issue is not the physical maintenance regimes required to maintain optimum functionality, but the designation of responsibilities and funding. This links with the barrier 'legislation, regulation and governance'. The 2010 Flood and Water Management Act (FWMA 2010) intended local authority SuDS Approval Bodies (SABs) to address issues of ownership and maintenance. As SABs were not implemented these issues remain unresolved and present specific barriers to SuDS and BGI in new developments.

Funding was also ranked highly by many respondents yet the fact that this was not the highest ranking barrier is revealing. The respondents generally recognised that the capital costs of BGI schemes are less than the equivalent grey infrastructure but the sustainability of BGI requires longer term funding commitments. Funding appears to be less of a barrier regarding implementation of BGI (the primary focus of the interview questions) but a larger issue for longer term operation to realise the benefits.

Overcoming barriers to BGI

The challenges and barriers faced by practitioners and decision makers regarding the delivery of sustainable urban water management are relatively well understood, yet there is a lack of targeted strategies to overcome the barriers beyond generic suggestions such as education and outreach (Lee 1999). The interview respondents in this study suggested a range of general and targeted strategies with a high level of consistency in responses. Some of the strategies align with ideas reported in earlier literature (e.g. Brown and Farrelly 2009; Carlet 2015; Thorne *et al*. 2015). For instance, our finding that 63% of the respondents identified a need to improve education, community engagement and raise awareness of BGI supports these previous studies and suggests that this approach remains a vital component for future implementation of BGI. Our respondents identified that education and engagement was needed across all stakeholders from high level decision makers to communities where the installations would be housed. Specific strategies were suggested for different stakeholders, e.g. awareness raising for political leaders and co-design or community led schemes for publics as well as informative signage and local champions to ensure long term sustainability. Despite this, one respondent stated that the impact of education and engagement may be limited if behaviour does not change concurrently so that the approach becomes 'normalised';

> 'Is there enough education about recycling? Well, there's plenty out there but do people recycle, and the answer is not everybody does' (Respondent #14).

Other strategies offer a different perspective to earlier literature. For instance, most respondents repeatedly cited the importance of promoting multifunctional space and assessing the multiple benefits of BGI. This suggests that respondents acknowledge that BGI has greater value beyond flood and water management and believe that highlighting the multiple benefits will increase the scope of stakeholders involved in BGI schemes. Respondents also generally perceive that decision makers will be more likely to support a BGI scheme that will provide benefits to meet the objectives of their organisation/department. Identification of the beneficiaries was suggested as a mechanism to highlight organisations and departments that could work together to deliver (and potentially co-fund) multifunctional BGI. Typically, organisations are not statutorily required to provide the multiple benefits and so find it a challenge to include these in their own business case. Changing how we plan and deliver BGI towards greater collaborative working and co-funding from organisations and departments with a range of different remits that can be met by BGI may be the optimal approach to create multifunctional, multi-beneficial and resilient infrastructure.

Partnership working is fundamental to the change in mindset that we propose towards valuing BGI as multifunctional infrastructure, and was frequently mentioned by the interview respondents. This includes engaging partners at the start of the process so all have 'ownership' over the project and the opportunity to contribute. For instance, representatives from Newcastle City Golf Course may have felt that their concerns were not being heard during the early stages of development of the Brunton Park river realignment scheme. However, interview respondents stated that the inclusion of a golf course designer helped manage the visual impact of the scheme and illustrated the potential benefits that could accrue to the golf course. Several respondents also cited recent successful partnership working between Newcastle City Council, Northumbrian Water and the Environment Agency, suggesting that city stakeholders are already taking positive steps to overcome some of the barriers to BGI. Some respondents also advocated the inclusion of a wider range of partners not typically involved in flood risk management discussions in BGI debates. This includes other potential beneficiaries of multifunctional BGI, e.g. the NHS, urban developers and landowners.

Recommendations: a wider perspective

Several recommendations for practitioners involved in implementing BGI are now presented that draw on the original findings from the Newcastle interviews and knowledge synthesised from the wider literature. We first recommend that the multifunctionality of BGI should be acknowledged at an institutional level. BGI should be promoted outside the flood risk and water management discipline as a concept that delivers benefits to multiple stakeholders and meets multiple policy and strategic objectives, such as Local Authority departmental targets for urban regeneration, climate change adaptation, water quality, recreation and public amenity, health and wellbeing, open space improvements and biodiversity. The flood risk management literature does not typically focus on how BGI/SuDS could be badged other than flood risk management schemes but for actual implementation the multifunctionality must be identified, supported with scientific evidence, and championed by stakeholders who will benefit. To engender greater public support for BGI, we recommend first identifying the types of benefits that could accrue to the different beneficiaries and using this as a foundation for public engagement and consultations. The values placed on costs and benefits depend on the social context and environmental setting, hence engaging with communities can help develop shared understandings of the multiple benefits of BGI and a negotiated set of values. This may lead to beneficiary communities that are more inclined to support implementation, and take ownership, of BGI. In practice, this is challenging as these benefits are seldom valued monetarily and are difficult to include in cost-benefit analyses and business cases. We concur with Ashley *et al*. (2015) in their suggestion that without strict regulation and legislation, a business case is invaluable in order for the wider value of SuDS and BGI to be taken into account. Multiple benefit assessment is gaining increased traction within academia and industry with the development of new tools including the CIRIA Benefits of SuDS Tool (BeST), which enables cost-benefit analysis through a structured assessment to help quantify and monetise each benefit (CIRIA 2015). The Blue-Green Cities Multiple Benefit GIS Toolbox can create benefit maps and profiles to provide context-specific evaluations of the spatial extent and intensity of benefits, thus giving insight into the beneficiaries (Hoang *et al*. 2016, Morgan and Fenner *in review*). We recommend using tools such as these when designing BGI projects and discussing with institutional and industry beneficiaries how they might benefit from the scheme and potentially be included in co-funding working partnerships. Monitoring and evaluation of assets after construction has finished, to demonstrate the continued accrual of benefits, is also advised. There is also the opportunity to 'work smarter' by including BGI during the construction phase of other infrastructure projects. This would promote multifunctionality and reduce any potential disruption caused by adding BGI to the site at a later date.

We recommend continuing to invest in improving education, raising awareness of BGI and engaging with communities to help break down socio-institutional barriers related to lack of knowledge and understanding. This should move beyond passive engagement (e.g. notices explaining the functions of BGI assets) as active engagement holds greater potential for behavioural and cultural change compared with solely relying on public observation of BGI (Johannessen and Hahn 2013; Shandas 2015). Holding training events and technology demonstrations at exemplar BGI assets could also help build trust and confidence in performance and technical feasibility (Brown and Farrelly 2008; Carlet 2015). Using local terminology when discussing BGI may also help establish awareness and credibility of the new schemes (Fletcher *et al*. 2015).

Finally, we recommend that departments and organisations invest resources in improving collaborative working and promoting partnerships to deliver BGI. For successful partnership working, there is a need for leadership from individuals within organisations who are able to span boundaries, and build trust and relationships (Margerum and Robinson 2015). Developing shared practices that foster collaboration would help address the risk of interagency fragmentation and ineffective communication. In addition to flood and water management professionals, such partnerships should include a wider range of city actors, such as developers, social housing corporations and other landowners who are responsible for large parts of the estates in the city, in order to support a transition towards sustainable water management. Partnership working can also facilitate social learning, which in turn can help manage the risk perceptions that different stakeholders hold regarding future implementation of sustainable urban water infrastructure (Dobbie and Brown 2014).

Conclusion

Barriers to BGI and sustainable water management span the biophysical and socio-political spheres. Specific strategies are required to overcome these challenges, to generate acceptance and support, and to promote delivery of BGI, in order to facilitate a change in how the UK manages urban water and flood risk towards an approach centred on 'living with and making space for water'. Professional stakeholders in Newcastle generally perceive the socio-political barriers to exert a more significant negative influence on the widespread implementation of BGI than the biophysical barriers. Most prevalent among the socio-political barriers was the reluctance to support perceived novel approaches and change practices, and the lack of knowledge, education and awareness (of publics and decision makers). In the context of the interviews, many of these barriers were specific to BGI. This suggests that while general strategies such as improving education and raising awareness are essential to improving the understanding of BGI, the lack in specificity suggests they are of limited use to water management professionals in practice. Barriers are inter-dependent and so strategies to overcome them should not be mutually exclusive. Decision makers, practitioners, professionals and communities all have a role. We identify several specific strategies to overcome the barriers, notably the promotion of multifunctional space, assessment and quantification (and monetisation) of the multiple benefits of BGI, and more effective (and more wide-reaching) partnership working to deliver such projects. The potential impact of BGI on city infrastructure is currently unknown and hence valuing the impacts is germane to policy discussions that attempt to link BGI with quantifiable measures that are needed for decision-making processes. We recommend that BGI is promoted as a concept that can meet numerous policy and strategic objectives of different organisations and departments in addition to providing a flood and water management function. The benefits, and beneficiaries, of BGI extend beyond flood risk management and hence, can contribute to other city initiatives such as climate change adaptation, urban regeneration and health and wellbeing. Strong business cases supported by evidence of the benefits, combined with collaborative, inter-agency working and sustainable co-funding mechanisms could help advance the implementation of BGI. Long term strategic thinking is also needed; it is not enough to just build a scheme as active engagement with residents and decision makers is needed in order to change behaviours and increase acceptance. We also suggest that a concerted effort should be made to reduce some of the biophysical uncertainties and barriers through better data and improved scientific understanding in order to construct infrastructure that is scientifically sound, and accepted and supported by city stakeholders.

Acknowledgements

This research was performed as part of an interdisciplinary project undertaken by the Blue-Green Cities (B-GC) Research Consortium (www.bluegreencities.ac.uk). This work was supported by the UK Engineering and Physical Sciences Research Council [grant number EP/K013661/1], with additional contributions from the Environment Agency and Rivers Agency (Northern Ireland). We thank all interview respondents for their time and participation in this research. We would also like to thank Leonard Smith for his ideas on presenting the frequency and intensity of mention of the barriers and strategies to overcome the barriers as illustrated in Appendix Figures 1 and 2. Finally, we thank the three reviewers for helping improve the manuscript. For ethical reasons, the transcripts and audio files cannot be made openly available. Parties interested in this data should in the first instance contact the corresponding author. The associated metadata is available at http://dx.doi.org/10.17639/nott.39.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This work was supported by Engineering and Physical Sciences Research Council [grant no EP/K013661/1].

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