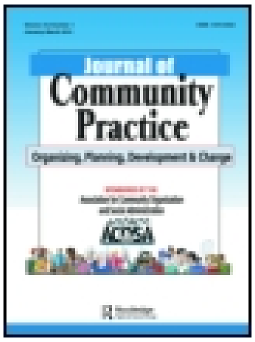

Journal of Community Practice

ISSN: 1070-5422 (Print) 1543-3706 (Online) Journal homepage: https://www.tandfonline.com/loi/wcom20

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To cite this article: Lisa Reyes Mason, Kelsey N. Ellis & Jon M. Hathaway (2019): Urban flooding, social equity, and "backyard" green infrastructure: an area for multidisciplinary practice, Journal of Community Practice, DOI: 10.1080/10705422.2019.1655125

To link to this article: https://doi.org/10.1080/10705422.2019.1655125

Published online: 08 Sep 2019.

JOURNAL OF COMMUNITY PRACTICE
https://doi.org/10.1080/10705422.2019.1655125

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Urban flooding, social equity, and "backyard" green infrastructure: an area for multidisciplinary practice

Lisa Reyes Mason [a], Kelsey N. Ellis[b], and Jon M. Hathaway[c]

[a]College of Social Work, University of Tennessee, Knoxville, Tennessee, USA; [b]Department of Geography, University of Tennessee, Knoxville, Tennessee, USA; [c]Department of Civil and Environmental Engineering, University of Tennessee, Knoxville, Tennessee, USA

ABSTRACT

"Backyard" green infrastructure programs are an innovative way to manage urban stormwater, with many social and ecologic benefits. In many programs, however, residents with lower incomes are not reached, though they could benefit from participation, and though their participation could benefit the socioecological system. We examined awareness of and interest in backyard green infrastructure among lower- and moderate-income residents (N = 234). Awareness among our study population is low to moderate, but interest is moderate to high, with variability by some demographic and other characteristics. A spouse/partner, city agency, and/or neighbor may have influential roles in increasing participation in backyard green infrastructure.

KEYWORDS
Urban; climate change; flooding; green infrastructure; income

Introduction

Urban flooding is a social, environmental, and engineering concern in many cities. As populations surge in urban areas, impervious surfaces increase. When open lands and green space are replaced with pavement and new buildings, the rainfall absorption capacity of watersheds decreases, creating more runoff that can overwhelm aging stormwater infrastructure. Increased imperviousness can cause hydrologic imbalance, stream bank erosion, and urban flooding, with consequent impacts on human and ecosystem health (Hammond, Chen, Djordjević, Butler, & Mark, 2015; Klein, 1979). With climate change comes a greater chance of more frequent and severe flood events in the future (Gao, Fu, Drake, Liu, & Lamarque, 2012; Schreider, Smith, & Jakeman, 2000), and with more flooding comes greater threat to human well-being and, in some cases, survival (National Weather Service, 2019). The sustainable management of urban stormwater is thus critical for a healthy and sustainable urban environment.

Despite this understanding, there are limitations to what can be achieved by traditional municipal interventions. Improvements in urban infrastructure, such as installing larger stormwater conveyances, can lessen the effects

CONTACT Lisa Reyes Mason mason@utk.edu College of Social Work, University of Tennessee, Knoxville, TN, USA

of urban flooding, but these efforts are more effective when paired with initiatives to store rainwater throughout the watershed, thereby reducing the amount quickly conveyed to local waterways (Pennino, McDonald, & Jaffe, 2016). Storing rainwater in innovative ways requires engagement with a diversity of stakeholders, leading to new challenges for municipalities interested in working with individuals to achieve societal benefits (Heckert & Rosan, 2016).

Green infrastructure (GI) is an innovative way to manage urban stormwater with many social and ecologic benefits (U.S. Environmental Protection Agency, 2018). Under the core principles of GI-based stormwater management, runoff is stored and treated in a highly localized manner, as close to its origin as possible. Common types of GI include bioretention ponds, bioswales, rain gardens, and rain barrels. A substantial amount of the impervious area in an urban watershed where GI could be beneficial, however, is on private property, where traditional stormwater abatement programs (e.g., large bioretention areas) cannot be implemented. At the same time, this creates potential for rich community engagement around urban flooding and stormwater management through programs that connect people with "backyard" GI (e.g., Shuster & Rhea, 2013). These programs work directly with residents to install and maintain small-scale GI on their property (e.g., rain gardens). These programs have the potential to generate positive, collective impacts at both community and watershed scales. Reduced urban flooding and improved water quality help utilities and stormwater managers achieve their goals of environmental stewardship and provision of clean water to the public. Meanwhile, residents can benefit from improved quality of life due to more green space exposure and less damage and stress from property flooding (U.S. Environmental Protection Agency, 2018).

Research on backyard GI programs, however, is only recently emerging. Further, and of importance to social work, there is an overlooked dimension of social equity in many programs. Lower- and moderate-income residents are often not reached by these programs, even though people in these groups often live in areas of cities that are more vulnerable to flooding or have fewer resources to cope with heavy rains (e.g., Few, 2003; Fothergill & Peek, 2004; Wickes, Zahnow, Taylor, & Piquero, 2015).

Grounded in a social work perspective that values equity and opportunity – and also conducted with a multidisciplinary team of the kind needed for collaborative research and practice moving forward – this exploratory study aims to better understand awareness of and interest in backyard GI among a sample of lower- and moderate-income residents in an urban watershed, using survey research methods and descriptive and bivariate analyses. With new knowledge about the potential of backyard GI from a social work lens, results can be used toward multidisciplinary efforts in which community organizers, urban planners, county extension agents, and stormwater personnel work together to identify how to reach groups not traditionally served by backyard GI. If these groups are effectively reached and GI adoption rates increase, both participating individuals and the broader socio-ecological system can benefit from lower flood risk, less property damage, more green space, and improved watershed health.

Background

Backyard green infrastructure

GI is a sociotechnical (Chini, Canning, Schreiber, Peschel, & Stillwell, 2017) or socioecological (Flynn & Davidson, 2016) system, requiring adoption from many stakeholders including municipalities, schools, businesses, and private citizens to successfully improve water issues (Heckert & Rosan, 2016). This provides an opportunity for communities to be involved and to advance inclusive and equitable decisions regarding infrastructure improvements, but also provides the challenge of gaining support and adoption of individuals (Heckert & Rosan, 2016).

The first step to understanding the potential for public support of backyard GI for stormwater management is assessing people's understanding of stormwater related topics and GI capabilities. In previous studies, public understanding of stormwater was site and situation specific. For instance, understanding of stormwater issues may be related to firsthand flood experience (Baptiste, 2014), just as flood protection benefits of GI are likely better understood by those living in an area where GI is already being practiced (Derkzen, van Teeffelen, & Verburg, 2017). Conversely, in Australia where water scarcity is a concern, many residents considered stormwater runoff a benefit to waterways and not a flood risk, for example, by providing flow when water demands are high (Brown, Bos, Walsh, Fletcher, & RossRakesh, 2016). More specific to GI literacy, people with prior knowledge of these practices are more likely to adopt the practices (Gao et al., 2016). As an example, after the "Save the Rain" campaign, residents of two Syracuse, New York, neighborhoods demonstrated a strong understanding of stormwater issues, regardless of demographics (Baptiste, Foley, & Smardon, 2015). This is critical to community buy-in, as practitioners interviewed in one study identified "weak community understanding" of stormwater problems as a barrier to integrating GI (Keeley et al., 2013).

Willingness of an individual to participate in backyard GI for stormwater management depends on a variety of factors, the primary of which is often cost (Brown et al., 2016). Success of financial incentives and potential financial gains are an important topic in prior literature (Baptiste et al., 2015; Tayouga & Gagné, 2016). Newburn and Alberini (2016), for example, found that expected adoption rate of rain gardens tripled when people were offered a one-third government rebate; however, lack of knowledge kept some participants from adopting rain gardens even when the rebate was offered.

While funding is among the most frequently cited barriers to GI adoption by stormwater managers (Flynn & Davidson, 2016) and municipalities (Rowe, Rector, & Bakacs, 2016), other factors have also been shown to matter in the emerging literature. At the individual level––the level of backyard GI implementation––studies have found that social capital and social characteristics of a neighborhood may have a strong influence on adoption (Green, Shuster, Rhea, Garmestani, & Thurston, 2012; Montalto et al., 2013). Stronger relationships with and/or concern for the environment (Ando & Freitas, 2011; Gao et al., 2016; Newburn & Alberini, 2016), a higher income (Ando & Freitas, 2011; Newburn & Alberini, 2016), and being a non-senior citizen (Newburn & Alberini, 2016) may also increase the likelihood of being willing to pay when adopting GI or of having already adopted it. Meanwhile, government distrust led to negative feelings toward some GI stormwater management programs, including fear over formally registering a rain barrel and distrust of pro-environmental causes (Brown et al., 2016). Because some residents may distrust programs encouraging GI, interpersonal approaches to recruitment have been recommended (Bos & Brown, 2015). Finally, and especially relevant for our focus on lower income groups who may be less likely to own their home, landlord-tenant relationships have also been shown to matter in GI adoption (Ando & Freitas, 2011).

Multidisciplinary approaches and the current study

Recent studies such as Gilbert, Held, Ellzey, Bailey, and Young (2015) have suggested the benefits of multidisciplinary approaches to sustainability challenges, particularly those at the interface of social and engineering challenges. Such approaches are critical when attempting to manage stormwater via backyard GI. As noted above, the goal of GI strategies is to treat rainfall in a highly localized manner, which requires engagement of diverse stakeholders to encourage participation across the extent of an urban watershed. Yet, in studies such as Shuster and Rhea (2013) and Jarden, Jefferson, and Grieser (2016), participation in backyard GI programs ranged between just 14 and 32%. Rates of participation must be increased (and maintained long-term) if such programs are to successfully mitigate the impacts of urbanization on local waterways. As noted in Roy et al. (2008), knowledge of innovative stormwater controls is historically limited in communities, contributing to one major barrier to achieving sustainable stormwater management: "resistance to change." However, increased public engagement and awareness has started to prove valuable in gaining more acceptance of GI in some cities in the United States.

Given the salience of financial barriers to backyard GI adoption, the need to diversify and expand program participation for both individual and socio-ecologic benefits, and a social work focus on equity and opportunity, this study examines awareness of and interest in backyard GI among lower- and moderate-income residents of an urban watershed. Our focus on a group of people who are often not participating in backyard GI, but who could potentially benefit from it, reflects social work values of social justice and inclusion. Pursuing this work in an empirically grounded and multidisciplinary way reflects recent calls in the social work profession for new and collaborative research on social aspects of environmental issues that can lead directly to implications for practice and social change (e.g., Kemp & Palinkas, 2015; Krings, Victor, Mathias, & Perron, 2018; Mason, Shires, Arwood, & Borst, 2017).

Methods

Sample and data collection

We surveyed residents of the First Creek Watershed in Knoxville, Tennessee, between November 2017 and March 2018. The First Creek Watershed has an area of approximately 5,320 hectares and is nearly entirely within the Knoxville city limits. The watershed is just over 18% impervious and has a variety of land use/land cover including a small amount of forest, single family residential, and more densely developed commercial and multi-family residential areas (Figure 1). At its terminus, First Creek flows to the west of downtown Knoxville before spilling into the Tennessee River.

First Creek has been one focal point of the City of Knoxville's Stormwater Engineering Division due to historical flooding in the watershed. The city's efforts have included developing hydrologic models to better understand the system and improvement of drainage infrastructure on the main stem, which has the highest risk for flooding. Due to the historical flood risks in this watershed, recent studies have aimed to understand how additional stormwater interventions may benefit the watershed (Epps & Hathaway, 2019). As noted above, efforts to reduce flooding will benefit from providing stormwater storage around the watershed, necessitating engagement with the local community to better understand how individual needs and preferences may affect GI installations in public and private spaces. Further, although catastrophic flooding is most likely along the main stem of First Creek, localized flooding occurs in other locations within the watershed to a degree that concerns residents.

Due to the scope and available budget for the project, we initially recruited randomly-sampled participants by landline and cell phone using a standard, purchased list from a third-party sampling company (in lieu of, for example,

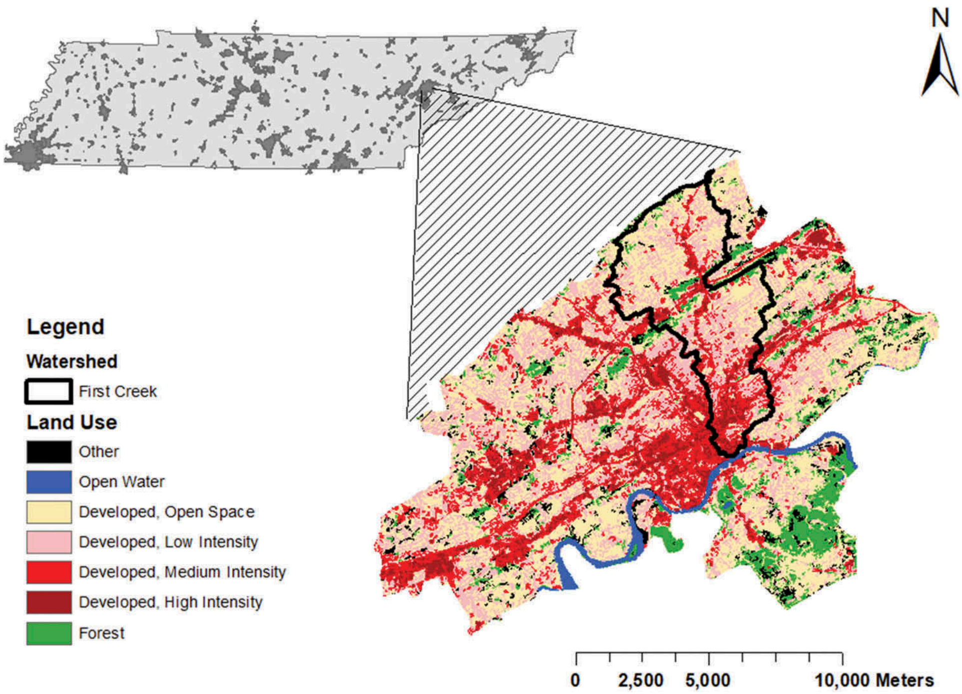

Figure 1. First Creek Watershed, Knoxville, Tennessee

cost-prohibitive, door-to-door surveying across the watershed). However, many of those contacted by cell phone were ineligible because they lived outside of the study's geographic scope. To supplement the sample, we added a non-randomly sampled online recruitment method. We purchased targeted Facebook advertisements, chosen for their affordability with our project budget and due to the wide reach of this social media platform; interested and eligible participants completed a survey instrument online that was identical to the one administered by phone. Participants who completed the survey by cell phone or online received a $5 incentive. A total of 511 participants completed the survey, 396 of whom provided a cross-street that could be mapped as within the watershed boundaries. For the purposes of this study, with its focus on lower- and moderate-income residents, we examine data for the 234 of 396 participants who reported an annual household income up to $50,000.

Measures and analyses

The survey instrument, part of a larger project on social vulnerability to urban flooding, asked 57 questions in the following general order: prior experience with neighborhood flooding and water in the home, individual and household impacts of those experiences (e.g., social, emotional, health, financial), awareness of efforts to address flooding, knowledge of and interest in GI, climate change related knowledge/concerns, perceptions of local governance, neighborhood social cohesion, and several individual and household demographic characteristics. Below, we describe the measures relevant for and analyzed in this study.

Dependent variables

Awareness. We measured general awareness of GI with a Likert-like item, "How familiar are you with the term 'green infrastructure'?" with response options of 1 = not at all, 2 = slightly, 3 = somewhat, and 4 = very familiar. We also asked three dichotomous (1 = yes, 0 = no) questions about familiarity with each of three types of GI (rain barrels, rain gardens, permeable pavement) with the questions: "Have you heard of ________ before?"

Interest. We measured interest in GI with a Likert-like item, "How interested would you be in learning more about how green infrastructure – like rain barrels, rain gardens, or permeable pavement – can help manage the flow of water in your neighborhood?" Response options were 1 = not at all, 2 = slightly, 3 = somewhat, or 4 = very interested.

We also asked about several potential influencers on interest: whether (1 = yes, 0 = no) talking with each of the following people would increase the participant's interest in GI, if the former was to try and encourage the participant to use GI: spouse or partner (if applicable), child (if applicable), someone else in the participant's family, a close friend, a neighbor, someone from the participant's neighborhood association, someone from a City of Knoxville agency or department.

Independent variables

We measured demographic characteristics including gender (1 = female); age (years); race or ethnicity (1 = white or Caucasian, 2 = black or African American, 3 = other which includes American Indian or Alaska Native, Asian, Hispanic or Latino, other (specified by the participant), biracial, and multiracial); marital status (1 = married or living with a long-term partner); education level (1 = high school diploma or less, 2 = some college or technical/associate's degree, 3 = college degree or more); annual household income (1 = $20,000 or less, 2 = $20,000 to less than $35,000; 3 = $35,000 to less than $50,000); and homeownership (1 = yes).

We also measured several non-demographic characteristics: prior experience with flooding/water, perceptions of local government, knowledge and concerns about climate change, and social cohesion. For prior experience with flooding in the neighborhood, we asked, "When there is heavy rain, how often are there pools of standing water in your neighborhood" and "When there is heavy rain, how often do creeks and streams overflow in your neighborhood?" Response options for each item were never, sometimes, often, and always. If a participant responded sometimes, other, or always to either item, the participant was recorded as having prior experience with flooding in the neighborhood (1 = yes). For prior experience with water in the home, we asked, “When there is heavy rain, how often does water get inside your home?” Response options were never, sometimes, often, and always. If a participant responded sometimes, often, or always, the participant was recorded as having prior experience with water in the home (1 = yes).

We measured perceived helpfulness of and trust in the local government. Participants responded to a Likert-like statement, “The City of Knoxville does a good job helping people address concerns they have about their neighborhood,” with response options ranging from 1 = strongly disagree to 5 = strongly agree; responses of “do not know” were coded with 3 = neither agree nor disagree. Participants also responded with similar options to the statement, “In general, I trust the city of Knoxville government.”

For knowledge and concerns about climate change, we used three Likert-like statements with response options identical to those for perceptions of local government. The statements were: 1) Human activity is the cause of climate change; 2) In the future, rainfall amounts in Knoxville will be affected by climate change; and 3) I feel concerned about climate change.

We measured perceived neighborhood social cohesion with the Social Cohesion and Trust scale (Sampson, Raudenbush, & Earls, 1997). This scale consists of five items that ask the extent of participant agreement (1 = strongly disagree, 5 = strongly agree) with each of the following statements: “People around here are willing to help their neighbors,” “This is a close knit neighborhood,” “People in this neighborhood can be trusted,” “People in this neighborhood generally don’t get along with each other,” and “People in this neighborhood do not share the same values.” We reverse coded the last two items for analysis, replaced any “don’t know” responses with a value of 3 = neither agree nor disagree, and averaged the five responses to create a social cohesion score.

Analyses

We conducted descriptive statistics and bivariate analyses in SPSS 25. In some cases, variables were collapsed into fewer categories for analysis, based on the distribution of the data. Select ordinal variables (helpfulness, trust, and social cohesion) were treated as continuous for analysis, also based on data distribution.

Results

Sample characteristics are summarized in Table 1. The typical participant was female, in her mid-60s, white or Caucasian, and with a high school education or less. About one-third of participants (37.2%) were married or living with a long-term partner, and about three-quarters (77.7%) were homeowners.

Table 1. Sample characteristics (N = 234).

Variable	% or Mean (SD)
Demographic characteristics	
Gender, female	71.2
Age, years	65.9 (18.5)[b]
Race or ethnicity	
White or Caucasian	86.7
Black or African American	10.3
Other[a]	3.0
Married or living with a long-term partner	37.2
Education level	
High school diploma or less	51.5
Some college, or technical/associate's degree	26.6
College degree or more	21.9
Income	
Less than \$20,000	32.5
\$20,000 to less than \$35,000	36.3
\$35,000 to less than \$50,000	31.2
Homeownership	77.7
Non-demographic characteristics	
Prior experience with flooding/water	
In the neighborhood	64.5
In the home	28.3
Perceptions of local government	
Helpfulness	3.2 (1.1)[b]
Trust	3.4 (1.2)[b]
Climate change beliefs or concerns, agree/strongly agree	
Human activity is cause	61.1
Rainfall amounts will increase	62.0
Feel concerned	65.0
Social cohesion, score	3.5 (1.0)[b]

[a] Other includes American Indian or Alaska Native, Asian, Hispanic or Latino, other (specified by the participant), biracial, and multiracial. [b] Mean (SD) is reported.

Despite our efforts to broaden recruitment with a supplemental online component, our sample was not necessarily representative of the First Creek watershed population, a limitation discussed further below.

Awareness of green infrastructure

Most participants (62.9%) had no familiarity with the term "green infrastructure", while 22.4% were slightly familiar, 10.8% were somewhat familiar, and 3.9% were familiar. When specific types of GI were asked about, awareness was higher for one type, and lower for two others. About two-thirds of participants (67.5%) had heard of a rain barrel, whereas only 13.2% had heard of a rain garden, and 13.4% had heard of permeable pavement.

Having any degree of familiarity with the term "green infrastructure", compared to none at all, was associated in bivariate analyses with being younger, having more education, not being a homeowner, having prior experience with neighborhood flooding, and agreement with the climate change knowledge/concern statements in this study (Table 2). No associations were found with gender, race, marital status, income, prior experience with water in the home, perceptions of local government, or social cohesion.

Interest in green infrastructure

Almost 60% of participants reported some degree of interest in learning more about GI (17.5% slightly, 22.2% somewhat, and 18.4% very interested), while 41.9% were not at all interested. Having any degree of interest in GI, compared to none at all, was associated in bivariate analyses with being younger, being married or living with a long-term partner, having more education, not being a homeowner, prior experience with neighborhood flooding or water in the home, and agreement with the climate change knowledge/concern statements in this study (Table 3). No associations were found with gender, race, income, perceptions of local government, or social cohesion.

Table 2. Sample characteristics, by familiarity with green infrastructure (N = 234).

Variable	Not at all; % or Mean (SD)	Slightly, Somewhat, or Very; % or Mean (SD)	p^a
Demographic characteristics			
Gender, female	71.2	70.6	0.917
Age, years	69.3 (16.5)[b]	60.1 (20.2)[b]	**<0.001**
Race or ethnicity, white or Caucasian	88.4	83.5	0.299
Married or living with a long-term partner	38.4	34.9	0.597
Education level			**<0.001**[c]
High school diploma or less	62.1	32.6	
Some college, or technical/associate's degree	24.1	31.4	
College degree or more	13.8	36.0	
Income			0.167[c]
Less than $20,000	35.6	26.7	
$20,000 to less than $35,000	35.6	38.4	
$35,000 to less than $50,000	28.8	34.9	
Homeownership	82.1	70.9	**0.048**
Non-demographic characteristics			
Prior experience with flooding/water			
In the neighborhood	59.6	73.3	**0.035**
In the home	29.7	26.7	0.636
Perceptions of local government			
Helpfulness	3.3 (1.2)[b]	3.2 (1.1)[b]	0.451
Trust	3.4 (1.2)[b]	3.4 (1.2)[b]	0.713
Climate change beliefs or concerns, agree/strongly agree			
Human activity is cause	55.5	70.9	**0.020**
Rainfall amounts will increase	55.5	73.3	**0.007**
Feel concerned	59.6	73.3	**0.035**
Social cohesion, score	3.5 (1.0)[b]	3.6 (1.0)[b]	0.452

[a] All *p* values are from chi-square analyses, except for age, helpfulness, trust, and social cohesion, whose *p* values are from an independent samples t-test; bold indicates statistical significance. [b] Mean (SD) is reported. [c] The *p* value for the linear-by-linear association is reported.

Table 3. Sample characteristics, by interest in green infrastructure (N = 234).

Variable	Not at all; % or Mean (SD)	Slightly, Somewhat, or Very; % or Mean (SD)	p^a
Demographic characteristics			
Gender, female	71.4	71.1	0.958
Age, years	74.3 (14.0)[b]	59.9 (19.0)[b]	**<0.001**
Race or ethnicity, white or Caucasian	86.7	86.7	0.988
Married or living with a long-term partner	29.6	42.6	**0.041**
Education level			**0.001**[c]
High school diploma or less	64.3	42.2	
Some college, or technical/associate's degree	22.4	29.6	
College degree or more	13.3	28.1	
Income			0.902[c]
Less than $20,000	32.7	32.4	
$20,000 to less than $35,000	36.7	36.0	
$35,000 to less than $50,000	30.6	31.6	
Homeownership	85.7	71.9	**0.012**
Non-demographic characteristics			
Prior experience with flooding/water			
In the neighborhood	48.0	76.5	**<0.001**
In the home	20.6	33.8	**0.027**
Perceptions of local government			
Helpfulness	3.4 (1.1)[b]	3.1 (1.1)[b]	0.119
Trust	3.5 (1.2)[b]	3.3 (1.2)[b]	0.112
Climate change beliefs or concerns, agree/strongly agree			
Human activity is cause	50.0	69.1	**0.003**
Rainfall amounts will increase	46.9	72.8	**<0.001**
Feel concerned	50.0	75.7	**<0.001**
Social cohesion, score	3.6 (1.0)[b]	3.4 (1.0)[b]	0.134

[a] All *p* values are from chi-square analyses, except for age, helpfulness, trust, and social cohesion, whose *p* values are from an independent samples t-test; bold indicates statistical significance. [b] Mean (SD) is reported. [c] The *p* value for the linear-by-linear association is reported.

Among those with a spouse or partner, 32.1% said this person could influence them to have increased interest in GI; while 18.1% of those with a child said the same. For other potential influencers on interest, the percentage of positive (yes) responses were as follows: 17.5% if someone else in the participant's family, 22.6% if a close friend, 23.1% if a neighbor, 19.7% if someone from the participant's neighborhood association, 28.6% if someone from a City of Knoxville agency or department.

When potential influence on interest is compared with baseline interest in GI (Table 4), a small percentage of participants (4.2% to 7.9%) whose interest was "none at all" said that talking with the indicated person could increase the participant's own interest; the top three types of possible influencers were spouse or partner (7.9%), city agency (7.2%), and neighborhood association (6.2%). For those whose interest was "slightly", the top three types were spouse or partner (52.9%), city agency (39.4%), and neighborhood association (30.3%). Finally, for those whose interest was "somewhat", the top three types were spouse or partner (52.8%), city agency (47.9%), and neighbor (45.8%).

Table 4. Interest in green infrastructure and the potential influence of encouragement from other people[a]

Baseline Interest	Spouse or Partner (n = 190)	Child (n = 199)	Other Family Member (n = 210)	Close Friend (n = 214)	Neighbor (n = 211)	Neighborhood Association (n = 217)	City Agency (n = 217)
None at all	7.9	5.4	4.2	5.2	5.2	6.2	7.2
Slightly	52.9	19.4	27.3	26.5	24.2	30.3	39.4
Somewhat	52.8	34.1	21.7	38.3	45.8	22.0	47.9
Very Much	54.8	32.3	51.4	58.3	55.9	51.4	61.5

[a] Values in the table are the percentage of participants, by category of baseline interest in green infrastructure (GI), who said their interest in GI would increase if they were encouraged by the other person to use GI (e.g., spouse or partner, child, other family member, etc.).

Study limitations

Due to the geographic scope of the study (one watershed's boundary), conventional methods of purchasing landline and cell phone samples, and particularly the latter, were a challenge. Though we added an online recruitment and survey method, the final sample is skewed to older adults and females. Thus, results should not be taken as necessarily representative of First Creek Watershed residents. Since similar challenges will likely be present for other studies in individual urban watersheds, which tend to be more limited in size and thus require targeted recruitment efforts, future studies could potentially address these challenges through more intensive, door-to-door recruitment efforts if sufficient funding is secured in advance.

In addition, our measure of prior flooding hinged on the participant's conception of "heavy rain", which may vary among participants. Future studies could consider more detailed explanations of what is meant by "heavy rain" or could gather and analyze open-ended responses from participants to address this.

Discussion and conclusions

Site-specific, community-engaged research on backyard GI is essential for effective program planning and implementation to reach groups not traditionally served by these programs. In this study, we examined awareness of and interest in backyard GI among a sample of lower- and moderate-income residents in an urban watershed. Awareness of GI was low to moderate (about 37% had some familiarity with the general term), with higher awareness of rain barrels, but low awareness of rain gardens or permeable pavement. Meanwhile, interest in GI was moderate to high, at about 60% of the study sample expressing interest. These results suggest that there is substantial room to increase awareness of GI among lower- and moderate-income residents, and that programs intentionally designed to reach this population could be well received.

That younger and more highly educated residents, and ones with prior experience with flooding and/or concerns about the environment (here, measured through climate change statements), had both greater awareness of and interest in GI is not surprising and is consistent with prior research (e.g., Ando & Freitas, 2011; Gao et al., 2016; Newburn & Alberini, 2016). This finding has two possible implications for addressing social equity and expanding opportunities to participate in backyard GI. First, it helps identify which groups have less familiarity and/or interest, and thus who might be targeted through outreach and engagement efforts (e.g., older residents, ones with less education.). Second, if there are positive feedback cycles of how GI can spread in communities as early adopters take a role in informing and influencing others (e.g., Bos & Brown, 2015; Green et al., 2012), then efforts that specifically focus on increasing adoption among these groups could help spread GI to other lower- and moderate-income residents in urban communities.

To create, promote, and expand such efforts, social workers can bring needed skills and perspectives to multidisciplinary teams, drawing on the profession's expertise in program development, participatory approaches, cultural competence, and systems thinking that considers how flood risk and GI may fit in an individual's overall risk milieu or priority of needs. Social workers practicing in community-based organizations can seek new partnerships with city or county offices that manage stormwater or GI programs, as well as university extension programs that already have active GI efforts in wealthier parts of a city or county. These partnerships could take multiple forms. Social workers might engage in door-to-door efforts to raise awareness about GI and available programs, work with children in schools to increase knowledge that they in turn bring home to their parents, or train other professionals in effective communication and engagement strategies for working with lower- and moderate-income residents. Working with existing agencies such as Habitat for Humanity or environmentally-focused AmeriCorps or VISTA programs is another route social workers could explore to address GI awareness and interest.

The finding that homeownership was associated with less familiarity and interest in GI is an interesting finding from this study. Since homeowners have more control over private property investments than non-homeowners (i.e., renters), the opposite relationship is expected, like the one found by Ando and Freitas (2011) for rain barrel adoption. Finding ways to build from non-homeowners' interest in GI to landlord willingness to install GI and meet their tenants' preferences is an interesting avenue for future community-engaged research and practice on this topic, and one little explored in the literature to date. Adding an ecosocial or sustainability element about flood risk and GI to social work practice on tenant rights or neighborhood organizing, for example, would expand existing social work practice in new and innovative ways. Social workers already practicing in these areas might benefit from new post-BSW or post-MSW training (e.g., continuing education units, certificate programs) on environmental justice and sustainability issues, which speaks to the profession's broader effort to infuse environment-related competencies and skills across the profession (e.g., Council on Social Work Education, 2018). To further support such infusion, social work schools and departments can also actively create more field placements to support ecosocial work practice, such as with municipal sustainability offices or local environmental organizations.

Given this study's primary focus on social equity and inclusion in backyard GI among residents with lower incomes, it is interesting that no statistically significant associations were found between income and either awareness of or interest in GI. In fact, the proportion of participants who had at least some interest in GI was nearly equally spread among the three income categories in this study. Since so much prior literature has emphasized the role of financial barriers in GI adoption, this study provides further support for identifying ways – through future research that delves into participant preferences and perspectives in more depth – to overcome these barriers for lower- and moderate-income residents, in particular. Sliding fee scales, rebates, and utility bill reductions are just some of the financial incentives that could be further explored with these specific communities in mind. Social workers engaged in community practice can pursue advocacy with utility companies, stormwater programs, and city or county sustainability offices to create and promote programs that offer such incentives, and help evaluate their uptake and impact.

Finally, prior studies have found that individuals can positively influence GI adoption of other individuals, and that formal social networks such as community meetings (Afzalan & Muller, 2014) and informal social networks (Bos & Brown, 2015) can play important roles. This study provides similar support for efforts to increase awareness and adoption among lower- and moderate-income residents, who have infrequently been the focus of prior research in this area. That city agencies and neighborhood associations (or neighbors) were among the top three potential influencers on someone's self-report likelihood of having greater interest in GI makes community practice that connects these influencers with residents a relevant way forward. In line with the Tayouga and Gagné (2016) recommendation that professional educators, governmental agencies, and non-profits incorporate material on GI into their curricula and outreach efforts, this study suggests that this outreach should include ways of reaching lower- and moderate-income residents in particular, as many people in these groups do indeed have interest in learning more about and potentially participating in backyard GI programs despite the possibility of financial barriers still being a concern. In addition, social workers engaged in policy practice or who work in government can strive to influence trust and rapport from the top-down, by working to influence government agency views of lower- and moderate-income residents and the importance of valuing their perspective and participation, when social workers assess that such views need challenging.

The sustainable management of urban stormwater through backyard GI is an emerging area for multidisciplinary research and practice. Prior studies have identified financial barriers as an important factor, and have also highlighted the need for a site-specific, community engaged understanding of how to best move forward. When social workers, in particular, collaborate with other disciplines and sectors on this work, priorities of social equity and opportunity for all to participate in GI may be more likely to become a priority, or at least remain on the agenda. Through future research and practice at the nexus of urban flooding, stormwater, and the potential role of backyard GI, new efforts can advance the well-being of both social and ecological systems.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This work was funded by the Institute for a Secure and Sustainable Environment at the University of Tennessee.

ORCID

Lisa Reyes Mason http://orcid.org/0000-0001-5386-4425

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