



Greener streets and behaviours, and green-eyed neighbours: a controlled study evaluating the impact of a sustainable urban drainage scheme in Wales on sustainability

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Abstract

This study assessed the impact of introducing a Sustainable Urban Drainage (SuDs) scheme to a socioeconomically deprived area, on residents buy-in and sustainable behaviours. Surveys were completed before the scheme was implemented by 180 residents (in affected $n = 79$ and neighbouring streets $n = 101$) and 1 year after the schemes completion by 51 residents. Following scheme completion, sustainable behaviours significantly increased by 17% in the scheme area and by 9% in the neighbouring streets. Written feedback indicated increased buy-in from residents affected by the scheme, and from neighbouring areas. Written feedback before the scheme included: (i) Concerns about parking; (ii) Liking the scheme; (iii) Feeling consultation was lacking; and (iv) Feeling the scheme was a waste of funds. Feedback after scheme completion included: (i) Feeling the SuDs improved the area; (ii) Remaining concerns about parking; (iii) Valuing the extra green space in the neighbouring area; and (iv) Wanting the SuDs in neighbouring streets. Introducing Green Infrastructure may improve resident's sustainable behaviours. Importantly, residents in neighbouring areas became envious of the SuDs once completed and showed increased sustainable behaviours indicating spill-over effects. The 2021 United Nations Climate Change Conference (COP26) recently took place, and England is considering statutory SuDs as seen in the scheme discussed here. Therefore, this research is particularly relevant to local authorities and stakeholders who can struggle to communicate the multi-benefits of sustainable urban design solutions.

Keywords Green infrastructure · Health · Nature connection · Sustainable behaviours · Sustainable urban drainage

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Introduction

Urban planning treatments, namely, Green Infrastructure (GI) can provide access to green and blue spaces whilst reducing the impact of climate-change and urbanization. In the current climate crisis and with COP26 recently taking place, it is essential that evidence is gathered to convince and guide Local Authorities, urban planners and the public on incorporating GI into urban areas, to provide urban residents with greater climate-change resilience and to model and encourage more sustainable behaviours. The need for GI to support and improve urban living is becoming a focus of urban planning solutions in the UK (Greater Manchester Green Infrastructure and the Health and Wellbeing Influences on an Ageing Population-GHIA 2016; Glasgow and Clyde Valley Green Network Partnership 2016; Greater London Authority 2017; Grey to Green, Sheffield 2013). In the UK Local Authority scheme researched here, SuDs were introduced with the goals of reduced carbon emissions, improved management of surface water, water treatment efficiency, cost and quality and mitigation of future demand on stormwater processing due to increased storm occurrence and intensity. The aim of the research accompanying this scheme was to assess any improvement to residents' sustainable behaviours, sense of community, nature connection and wellbeing.

Sustainable Urban Drainage can manage rainfall close to where it falls by mimicking the natural filtration processes of nature. It can transport surface water, slow-down runoff before it enters watercourses, provide storage for water in natural contours and allow water to soak into the ground or evaporate from surface water or vegetation (Sudrain 2019). In terms of performance, research found statistically significant differences in the detected flow level in manholes downstream of SuDS interventions (Cotterill and Bracken 2020). Sustainable Urban Drainage can provide the following benefits: climate change resilience, improved wildlife and biodiversity, improved health and wellbeing, neighbourhood amenities and aesthetic value (Fenner 2017; Woods Ballard et al 2015). Hence SuDs provide a wide range of benefits beyond efficient stormwater management. There are tools such as the Benefits of SuDS Tool (BeST) (CIRIA 2015) and case study papers (Perales-Momparler et al. 2017) which present case studies from the UK, Netherlands and Spain to illustrate implementation procedures and the environmental and cost benefits provided by SuDs. For example, Perales-Momparler et al. (2017) presented six showcase projects in Spain (featuring rain gardens, swales and a green roof) and found that SuDs reduced runoff (peak flows and volumes), improved water quality and provided rainwater harvesting and building insulation, contributing to the goal of healthier and

liveable cities. A review noted that although SuDs were useful for stormwater management, their implementation faced the following challenges: lack of proper knowledge for implementation; uncertainties about the benefits of SuDs/GI practices; and lack of cooperation and collaboration between different agencies for the expansion of SuDs projects (Shafique and Kim 2018). Unlike traditional drainage solutions which are largely hidden underground, SuDs are visible interventions that require support from Local Authorities and residents to be implemented and maintained (Everett et al. 2018). Understanding public perception of SuDs is, therefore, crucial in reducing barriers to their implementation and improving buy-in (O'Donnell et al. 2017). Hence, this study examined resident buy-in of the SuDs scheme and resident sustainable behaviours before and after scheme completion.

This study addresses two research gaps in the field of GI scheme implementation research. First most GI interventions tend to be assessed retrospectively without collecting data before the scheme begins and without any form of comparison group (for example, a control group comprising residents living nearby but not directly affected by that scheme). This makes it difficult to ascertain whether GI improvements have any impact upon residents' lives (Venkataramanan et al. 2019; Moore et al. 2018 for reviews). Reviews of the impacts of GI interventions on local residents (Moore et al. 2018; Venkataramanan et al. 2019) concluded that future research needs experimental study designs (e.g., measuring variables before and after scheme introductions and including a comparison group) and the involvement of social scientists, public health, planning and urban design experts to facilitate more thorough evaluations. The current case study addresses this gap by use of a survey before and after GI scheme completion, a comparison group of residents living on nearby streets out of sight of the improvements and bringing expertise from social sciences and public health (Centre for Trials Research, Cardiff University), Local Government (Cardiff Council) and urban designers (ARUP). Second, urban GI is said to allow people to maintain a regular connection with the natural world (Dunn et al. 2006). Previous research found that encouraging an individual's connection to a natural setting can facilitate the development of sustainable behaviours (Vaske and Kobrin 2010). No studies have specifically examined the potential for the implementation of urban GI to improve residents' sustainable behaviours. The current study aimed to address this gap, by assessing resident's sustainable behaviours before and after the introduction of an urban GI scheme.

The GI scheme was installed in an area of socio-economic deprivation. Hence, the current study also assessed whether the introduction of GI influenced wider socio-economic benefits through measurement of neighbourhood cohesion, health and wellbeing. Living close to urban GI can have

social benefits such as providing a common space for social recreation and interactions (Roy et al. 2012). In contrast, a lack of access to urban green space is associated with feelings of loneliness (Maas et al. 2009). GI also improves the desirability of an area, as reflected in increased market values of properties following green improvements (De Groot et al. 2012) and in residents willingness to pay 2% more in rent or mortgage payments to live in locations that have green space (Mell et al. 2016). Living close to GI can also benefit health and wellbeing. Reviews (Suppakittpaisarn et al. 2017) found that familiar GI, such as trees and green spaces, were associated with benefits to health (cardiovascular system, cortisol regulation, and pregnancy health), wellbeing (attention capacity and mental health), and behaviour (lower anti-social behaviour, crime, and greater prosocial behaviours) (Branas et al. 2011; Kondo et al. 2015).

Whilst there is research into residents perceptions of GI and SuDs after the implementation of schemes or concerning the hypothetical introduction of schemes, there is less research assessing residents perceptions both before and after implementation of schemes, the current project will address this gap. In terms of previous research into residents perceptions of GI, a review by Venkataramanan et al. (2020) found that knowledge and adoption rates were low, whilst willingness to implement or pay for GI was mixed. In a further review, Biddulph (2008) found mixed results with residents feeling that whilst over 50% of GI schemes had improved streets, neighbourhood cohesion, vandalism and antisocial behaviour had worsened. Likewise, Shandas (2015) found mixed results in terms of high levels of anticipation for GI, followed by negative perceptions of neighbourhood facilities and services immediately following construction. Some people prefer urban landscapes that indicate care, control, and tidiness (Nassauer 1995; Ford 2000) and wilder urban vegetation can be perceived as messy (Hands and Brown 2002; Nassauer 1995), unsafe (Chiesura 2004) or scary (Bixler and Floyd 1997). In contrast, Weber et al. (2014) found that residents supported wilder urban vegetation and attached a wide range of meanings and values to it, showing a surprisingly high awareness of associated ecosystem services. Likewise, Southon et al. (2017) found that residents preferred the planting of more species and structural diversity of tall or medium height vegetation. Derkzen et al. (2017) found residents tended to prefer diverse, familiar and visually attractive schemes, and education about functional aspects of schemes could increase residents support further.

In terms of SuDs schemes specifically, previous studies noted that residents often lacked awareness of the functional benefits of SuDs (i.e., efficient water processing and flood mitigation) (Everett et al. 2016, 2018; Gazzard and Booth 2020). For example, Gazzard and Booth (2020) found the public did not form a link between the visual appearance of SuDs and their beneficial functions of water management,

despite the architects intention for the scheme to be readily understood by the public. Indeed, successful SuDs implementation was found to be partly driven by residents perceived threat and exposure to previous flood damage (Pagliacci et al. 2020). In some cases residents living on sites with pre-existing SuDs, can appreciate their functional qualities (e.g., flood mitigation) (Williams et al. 2019). If the public lack awareness about the functions of SuDs or have not previously experienced flooding, they may be less likely to hold strong opinions of drainage features and may just view SuDs as additional amenity greenspace, appreciating them for their aesthetics (Jose et al. 2015; Gazzard and Booth 2020), increased wildlife (Bastien et al. 2012; Jarvie et al. 2017), amenity and creating more opportunities for recreation (Apostolaki and Jefferies 2005; Jose et al. 2015; Jarvie et al. 2017; Alves et al. 2018).

Similar to the literature on residents mixed perceptions of GI, not all residents hold positive views of SuDs. Bastien et al. (2012) found that residents were concerned over health and safety risks posed to children and pets, whilst the presence of litter (Bastien et al. 2012; Everett et al. 2018; Williams et al. 2019) and pests such as rats and mosquitoes (Gao et al. 2018; Williams et al. 2019) were also concerns. Resident perceptions of SuDs can also operate at different levels of self-awareness, for example O'Donnell et al. (2020) found that respondents implicitly and explicitly perceived greenspace without SuDs as more attractive, tidier and safer. However, these views were mixed and strongly negative explicit scores did not correlate with implicit scores, suggesting that attitudes towards tidiness and safety may be coloured by social bias and not be deep-rooted. More research is needed to fully understand how to gain buy-in from local communities. The current study, therefore, aimed to collect resident feedback before and after SuDs scheme completion.

Aims

The aim of the research was to assess the impact of introducing SuDs on sustainable behaviours, neighbourhood cohesion, health, wellbeing, and nature connection using surveys completed both before and 1 year after the completion of the scheme. Residents' buy-in was captured with brief written feedback. The research also aimed to gather further evidence for spill-over effects to neighbouring areas by surveying residents directly affected by the scheme and residents living in neighbouring areas.

Materials and methods

Design

The design was experimental, with surveys completed by residents affected by the scheme before construction (2016) and 1 year after scheme completion (2019), and compared with residents living in the neighbouring area (matched in demographics and deprivation score) who did not receive the scheme.

The site and scheme

The site Grangetown is an area of high deprivation within Cardiff, Wales, UK with residents living in the top four most deprived areas according to the overall score on the Welsh Index of Multiple Deprivation (which includes categories of income, employment, health, education, access to services, housing, community safety, physical environment) (WIMD 2019). Grangetown is also within the top two most deprived areas in terms of housing and the physical environment (WIMD 2019). The Council report the population to be highly transient, multicultural (with 48 languages spoken at a local school) and struggling with the pressures of low socio-economic status.

The 'Greener Grangetown' scheme was informed by policy (Wellbeing of Future Generations Act 2015, Wales; Sustainable Development Goals 2015 UN) which aims to use long-term strategies to prevent persistent problems, such as climate-change, poverty and health inequalities. Cardiff Council, Welsh Water and Natural Resources Wales (2010) initiated the scheme design and consultation with residents between June and October 2014, with construction between January 2017 and July 2018.

ARUP used a Sustainable Project Appraisal Routine (SPeAR) assessment to identify scope for improvement in aspects, such as climate-change resilience, availability of ecosystem services, outdoor experience, community pride and encouraging sustainable behaviours in the community. This revealed scope for improvement in the following aspects: (i) The streets had a poor quality streetscape environment, e.g., there were some mature trees but insufficient space for healthy growth; (ii) There were degraded and narrow pedestrian paths; (iii) There was a major Sustrans cycle route (the Taff trail) but the path narrowed and could not support pedestrians and/or cyclists; (iv) Commuters regularly parked in the area; (v) There were issues with antisocial behaviour, fly-tipping, prostitution and drug use around alleyways and dead-end streets; (vi) The lack of Sustainable Drainage systems (SuDs) meant that surface water entered the sewer and had to be pumped for treatment eight miles away, before being pumped out to sea.

The primary aim of the scheme was, therefore, to introduce SuDs (such as rain gardens, tree pits, permeable paving, combined kerb drainage and channel drainage) to provide improved management of surface water, water treatment efficiency, cost and quality through natural filtration processes and reduced carbon emissions caused by pumping water to treatment sites and out to sea. The secondary aim of the scheme was to improve residents' sustainable behaviours, sense of community and wellbeing by significantly improving the quality and quantity of GI (e.g., communal green space, rain gardens, green/blue corridors, community orchard/gardens, pedestrian and cycle paths). Once implemented, the scheme affected 12 streets and resulted in 1,700 square metres of new green space, 108 rain gardens, 130 new trees, and the first 'bicycle street' in Wales (Susdrain 2019) (Figs. 1, 2).

In addition positive early results were revealed on operations, electricity/carbon emissions, cost savings and future-proofing of the sewage network by removing more than 40,000m³ rainwater annually hence freeing up capacity to deal with the effects of climate change (Susdrain 2019).

Participants

Ethical approval and Clinical Trials support were obtained from the Centre for Trials Research, Cardiff University. Adult participants from 709 residential households (341 houses in the streets receiving the scheme, and 368 houses not receiving the scheme) were approached to participate in the study. Inclusion criteria were being a Grangetown resident affected by the Council scheme or being a resident in a comparison area of Grangetown not receiving the scheme and being over 18 years. The Cardiff University Community Gateway project assisted with the initial approach to residents via their newsletters and postage of the study information sheet and a flyer. Community Gateway had an existing trusted relationship with residents and their branding on the study flyer supported study recruitment. The research team followed-up on this initial approach by knocking on residents' doors to briefly explain the study and distribute consent forms, surveys, and postage-paid envelopes. A return visit was made 2 weeks later to collect completed surveys that had not been returned by post.

Based on the 30% ($n = 160$) response rate to the Council Consultation, a similar response rate to the research was expected. The streets affected by the scheme had a 28.74% response rate before construction and a 18.37% response rate 1 year after construction. The comparison area not receiving the scheme provided a better response rate of 36.41% before construction and 24.63% 1 year after construction. Response rates were better for residents who were home to speak with the researchers when home visits took place (42.20% response rate), than if they were not home and the

Fig. 1 Map provided by ARUP showing the scope of the GI scheme



researchers posted the surveys (14.15% response rate). The final study sample before construction, therefore, comprised 180 adults (101 comparison, 79 affected area), with 96 females, 80 males, 4 unreported, 145 were homeowners, 29 rented (6 unreported), 84% identified as White British (146) and 28 participants identifying as Black, Asian and Minority Ethnic-BAME (6 unreported), ages ranged from 18 to 88 years ($M = 47.80$, $SD = 15.86$ years) (4 not reported). There were no significant differences in residents' demographics for the affected and comparison areas before construction except the affected area had more participants renting property (Chi-square = 4.78 (df 1) $p = 0.029$ and showed a trend for older participants ($t = -1.98$ (df 174), $p = 0.050$). After construction there was a reduction in responses with 51 residents (33 comparison, 18 affected area) supplying data.

Measures

Self-report questionnaires comprised validated, published outcome measures of the following themes:

1. Sustainable behaviours, e.g., 'I ride a bicycle or take public transportation to work or school' (Goal-directed conservation behaviours scale, Kaiser and Wilson 2004), which is scored on a 0–4 Likert scale, with a 'not applicable' option;
2. Sense of community, e.g., 'Living in this neighbourhood gives me a sense of community' (Neighbourhood cohesion scale, Buckner 1988), which is scored on a -2–2 Likert scale;

Fig. 2 Photographs of Greener Grangetown before and 1 year after completion of the SuDS scheme

(a) Before



(b) After: Addition of SuDS and Tree Pits



(c) Before



(d) After: Addition of SuDS, tree pits, and rain gardens



3. General health, e.g., 'I have no problems in walking about' (EQ5D, Herdman et al 2011), which is scored on a 0–2 Likert scale;

4. Perceived stress, e.g., 'How often have you felt nervous and "stressed"?' (Perceived stress scale, Cohen et al. 1983), which is scored on a 0–4 Likert scale;

5. Nature connection, e.g., ‘I take notice of wildlife wherever I am.’ (Nature relatedness scale, Nisbet et al. 2008) which is scored on a 1-5 Likert scale.

Demographic measures featured at the start of the survey included age, gender, ethnicity, nationality, and home ownership. Surveys were distributed by the researchers through home visits before construction (Spring 2016) and 1 year after scheme completion (Spring 2019) to allow for fuller establishment of the planting. The residents completed paper copies of surveys in their own time and were invited to provide brief open-ended written feedback in their survey about what they thought of the scheme. It was made clear that the researchers were employees of Cardiff University and were independent of the Council responsible for the scheme. The researchers encouraged both positive and negative feedback and assured residents of their anonymity via their self-generated unique ID code which comprised the last three letters of their surname and the last three digits of their phone number. Completed surveys were either collected by researchers at a follow-up home visit, or were returned by residents in postage-paid envelopes.

Results

Survey data

Survey data were checked for normality and outliers and analysed using SPSS software (IBM Version 26). Where there were 1–2 missing responses per survey, these were replaced with the mode before being summed to produce total scores. An independent measures *t* test was conducted with before ($n = 79$ affected area; 101 comparison area) and after ($n = 18$ affected area; 33 comparison area) scheme survey scores as the grouping variable, and results were

calculated separately for area (affected or comparison area). Means and standard deviations of survey scores are shown in Table 1.

The *t* test revealed a significant effect, that sustainable behaviours increased between the initial survey and the survey 1 year on, and this was significant for both the affected ($t = 2.33$, $df = 95$, $p = 0.022$) and comparison areas ($t = -2.24$, $df = 132$, $p = 0.027$). The increase in sustainable behaviours was greater in the affected area (change score of $M = 7.78$) compared with the comparison area (change score of $M = 4.90$). A second independent measures *t* test was conducted with area (affected or comparison area) as the grouping variable and results were calculated separately for before and after construction. This found no significant differences between areas (affected or comparison area) before or after scheme completion. Previous research found that certain demographic groups are more supportive of urban GI than others, these include women and those with better health (Ståhl et al. 2013). Demographic variables such as gender, age and health status did not influence outcomes in the current study.

Written feedback

Brief written feedback to the single open question ‘What do you think of the Greener Grangetown scheme’ was thematically analysed in NVIVO (version 12). Before the scheme four main themes (where more than four comments were made by residents about a specific issue) and six minor themes were identified from the 36 participants who provided comments from the affected area. As anticipated there were no comments from the comparison area who were unaware or felt unaffected by the scheme. After scheme completion two main and three minor themes were identified within the responses from the 14 participants in the affected area,

Table 1 Mean survey scores (high scores indicate positive outcomes, except stress)

	Affected area		Comparison area	
	Before <i>M</i> (SD) <i>n</i> = 79	After <i>M</i> (SD) <i>n</i> = 18	Before <i>M</i> (SD) <i>n</i> = 101	After <i>M</i> (SD) <i>n</i> = 33
Sustainable behaviours	55.83 (13.03)	65.17 (9.25)	55.68 (11.57)	60.57 (8.38)
Neighbourhood cohesion	6.32 (13.09)	7.50 (11.24)	7.45 (12.95)	11.57 (11.37)
Mobility-EQ5D	1.81 (.39)	1.78 (.43)	1.88 (.33)	1.94 (.24)
Self-care-EQ5D	1.94 (.25)	1.94 (.24)	1.94 (.24)	1.97 (.17)
Usual activities-EQ5D	1.85 (.36)	1.83 (.38)	1.88 (.36)	1.91 (.29)
Pain/discomfort-EQ5D	1.62 (.56)	1.61 (.50)	1.74 (.55)	1.70 (.58)
Depression/anxiety-EQ5D	1.80 (.43)	1.94 (.24)	1.77 (.47)	1.70 (.47)
General health-EQ5D	81.54 (17.21)	84.44 (8.56)	79.60 (17.69)	79.39 (18.53)
Stress	13.81 (6.93)	13.83 (9.08)	15.88 (7.58)	15.81 (5.52)
Nature connection	2.69 (6.14)	4.00 (5.54)	2.82 (6.01)	4.56 (4.45)

Table 2 Themes emerging from residents' comments

Affected area (<i>n</i>)		Comparison area (<i>n</i>)	
Before	After	Before	After
Concerns about reduced parking (16)	Like the scheme, area improved (6)	–	Like the scheme, area improved (14)
Like scheme, looking forward to it (10)	Concerns about reduced parking (6)	–	Want the scheme for their streets (5)
Lack of consultation (6)	Flooding is still an issue (3)	–	–
Waste of funds (5)	–	–	–
Concerns about ongoing maintenance (4)	–	–	–
Litter was a greater concern (4)	–	–	–
Fast traffic was a greater concern (3)	–	–	–
Concern about possible loss of street trees (3)	–	–	–

whilst two main and five minor themes were identified from 16 participants in the comparison area. All themes are summarised in Table 2.

The most prominent theme (16 references) was residents' concerns around a current lack of parking outside their homes due to commuters, and the expectation that this may get worse following the scheme due to existing parking spaces being allocated to new green space. For example, 'There is already too little space for residents. Any reduction in parking would be totally unacceptable.' Of the 16 references, two residents stated that they had started a petition based on parking concerns.

The second most prominent theme (10 references) was that residents liked the scheme, comments included, 'Really looking forward to it', 'Those against it have 3 or more cars', 'I really like green space, and hate cars, I'm looking forward to it!'

The third most prominent theme (6 references) was that residents felt there had been a lack of consultation and said they either had not been consulted at all or that 'It seems that this project was already approved before the residents were consulted'

The fourth theme was that residents felt the scheme was a waste of funds (5 references), with comments including 'It would be better to pay litter-pickers to regenerate the area' 'I don't feel it will make a difference'.

After scheme completion, comments from the affected area revealed two dominant themes which were (i) residents liking the scheme and feeling aspirational about their neighbourhood (6 references) for example, 'It's a big improvement, it feels like being in the country, it's so lovely'; and (ii) continued concerns around limited parking (6 references) for example, 'There's not enough parking for residents, people are parking on trees.'

In the comparison area the most prominent theme after scheme completion was that residents liked the scheme and consistent with the affected area, felt aspirational about the community space (14 references), with comments including 'It looks great', 'I really appreciate the extra greenery', 'It has improved, regenerated and gentrified the area'. The second most prominent theme was wanting the scheme for their area (5 references), with comments including: 'I want it here, I'm upset about the lack of green on our street'. This theme may reflect that, once residents can see what a scheme will look like and find it aesthetically pleasing, they are more likely to accept the change to their street.

Discussion

The study aimed to assess the impact of a scheme to introduce SuDs on resident buy-in, sustainable behaviours, neighbourhood cohesion, health, wellbeing, and nature connection. It was hypothesised that these would show greater improvement in the area affected by the scheme after completion, relative to a comparison area in the same neighbourhood who did not receive the scheme. In support of this hypothesis, sustainable behaviours showed a significant increase after scheme completion in both areas, with a trend for this increase to be greater in the affected area (17% increase) compared with the neighbouring area (9% increase). Sustainable behaviours measured in the self-report scale include behaviours, such as cycling or taking public transport instead of driving, recycling, using renewable energy and energy efficient devices at home, giving money to environmental organisations, and discussing sustainable behaviours with friends. It is possible that the introduction of SuDs and more green space may have increased the

frequency of access to nature and increased awareness of nature which can contribute to environmental values (Ryan 2005). The increase in sustainable behaviours in the comparison area might be a result of spill-over effects (Nash et al. 2017). Indeed, there was evidence from residents' written feedback that once the SuDs scheme was completed, residents in the comparison area were envious of the additional green space and wanted the scheme initiated in their area.

There were no significant changes to neighbourhood cohesion, health, stress and nature connection and no significant differences between outcomes for the affected or comparison areas. The lack of demonstrable change in neighbourhood cohesion is consistent with a previous study of SuDs (Shandas 2015), whose authors suggested that those who give their time to participate in a study and provide feedback on urban schemes are already actively engaged with their community and, therefore, may not perceive any changes in neighbourhood cohesion. In the current study neighbourhood cohesion scores were already very strong at baseline ($M > 6$), according to normative data (strong cohesion = 3.5–5) (Buckner 1988).

The lack of findings in relation to health and wellbeing could be due to the type of GI intervention (i.e., SuDs), for example, a review (Suppakittpaisarn et al. 2017) found that whilst there was evidence for the benefits of familiar GI (e.g., trees and green spaces) on health and wellbeing, there was little evidence for the benefits of newer types of GI, such as SuDs or rain gardens on human health.

It is also possible that any benefits of neighbourhood cohesion, health, and wellbeing may be masked by the threat of change to one's place attachment. Any change to one's neighbourhood can be perceived as a threat due to a strong place attachment, where even very ordinary urban places could reflect people's identity, and provide opportunities for self-development, self-understanding, and nurturance (Manzo and Devine-Wright 2020). For example, Southon et al. (2017) found that preferences for biodiverse and structurally diverse urban vegetation were diminished amongst residents who most frequently used the site. Concerns about changes to the immediate environment outside residents' property are termed 'Not in my backyard' (NIMBY or Nimbyism) and concern about local developments in close spatial proximity to an individual's home represent 40% of dispute letters to Local Government (Eranti 2017).

It is important to note that the primary aim of the GI improvements in Greener Grangetown was to provide greater environmental resilience to climate change and urbanization, reduce carbon emissions, provide better water management and flood-proofing. Consistent with previous findings (Gazzard and Booth 2020) the functional value of the SuDs was not mentioned by residents. The perceptions of the residents, reveal different priorities, such as addressing a lack of parking, as well as littering and anti-social behaviour. This points

to somewhat of a mismatch between the aims and expectations of the planners and those of the residents.

Nonetheless there were positive shifts towards greater buy-in and appreciation of the scheme reflected in the residents written feedback provided by a proportion of residents. Prior to construction residents expressed mixed views, including: (i) Concerns about reduced parking spaces; (ii) Liking the scheme and looking forward to it; (iii) Feeling there was a lack of consultation; and (iv) Concerns that the scheme was a waste of funds. In contrast, after scheme completion residents' views had shifted with equal numbers of residents who provided written feedback: (i) approving the scheme, enjoying the new green space, and stating it had improved the area, or alternatively (ii) still having concerns about reduced parking. Importantly, once completed, residents in neighbouring areas were envious of the green improvements and wanted the scheme implemented in their streets. It can be challenging to enable residents to see beyond short term costs (such as disruption to access and parking) and toward long-term gains (such as more aesthetic and functional streetscapes offering climate-change resilience) and with a transient population, some residents may not be invested enough in the long-term vision for the area. Identifying multiple socio-cultural values of residents and actively involving stakeholders from the beginning of planning is recommended to increase support and avoid conflict in urban GI projects (Kati and Jari 2016).

Limitations and future developments

Although the response rate to the research study was similar to that of the Council's consultation process, it would have been preferable to obtain a greater response rate, particularly after scheme completion, where response rate decreased. It was noted that when researchers were able to speak with residents who were home at the time of home visits, the response rate was much better. In future research, it would be advisable to put greater resource into repeated efforts at home visits with the aim of speaking with all residents affected by such schemes, particularly where it is known that there is a population less likely to engage in research.

The site of the scheme (Grangetown) is a multicultural community where according to Council data 74% identify as White British. The study respondents comprised 84% identifying themselves as White British; therefore, the study may have underrepresented BAME residents. During data collection it was noted that 2.64% of residents in the intervention area and 3.80% of residents in the control area declined to participate as they did not speak English. The researchers had hoped to provide translation through local Community leaders (e.g., Faith leaders, Neighbourhood Watch, Police-community consultation groups, etc.), but this did not materialise. Future studies may want to

consider providing resources for translation to attract more representative samples.

Future studies may also benefit from gathering more detailed feedback through walking focus groups before and after the introduction of such schemes, giving residents the opportunity to point out issues in their community and design features that are preferred over others. Future research might also explore objective measures of health and wellbeing. These might be less subject to bias with regards to intervention perceptions (i.e., if residents know the questionnaire is linked to an urban planning scheme and they do not like it, this may influence how they respond to the questions).

It is important to note that sustainable behaviours were measured using self-report which can be subject to demand characteristics, particularly considering increased media attention to the current climate crisis. Future studies might aim to gather observational data, such as reduced household energy use. Although increases were found in sustainable behaviours, there might be scope to increase the impact of urban GI on sustainable behaviours further. For example, Stern (2000) suggested that multiple stimuli were needed to induce behaviour change, and may require the presence of a physical object (e.g., a rain garden planter), plus education, outreach materials, and stewardship programs that demonstrate ways of correctly stewarding the new SuDs facilities. The introduction of SuDs alongside education (such as signage) has previously been shown to increase residents' awareness of the functional benefits of SuDs, and to increase their support of SuDs implementation (Church 2015; Derkzen et al. 2017). Educating residents about the SuDs using signage is, therefore, advisable, whilst making skills and knowledge more accessible to the public is recommended for increased buy-in (Gao et al. 2018). At the time of writing these results, Cardiff Council were trying to secure funding for permanent signage to explain what the rain gardens do.

Finally, although post-construction data collection took place 1 year following project completion to allow for planting to become more established, it would be advisable to conduct longer term follow-up, as much of the vegetation and particularly the trees, take time to mature and further benefits, such as community cohesion, improved health and wellbeing, or a reduction in urban flooding, may emerge at later stages. For example, Susdrain (2019) suggests a maximum payback period of around 12 and a half years, so follow-up during this period is recommended. Indeed, Gao et al (2018) found that residents' water quality awareness and sense of personal responsibility increased over a 10 year study period. Residents who showed buy-in of SuDs, showed greater appreciation of SuDs and their functions, and were supportive of integrating rain barrels and SuDs into urban spaces.

Conclusions

The Greener Grangetown scheme primarily aimed to improve management of surface water and reduce carbon-emissions through green improvements. Data from Susdrain (2019) indicates successful early results on operations, electricity/carbon emissions, cost savings and futureproofing of the sewage network by freeing up capacity to deal with the effects of climate change. In terms of social aims, the scheme aimed to improve sustainable behaviours, social cohesion, health, and wellbeing, we found a significant increase in sustainable behaviours (17% in the scheme area and 9% in the neighbouring area) after scheme completion. Whilst no improvements were observed in the self-reported health and wellbeing of residents in this study, this is comparable to previous research (Suppakittpaisarn et al. 2017) which found limited associations between newer types of GI (SuDs) and health and wellbeing.

After scheme completion more residents in the affected area were supportive of the scheme; and spill-over effects occurred with neighbours wanting the scheme for their own streets. However, the findings demonstrated that it can be challenging for urban planners to help residents visualise schemes and attract buy-in to urban GI. Improved visualization and education around schemes are needed to increase public buy-in. Gazzard and Booth (2020) note that: "changing public perceptions of 'blue-green infrastructure' will remain an obstacle until awareness of its value is far-reaching and celebrated beyond the confinements of architectural drawings and planning applications". A key concern remained about reduced parking, and this highlights the importance of resident consultation about what would make the most positive impact on residents lives to mitigate such concerns and facilitate the implementation and buy-in of urban GI schemes. Greener Grangetown is now recognised as one of the most successful SuDs retrofit projects in the UK, winning four design awards.

COP26 recently took place, and England is seriously considering a form of statutory SuDS. Therefore, this research is highly relevant, particularly to Local Authorities who often struggle to communicate the multi-benefits of sustainable urban design solutions. For Local Authorities who want to implement SuDs, the authors recommend careful consultation with residents to reduce implementation barriers, the use of signage and education to enable residents to see the functional (as well as the aesthetic) value, and the use of Decision Support Systems to identify the optimal scheme solution (see Ferrans et al. 2022 for a review SuDs models; Benefits of SuDS Tool (BeST) (CIRIA 2015) and case study papers (Perales-Momparler et al. 2017).

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Data availability Anonymised data are available for the purpose of research and audit on request by the corresponding author.

Declarations

Conflict of interest Author I.T. is an engineer on the Cardiff Council scheme. He was only involved in providing access to scheme details and stakeholders thus facilitating data collection and was not involved in the write-up of the findings. Hence any conflict of interest on his part is mitigated.

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