

Towards attaining green sustainability goals of cities through social transitions: Comparing stakeholders' knowledge and perceptions between two Chesapeake Bay watersheds, USA

Debasmita Patra^{a,*}, Victoria Chanse^b, Amanda Rockler^c, Sacoby Wilson^d, Hubert Montas^e, Adel Shirmohammadi^a, Paul T. Leisnham^a

^a Department of Environmental Science and Technology, University of Maryland, College Park, MD, 20742, USA

^b Victoria University of Wellington, New Zealand

^c University of Maryland Extension, University of Maryland, College Park, MD, 20742, USA

^d Maryland Institute for Applied Environmental Health (MIAEH) and Department of Epidemiology and Biostatistics, University of Maryland, College Park, MD, 20742, USA

^e Fischell Department of Bioengineering, University of Maryland, College Park, MD, 20742, USA

ARTICLE INFO

Keywords:

Barriers to adoptions
Best management practices (BMPs)
Chesapeake bay watersheds USA
Community-based participatory research (CBPR)
In-depth interviews
Green infrastructure (GI)
Social transition management
Stakeholders' responsibilities

ABSTRACT

Clean water is a significant challenge for the sustainability of expanding cities worldwide. The United Nations recognizes the importance of urban green space to improve sustainability and has proposed Sustainable Development Goals to be achieved by 2030. Political jurisdictions have their own sustainability goals and are instituting various policies to achieve them, but struggle to do so due to underlying socio-cultural, environmental, economic/financial, and other challenges. Utilizing a Community Based Participatory Research approach involving multi-stakeholders and transition management theory to frame different spheres of governance, this multi-disciplinary study aims to understand best management practices, sense of perceived responsibility, barriers, and future of Green Infrastructure (GI) in two Chesapeake Bay watersheds. We analyzed data from 42 in-depth interviews as well as GI policies. We identified five categories of perceived barriers, socio-cultural being the dominant category. More meaningful outreach activities are needed to build trust with residents, which can be achieved through modern channels of communications including smartphone applications and social media. This trust will increase the GI adoption rates and improve water quality in the USA and elsewhere. This can be achieved through an integrated governance approach.

1. Introduction

Globally, clean water is a significant challenge for expanding cities and their sustainability. The United Nations (UN) recognizes the importance of urban green space and has set several Sustainable Development Goals (SDG- 6 for clean water, and 11 for sustainable cities; SDG Sustainable Development Goals, 2020) to be achieved by 2030. Countries, states, cities, and local municipalities have their own sustainability goals and have been working to achieve them through various environmental policies (United Nations Educational, Scientific and Cultural Organization-UNESCO, 2018). However, environmental policies have been partially unsuccessful in changing behavior and bringing about societal transformations, and there are often conflicts

between short-term policy goals and the long-term changes needed for sustainability (Rotmans and Kemp, 2003). Social acceptance and societal transitions are of paramount importance to achieve those goals (Dhakal and Chevalier, 2017). Since its introduction, the concept of societal transitions has evolved to become a highly multi-disciplinary field. The field is becoming increasingly global and covers a broad range of sectors, domains, and societal issues (Geels, 2005; Carballo-Penela and Castroman-Diz, 2015; Loorback et al., 2017).

A broad appreciation of sustainability involves an integrated assessment of the ecological, social, and technological domains (Chaffin, et al., 2016; Dhakal and Chevalier, 2016; Chini et al., 2017; Ureta et al., 2021; Rendon et al., 2021). Urban watersheds are ideal models to explore environment-human interactions in achieving sustainability

* Corresponding author at: Department of Environmental Science and Technology, University of Maryland, College Park, MD, 20742, USA.

E-mail address: dpatra@umd.edu (D. Patra).

<https://doi.org/10.1016/j.scs.2021.103318>

Received 19 March 2021; Received in revised form 11 August 2021; Accepted 27 August 2021

Available online 1 September 2021

rights reserved.

goals, which have the potential to provide a significant contribution to the empirical and theoretical body of knowledge in the field. Watersheds are inherent to every region, have direct and indirect, immediate and diffuse impacts on human well-being, and have a strong influence on human behavior (Kates et al., 2001; Hester and Little, 2013; Coutts and Hahn, 2015). Urban green space and water governance is changing its composition to include municipalities, water utilities, private enterprises, community cooperatives, and individual households along with the call for in-depth case studies (De Haan et al., 2015; Liu and Russo, 2021).

1.1. Green infrastructure, best management practices, urban water regulations, and related challenges in the United States of America (USA)

Green Infrastructure can broadly be defined as green space that promotes access to recreational space, can preserve biodiversity, and leverages continuity of ecosystem processes and functions of ecological systems to regulate and manage technical problems like stormwater quality and quantity, as well as urban heat island effect (Tzoulas et al., 2007; Roy et al., 2008; BenDor et al., 2018; Balany et al., 2020). Urban stormwater Best Management Practices (BMPs) refer to a set of technologies and cover different types of practices such as: residential scale-rain garden, rain barrel, etc.; right-of-the way or public large-scale-bio-swales, stream restorations, etc.; and public engagement and education through outreach activities (Anderson et al., 2014; Lovell and Taylor, 2013; Liu et al., 2017; Kim, 2018; Environmental Protection Agency (EPA) 2020). This paper considers the systems of the BMPs and practices to manage stormwater as GI and uses the terminologies- GI BMPs, GI, and stormwater management- interchangeably.

In the USA, the Clean Water Act (CWA), Total Maximum Daily Load (TMDL) limits, and Municipal Separate Storm Sewer System (MS4) permit requirements have largely driven local government policies/actions to improve the water quality (Environmental Protection Agency (EPA) 2020). Introduced in 1972, the CWA is one of the USA's first and most influential modern environmental laws governing water pollution. Its objective is to restore and maintain the chemical, physical, and biological integrity of the nation's waters. A TMDL is the calculation of the maximum amount of a pollutant allowed to enter a waterbody so that the waterbody will meet water quality standards for that pollutant (Environmental Protection Agency (EPA) 2020). States are responsible for developing TMDLs and approval from the EPA. An MS4 is defined as "a system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains)" that is (1) designed or used for collecting or conveying stormwater and (2) is owned or operated by a city, county, or other governmental entities to discharge stormwater collected by their storm sewer systems to waters of the USA (Maryland Department of Environment, 2020). As per the EPA requirements, to satisfy minimum control measure, the operator of a regulated MS4 needs to implement six measures: public education and outreach in determining the appropriate BMPs, public participation, illicit discharge detection and elimination, construction site runoff control, post-construction runoff control, and good housekeeping (EPA, 2020).

Non-point source pollution is arguably the greatest environmental issue facing the Chesapeake Bay area, Maryland, and most of America's impaired watersheds (Millennium Ecosystem Assessment Board, 2005). Community related watershed concerns tend to differ from regulatory requirements, which are more technical in nature rather than inclusive of community needs. Every community has their unique characteristics, whereas regulatory requirements tend to use one-fit-for-all top-down approach (Huang et al., 2020). The cost and difficulty of achieving ambitious water quality standards for urban areas may be understood by program managers, but not by the public, hence undermining residents' support and involvement (NAP, 2019). Multiple legislative approaches regulate, and govern urban stormwater management, but their effectiveness due to lack of

incorporating social dimensions into planning and decision-making (Copeland, 2016; Schiffman et al., 2018). Multiple studies have suggested a critical need to better encourage and incorporate community perceptions, cultural and social values, education, and participation into stormwater management approaches (Söderberg and Aberg, 2002; Nassauer et al., 2009; Cettner et al. 2014; NAP, 2019). Despite decades of outreach and education, urban residents' knowledge of watershed boundaries and connections and the influence of specific activities on watershed health remains poor (Chanse et al., 2017; Maeda et al., 2018; Rickenbacker et al., 2019).

1.2. Our study approach and objectives

Given the complexities around urban stormwater management and GI, we assembled a multi-disciplinary team of researchers consisting of social scientist, water engineer, environmentalist, landscape architect, extension specialist, bioengineer, and public health expert for a holistic understanding of the issues. We followed a Community-Based Participatory Research approach (CBPR-Corburn, 2005; Srinivasan and Collman, 2005; Rickenbacker et al., 2019; Rendon et al., 2021), to involve multi-stakeholders since the inception of our project. The CBPR approach is a robust method, which deliberately involves community members and other stakeholders from the beginning and keeps them involved throughout the project to build partnership and trust. Other methods such as survey, structured interviews, and hypothesis-driven research, are mostly top-down approaches and are inadequate in understanding stakeholders' perspectives (Rickenbacker et al., 2019; Rendon et al., 2021). In this study we partnered with local community members, nonprofit organizations, government officials, and other GI experts in the region. We chose a dual/contrasting case study approach utilizing CBPR to achieve more powerful and meaningful analytic conclusions (Yin, 2014). Our study objectives were:

- 1 In-depth understanding of the underlying issues in water governance that facilitate or inhibit the implementation of GI BMPs in our two study watersheds with varying jurisdictional, physical, and socio-economic characteristics.
- 2 To understand the existing knowledge and perceptions of the GI BMPs across diverse stakeholder groups in terms of sense of responsibility, barriers, community educational outreach activities, and the future.
- 3 To provide policy suggestions based on our study results to increase GI BMPs adoptions, which would contribute to improved water quality in the Chesapeake Bay area.

1.3. Chesapeake Bay area focus and theoretical framework

The Baltimore-Washington Metropolitan area is the most populous urban area in the Chesapeake Bay watershed, with over 9 million residents spread across diverse socio-economic and environmental conditions (Appendix A). Since 1972, following the CWA, considerable research, data collection, and planning have been undertaken in the Chesapeake Bay area to improve water quality, yet it remains plagued by stressors, poor water quality, and hypoxic "dead zones" (Reckhow et al., 2011; Chesapeake EcoCheck, 2013). There is a critical need for participatory bottom-up approaches to achieve sustainability goals (Mayer et al., 2012; Dernoga et al., 2015). These participatory approaches can be achieved through transition management governance. These governance processes have been designed to facilitate short-term innovation and develop long-term sustainability visions based on desired societal transitions (Loorbach and Rotmans, 2006; Van der Brugge, 2009). Loorbach (2010) lists four different types of governance activities (spheres) that are relevant to societal transitions towards attaining sustainability goals: strategic, tactical, operational, and reflexive. In this paper, we use Loorbach's (2010) schema as follows:

- (a) **Strategic:** The strategic sphere involves activities related to processes of vision development, strategic discussions, long-term goal formulation, collective goal and norm setting. We discuss the existing regulations, requirements, policies, programs, goals, and visions related to GI BMPs adoption in our study watersheds under this sphere.
- (b) **Tactical:** In the tactical sphere, steering activities that are interest driven and related to the dominant structures of a societal (sub) system are identified. This includes all stakeholders that are developing programs, financial and institutional regulations and frameworks, infrastructure, and routines, organizing networks and coalitions. Under the tactical sphere, we discuss:
 - (i) how stakeholders from diverse agencies/organizations work together to achieve the sustainability goals set by local and national governments and,
 - (ii) popular GI BMPs that people adopt.
- (c) **Operational:** As operational activities, experiments and actions are identified that are short-term and are often carried out in the context of innovation projects and programs and are generally referred to as “innovation”. Under the operational sphere, we discuss:
 - (i) the best ways to manage stormwater as perceived by the stakeholders, and
 - (ii) how stakeholders perceive their responsibility towards achieving sustainability goals.
- (d) **Reflexive:** Reflexive activities relate to monitoring, assessments and evaluation of ongoing policies, and ongoing societal change. Reflexive activities are related to all three spheres mentioned above in this section. We evaluate:
 - (i) barriers to the GI BMPs adoptions, and
 - (ii) community educational outreach activities and related challenges under the reflexive sphere.

2. Methodology

2.1. The study watersheds

Our study focused on two Chesapeake Bay watersheds within the Baltimore-Washington Metropolitan area: Watershed 263 and Watts Branch with diverse socio-economic and environmental conditions (Appendix A). Watershed 263 is part of the governance of Baltimore city, Maryland whereas Watts Branch falls under two governances-Prince George's (PG) County, Maryland and Washington, District of Columbia (DC) (Fig. 1).

Both watersheds consist predominantly of residential areas and have majority African American populations but differ in other socio-economic and physical characteristics (Table 1).

Watershed 263 has a higher population density and proportion of built areas than Watts Branch, as measured by high percent of impervious surface. It has lower median household incomes, education attainment, and a substantially higher proportion of vacancy parcels as compared to Watts Branch (Table 1). The sanitary and sewer systems in Watts Branch and Watershed 263 are a combined system and a separate system, respectively.

2.2. Data collection

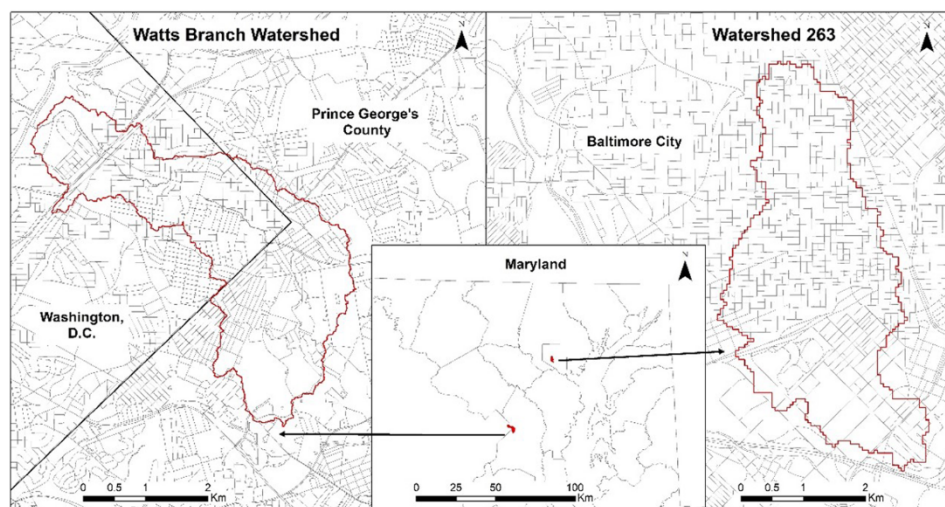
2.2.1. Sampling

Utilizing a CBPR approach, our multi-disciplinary team formed a Community Advisory Board consisting of residents and GI professionals from local nonprofit organizations, government organizations, and University of Maryland Extension (UME), to gain stakeholders' perspectives before the start of the project. The Board also advised us throughout our project. We then partnered with the local watershed organizations to identify potential respondents in our two study watersheds. We used a purposive sampling method to recruit respondents who were considered highly knowledgeable about GI and stormwater systems. In total, we recruited 22 professionals consisting of government officials, university researchers, GI experts with nonprofit organizations,

Table 1

Physical and socio-economic characteristics of Watershed 263, Baltimore, Maryland and Watts Branch, Prince George's County, Maryland and Washington, District of Columbia (Source: www.census.gov; 5-year estimated, 2014-18).

	Watershed names	
	Watershed 263	Watts Branch
Physical characteristics		
Size (km ²)	2.86	6.46
Percent residential land use	92.10%	64.65%
Percent impervious surface	65%	33%
Socio-economic characteristics		
Population density (km ²)	17,450	12,342
Percent 10-yr population change	-7.17%	14.04%
Percent population African American ethnicity	73.85%	90.44%
Median household income	\$27,181	\$46,260
Percent of residents with a college degree or higher	12.79%	14.51%
Percent of vacant lots	36.95%	10.61%



1. Geographic Location of Watershed 263, Baltimore and Watts Branch, Washington, DC.

funding agency officials, policy makers, and environmental activists, split evenly between each watershed. We recruited a total of 20 residents, also split evenly between each watershed. In our study, we had respondents affiliated with about 33 different institutions/organizations in the Chesapeake Bay area. Besides interviews, we also extensively gathered information on GI-related visions, goals, policies, and programs from the websites of different government agencies and nonprofit organizations.

2.2.2. Interview process

In-depth interviews with open-ended questions are a primary method of data collection in qualitative research (Legard et al., 2003). Open-ended questions allow participants to “capture how those being interviewed view their world, to learn their terminology and judgments, and to capture the complexities of their individual perceptions and experiences” (Patton, 2002). For the interviews, we guided the respondents with several open-ended questions designed to capture the dynamics of the four transition managements spheres. Some questions included: How has the residential stormwater been managed in your area? Who or what entity is responsible for managing stormwater in your area? How do you manage stormwater on your own property? What is the best way to manage residential stormwater? Do you see any barriers to stormwater management/GI adoptions? What are some solutions to address those barriers? What is the future of GI/stormwater management? Detailed discussions followed with several follow-up questions. Interviews were conducted between March and November of 2019 with University of Maryland’s Institutional Review Board (IRB) approval. Most of the interviews lasted between 45 minutes to 1.5 hours, were audiotaped and later transcribed. The transcripts were coded and all the identifying information were removed.

2.3. Data analyses

Coded interview transcripts were analyzed using both qualitative thematic analysis as well as quantitative analysis. Thematic analysis is “a method for identifying themes and patterns of measuring across a dataset in relation to a research question”, which can be applied across theoretical approaches (Braun and Clarke, 2013). It has a broad scope and may be used in analyzing social and cultural phenomena in addition to subjective human experiences (Guest et al., 2012). We thoroughly read each of the 42 interview transcripts and sorted the qualitative data into a total of six themes under 4 governance spheres of Loorback’s schema: (i) Perceived BMPs, (ii) Popular BMPs in use, (iii) Perceived sense of responsibilities, (iv) Barriers to GI BMPs adoptions, (v) Community educational outreach activities and related challenges, and (vi) Future of GI. After sorting, each theme yielded more than hundred pages of transcripts. Within these themes, responses were coded further into different categories of transition management to generate meaningful inferences on research questions. These analyses are represented with quotes and tables in the results section. For better representation of data, in this paper we have combined all the professionals into one category-GI professionals. To compare, we have divided our stakeholders into four groups (residents and professionals for two watersheds): Baltimore Residents (BR), Watts Branch Residents (WBR), Baltimore GI Professionals (BGIP), and Watts Branch GI Professionals (WBGIP). For ease in data interpretation and graphical representation, mosaic plots were developed for different categories of responses for each theme using JMP statistical software (JMP version 14, SAS Institute Inc., Cary, NC). Further, the information on visions, policies, and programs obtained from the websites were analyzed and listed in tables.

3. Results and discussion

In this section we discuss four strategic governance spheres (strategic, operational, institutional, and reflexive), and the future of GI as perceived by the stakeholders and their proposed solutions to achieve

sustainability goals.

3.1. Strategic sphere: the goals, policies, and programs related to GI in our study watersheds

The Strategic sphere in Loorback’s (2010) schema includes how different agencies/organizations, and individuals strategize varying planning, activities, policies, and programs to achieve the sustainability goals. The GI dimensions of the sustainability goal for Baltimore and Watts Branch are shaped by the broader CWA, TMDL limits, and MS4 permits [National Research Council (NRC) 2009]. So, the vision and activities surrounding formulating and achieving GI BMPs adoption goals have been shaping since the past 50 years. Here, we describe existing goals, policies, programs, and future plans in our study watersheds.

Baltimore’s Nature in the City chapter of its 2019 Baltimore Sustainability Plan highlights the role of strategic approaches to transforming vacant lots into community green spaces to manage its stormwater, specifically, “the installations of GI that is well-maintained and can address economic, social, and environmental challenges by increasing both green space and job opportunities” (Baltimore Office of Sustainability, 2019). Baltimore City has taken several steps to incorporate GI into its planning and implementation to manage urban stormwater runoff. These steps include a revised stormwater management ordinance that emphasizes on-site stormwater treatment, plans to replace 20% of its impervious surfaces, approximately 4,291 acres with conservation landscaping (Baltimore Office of Sustainability, 2019).

Watts Branch straddles two jurisdictions PG County, Maryland, and Washington, DC, making regulating and managing stormwater quantity and quality particularly challenging. In 2014, it was estimated that PG County’s MS4 permits would have required retrofitting 2,000 impervious acres with GI, a figure that could potentially have expanded to 15,000 acres of untreated impervious area by 2025 (The Clean Water Partnership, 2020). Due to the prohibitive projected cost of complying with the MS4 permit, PG County recently partnered with a private company, Corvias, in a community based public private partnership (The Clean Water Partnership, 2020) to address the magnitude of MS4 stormwater management requirements. As part of the policy requirements and municipalities mandates, PG County is implementing educational and incentive programs for public properties, right of the way properties, and residential private properties (since the county consists mainly of privately-owned residential land, hence are critical). Table 2 lists the existing stormwater management policies, programs, and agencies in both the study watersheds.

As per Loorback’s (2010) strategic sphere, we found that strategic activities to achieve sustainability goals set by local and national governments, were largely driven and shaped by the CWA, MS4 permit and TMDL requirements, in both Watershed 263 and Watts Branch. Although the Water Infrastructure Improvement Act (WIIA) became a law in 2019, the effects have not been realized yet in the USA (US Congress, 2019). Different government agencies such as Dept. of Public Works (DPW), Dept. of Transportation (DOT), EPA, and nonprofit organizations such as Blue Water Baltimore (BWB), Parks and People Foundation (PPF), Anacostia Watershed Society (AWS), Washington Parks and People (WPP), Urban Ecosystem Restoration (UER), and Chesapeake Bay Trust (CBT), have been partnering with each other and the residents through several programs. To make implementation more affordable for residents, PG County and Dept. of Energy and Environment, Washington, DC (DOEE) each offer rebate programs namely, (Rain Check Rebate, 2019) and RiverSmart Home, respectively. There are currently no rebate programs offered in Watershed 263, but the Baltimore City DPW provided credit on the stormwater fees for residents if they installed and maintained BMPs and volunteered for hands-on activities (DPW, 2020). Data comparing our two study watersheds had similar results on other parameters, hence we conclude that rebate programs probably had no bearing on the GI adoptions among residents.

Table 2

Stormwater management policies, programs, and agencies in Watershed 263, Baltimore, Maryland and Watts Branch, Prince George's County, Maryland and Washington, District of Columbia.

	Watershed 263	Watts Branch	Common in both
Jurisdiction	Baltimore City	PG County, Maryland, and Washington, DC	
Policy	Sustainability Plan	Sustainable DC 2.0 Plan, Clean Water Partnership	Clean Water Act, MS4 permit, TMDL requirements, Tree Canopy, Stormwater Fee, Water Infrastructure Improvement Act 2019
Government agencies	Baltimore City Dept. of Public Works, Dept. of Transportation	PG County, Washington, DC, Metropolitan Council of Governments, Dept. of Defense, Dept. of Energy and Environ., DC Water	EPA, USA Army Corps of Engineers, US Dept. Agricul.
Government rebate programs	Credit on stormwater fee	RainCheck Rebate, RiverSmart Homes	
Nonprofit organizations and their programs	Blue Water Baltimore, Civic Works, Flowering Tree Trails, Living Classrooms, Strength to Love, Parks and People Foundation, Tree Baltimore, Baltimore Urban Waters	Anacostia Watershed Society, Anacostia Riverkeeper, Alice Ferguson, Alliance for Chesapeake Bay, Audubon Naturalist Society, Casey Trees, Groundwork Anacostia, Washington Parks and People, Urban Ecosystem Restoration, Watershed Stewards Academy	Chesapeake Bay Trust, Interfaith Partners of the Chesapeake, Nature Conservancy, Sierra Club, Urban Waters Partnerships

Analyzing the exact effect of rebate programs was beyond the scope of this research. But some of the residents mentioned about not availing incentives where available because of the administrative huddles. According to a Watts Branch resident:

In terms of paperwork, you have to put down like \$5,000 first, they did reimburse us but it was kind of hard. They did not make it easy and spending time on that is like a full-time job.

3.2. Tactical sphere: how stakeholders in different agencies/organizations work concertedly

In this section we discuss: (3.2.1) how stakeholders from diverse agencies/organizations work together to achieve the sustainability goals set by local and national governments and, (3.2.2) popular GI BMPs that residents adopt.

3.2.1. Concerted efforts by different agencies/organizations/individuals

Along with different government agencies and nonprofit organizations' programs, there were several environmentally conscious residents who have been involved with GI installations on their properties without any offered incentives. They not

only installed GI on their own properties, but helped their neighbors, and served as the point of contact for the government agencies and nonprofit organizations who were interested in program expansion for communities. In Watershed 263, for example, Adopt-a-lot programs are run by community members. Baltimore Tool Bank is another example of a nonprofit organization, which is committed to provide tools and sites to the community for educational purposes. As Table 2 lists, nonprofit organizations such as PPF, Tree Baltimore, faith-based organization such as Interfaith Partners for the Chesapeake; government agencies such as DPW and DOT were all involved in the achievement of sustainability goals. Additionally, several universities were also involved with broader research and extension activities such as University of Maryland, Georgetown University, Baltimore Ecosystem Study, Johns Hopkins University, and others. Similarly, Watts Branch had several early adopters of GI and they also have an amalgamation of several nonprofit organizations and government agencies promoting GI adoptions. For example, Friends of Quincy Run, and Equity Advisory Group, are some grassroots community service organizations; nonprofit organizations such as AWS, Sierra Club, Anacostia Riverkeeper, UER, WPP; government agencies such as DOEE, DOT, ANC commissioners, PG Department of Environment, and Metropolitan Washington Council of Governments (MWCOG), have all been offering different programs related to GI adoptions in Watts Branch (Chesapeake Bay Partners 2020).

3.2.2. Popular GI BMPs that people adopt

Since all the respondents in our study were involved with GI-related activities, they were asked to describe the way they manage stormwater on their own properties or have been involved with around them. We qualitatively analyzed the BMPs listed by the respondents and sorted those into five broad categories: outreach, residential scale properties, clean-up activities, large scale practices, and property-dependent. The outreach category lists the public engagement activities conducted by different agencies; the residential scale BMPs were practices installed on private properties such as rain barrels/cisterns, rain gardens; clean-up activities were practices preventing pollutants from entering the water body and focused more on particular neighborhoods such as trash and litter clean up; large scale practices were on the public and right of way properties such as curve bump outs, bioswales, stream restorations; and in the property-dependent category respondents mentioned that the BMPs change according to the property type. Appendix B list specific examples of BMPs that were reported under each category.

As Fig. 2 indicates, out of total 115 (n) BMPs, residential scale BMPs (69) were the most common ones followed by large scale (20), outreach (14), and clean-up BMPs (7) with 5 saying they did not manage stormwater. However, the Baltimore GI professionals (BGIP) did not mention about clean-up activities as a BMP compared to the residents (BR) of the same watershed. This could possibly be due to predominantly residential properties in Baltimore and more involvement of residents in clean-up activities than the professionals. Outreach activities were popular among Watts Branch GI professionals and residents, whereas the Baltimore residents did not consider outreach as one of the BMPs and frequently complained about the inadequate outreach activities by the government agencies. Under the tactical sphere, we found that steering activities around achieving sustainability goals were carried out by several stakeholders that were developing programs, financial and institutional regulations and frameworks, infrastructure, and routines, organizing networks and coalitions. They included government agencies, nonprofit organizations, and individuals in both study watersheds. We found several agencies partnering with the residents to implement programs and residents adopting different types of BMPs, residential scale being the dominant category across all stakeholder groups.

3.3. Operational sphere: activities, experiments, and actions

This section discusses activities related to GI installations in both of

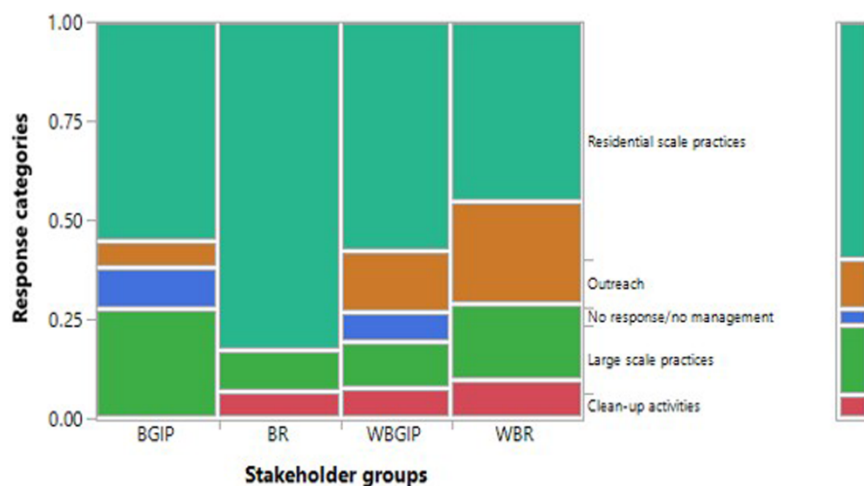


Fig. 2. Popular BMPs-Mosaic plot showing the proportion of responses sorted into different categories among four stakeholder groups: Baltimore Residents (BR), Watts Branch Residents (WBR), Baltimore GI Professionals (BGIP), and Watts Branch GI Professionals (WBGIP). The length of each rectangle (y-axis) represents the proportion of responses for each category (residential scale practices (sea-green), large scale practices (lime green), outreach (orange), clean-up activities (red), no response/no management (blue) within each stakeholder group. The width of each rectangle (x-axis) is proportional to the number of responses for each stakeholder group. Overall proportions of responses in each category for all stakeholder groups combined together are shown on the right.

our study watersheds. We discuss: (3.3.1) the best ways to manage stormwater as perceived by the stakeholders, and (3.3.2) how stakeholders perceive their responsibility towards achieving the sustainability goals set by local and national governments.

3.3.1. Best ways to manage stormwater

There are different ways that stormwater can be best managed, yet increased efforts by governments to implement BMPs is evidence that they have not been sufficiently managed to meet sustainability goals so far. Thus, it is important to know more about what the respondents consider are the best ways. All 42 respondents were asked to discuss on the best ways to manage stormwater. Forty-one (41) respondents discussed a total of 178 individual practices (one respondent saying, “I don’t know”) to manage stormwater. We sorted these responses into 5 broad categories of BMPs defined under Section 3.2.2 and qualitatively analyzed them (Appendix B). Out of the 178 (n) practices, 77 were residential scale, 42 large scale, 40 outreach, 12 clean-up activities, and 7 property-dependent practices.

Below are a few quotes from the stakeholder groups to illustrate the types of responses.

One of the long time Baltimore residents said about existing programs:

“You have places where everything’s a row home, which is gonna [going to] be different than individual houses with large lawns..... Tool Bank have done an amazing job they have built a rain barrel from where they pop out into watering beds where they grow herbs and stuff And the city is doing a good job of trying to get a lot out of the Adopt-a-lot.”

Another Baltimore resident emphasized on educating people:

“So I think one of the best ways to manage stormwater is to educate people about what they can do on almost any size footprint of land that they have.”

According to an official of a prominent environmental agency in Washington, DC:

“There’s so many different types of housing in DC, that they all have their own unique issues that we have to focus on. Which is why we can’t say every house can get all types of projects. Trees is number one, and rain barrels are close second. And then, it would be the landscaping projects. Permeable pavement is a bit more difficult, it’s very specific, it’s very expensive, so it’s not as popular.”

Our analyses indicated that residential scale BMPs were most common among stakeholder groups followed by large scale,

outreach, clean-up, and property-dependent practices. We did not observe any significant differences across the stakeholder groups. This once again proves our earlier conclusion that both the study watersheds have majority of privately owned properties.

3.3.2. Perceived sense of responsibilities among the stakeholders

Since a majority of the properties in both the study watersheds were privately-owned, it was imperative to know who respondents considered was responsible for achieving the green sustainability goals. The majority of the Baltimore GI Professionals (19.05%) thought that the government agencies (city, county, state) are responsible for managing stormwater, whereas majority of the Baltimore Residents said that both residents/individual organizations such as church (11.90%), as well as collective action/partnership/everybody (9.52%) are responsible for stormwater management (Fig. 3). Only 4.76% of GI professionals in each watershed thought that the responsibility depends upon the type of property-whether it is public or private. Below are a few quotes from interviews.

One of the Baltimore residents emphasized on the responsibility of the property owners:

“The property owners, each and every one, which there’s thousands of them. So they all have dramatically changed the landscape in their own way by putting in a house and living under a roof where there used to be probably forests and meadows, undeveloped property.”

One of the long time Watts Branch residents discussed about the government agency’s responsibility in the stormwater management. To quote:

“In the district [DC], Department of the Environment, for us locally, then of course the Department of Energy and then that goes up to Department of the Interior. And so, from the local to the federal, we start moving up the agency chain. Yeah, but for us locally we look to the DC department on the environment (DOEE).”

As per Looresback’s operational sphere, to achieve the sustainability goals, it is important to make a concerted effort involving all the stakeholders to promote more residential scale GI BMPs adoptions. One should identify short-term projects that are often carried out in the context of innovation programs, and everyone should take responsibilities for the program’s success. The residential scale BMPs dominated the list in both the study watersheds but, there is still a substantial need remaining for more people to adopt BMPs. Our study results suggest that GI professionals in both watersheds identified the government agencies as responsible for stormwater management, whereas the residents sided with government agencies along with individual and collective action, Watershed 263 residents giving more

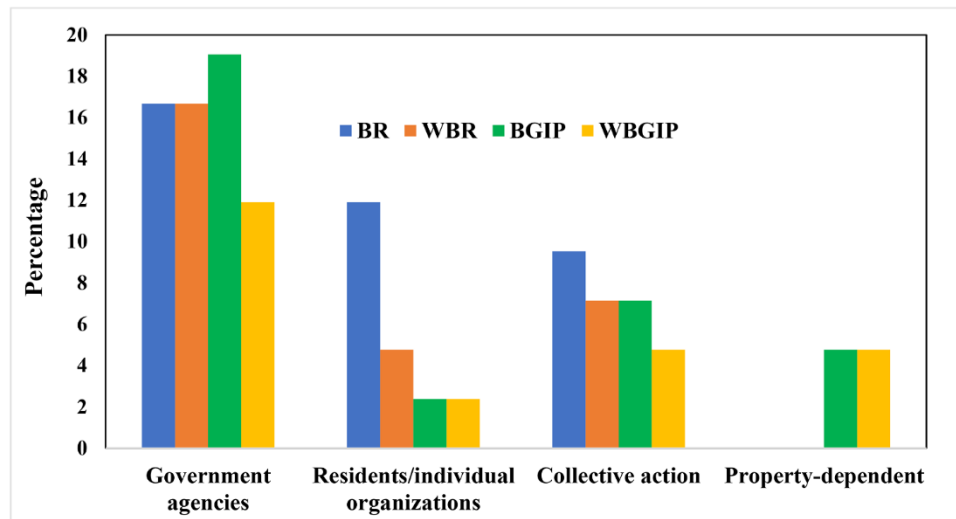


Fig. 3. Perception of Stormwater Management Responsibility - The percentage of different stakeholders (n=42) perceiving who/what entity is responsible for stormwater management (e.g., government agencies, residents, etc.). The stakeholders are Baltimore Residents (BR), Watts Branch Residents (WBR), Baltimore GI Professionals (BGIP), and Watts Branch GI Professionals (WBGIP).

importance to the latter. Our data suggested that stakeholders do realize their respective responsibilities and admitted that the responsibility lies both with the government as well as individual residents.

3.4. Reflexive sphere: evaluation of barriers to GI BMPs adoptions and community outreach

This section analyzes the stakeholder responses on the (3.4.1) barriers to the GI BMPs adoptions, and (3.4.2) community educational outreach activities and related challenges.

3.4.1. Barriers to GI BMPs adoptions

During the interviews, the respondents were asked to discuss about the factors that are perceived as barriers for GI BMPs adoptions. In many instances, the respondents revisited the question several times and listed different types of barriers. We carried out a qualitative analysis and sorted a total of 166 (n) barriers into six categories namely, socio-cultural, institutional, economic/financial, maintenance, environmental, and technological barriers. These categories resulted from our thematic analysis. As Fig. 4 indicates, socio-cultural barriers (65) proved

to be the dominant barrier, followed by institutional (40), economic/financial (24), maintenance (19), environmental (9), and technological barriers (9). We did not find many differences across the stakeholder groups on each category except for Watts Branch residents not mentioning about environmental barriers at all.

Appendix C expands further on each type of barrier listing the qualitative responses. Under socio-cultural barriers, lack of education and awareness, conflicting messaging, environmental issues not being a priority among people, growing geriatric community, mistrust with the system, vacant lots, crime and illegal dumping, disconnect between public agencies and people, not involving locals, people resisting change, etc. were discussed. As mentioned, both the study watersheds had varying physical and socio-economic characteristics, as well as several social issues such as crime, vacant lots, growing geriatric community, etc. Hence, it was not surprising to see these barriers arising in our study results. Institutional barriers included responses such as lack of governmental support, delay in getting permits, top-down approach of the city government, ineffective community engagement, etc. It was surprising that respondents across all the stakeholder groups discussed about institutional barriers, which further indicates that the government



The responses sorted into different categories among four stakeholder groups for the theme, Barriers to GI adoption.

agencies have already identified the institutional barriers and should devise strategies to address those. Economic/financial barriers included expensive water bills, lack of funding, financial burden on residents, paying stormwater fee, etc. For example, the stormwater fee for a regular single-family home in Baltimore city was \$10 (DPW, 2019), \$2.67 in Washington, DC, and \$3.45 in PG County per month. So, people referred to these fees as water bills and felt that they were enormous. Maintenance barriers mostly included lack of funding for maintenance, lack of maintenance, and reliance on residents for maintenance. Environmental barriers included trash, poor soil quality, topography not being conducive, etc. and under technological barriers, respondents discussed how using scientific jargons is not ideal for communication with public, knowledge gap, retrofitting everything that is not applicable to all places, lack of need-based solutions, etc.

We quote respondents discussing several barriers below.

One of the Baltimore City GI professional said,

"I'm not sure exactly how to solve this, but I do think if there were an incentive financially or materially to take care of stormwater, I think that would be the beginning of a solution to the actual problem....."

One of the Baltimore GI professional working for a nonprofit organization felt that it is very difficult to change the mind set of people.

"Changes are always hard. So the barrier would be the people agreeing to make changes..... Public Works have come, Chesapeake Trust have come, Civic Works, Interfaith Partners, Blue Water, Solar people. So we've had a number of informational type services come out to do brief talks, provide free giveaways and information so that people can take those things home."

One of the longtime Watts Branch resident, who has been very actively involved with the GI and environmental issues thought that the scientific language and implicit bias are challenges for people in general.

"The barriers. Language...Well, like I can only deal with [a prominent government agency] because I was on the board. The language was very scientific. And I think that communication is also another issue. I think another barrier is implicit bias as it relates to, oh do those poor people really care about what we're doing?"

One of the experts working for a nonprofit organization in the Watts Branch observed that maintenance is a big challenge:

"There's so much emphasis on getting things off the ground, on treating water to meet a short-term goal that if you don't maintain these systems over time they don't continue to look pretty."

One of the Baltimore residents felt that environmental conditions and trash are a few challenges.

"A lot of locations don't really allow for infiltration because of the soils. when you're in an urban area, and you want to talk about visible pollutants, nutrients and sediment are way low down when you're looking at things like trash, or concerns about bacteria, those are the pollutants that tend to come up a little bit higher."

From the analysis, Appendix C and the quotes, we found that BMPs adoption were not on the priority list of people compared to other issues such as crime, poverty, trash, etc. This could be due to lack of education, inadequate educational outreach activities to inform them, lack of trust in the system, and lack of time commitment from the residents.

3.4.2. Community educational outreach activities and related challenges

During the interviews, the majority of the respondents (88%) discussed community outreach educational activities without initial probe and detailed discussions followed. Out of 142 (n) responses on educational outreach programs, 54 were on government programs, 42 on nonprofit organizations, 20 on community level partners, 7 on faith-based organizations, and 9 on programs offered by university

Table 3

Best ways to reach residents as part of educational outreach programs as suggested by the stakeholder groups from Watershed 263, Baltimore, Maryland and Watts Branch, Prince George's County, Maryland and Washington, District of Columbia.

Stakeholder Groups	Best ways to reach residents
Baltimore Residents	Email, listserv, talking to community, educating kids, App like Next Door, flyers, community meetings
Watts Branch Residents	Social media, door-to-door walk, newsletter in mailbox, meetings, scavenger hunt
Baltimore GI Professionals	Incentives as credits on Water bill for larger builders, meetings
Watts Branch GI Professionals	River walk, community meetings, social media, community listservs, nature walks, door to door outreach, knocking, sending postcards, doing walking tours, barbecue, food, and music in the community, annual conferences, educating communities on maintenance

extensions. Educational outreach activities by the government agencies dominated the list across stakeholder groups followed by nonprofit organizations and community level partners. There were several outreach programs offered by different organizations in our study watersheds. For example, in Watershed 263, the Baltimore Green Resources & Outreach for Watersheds (GROW) Centers offered by the Baltimore City DPW were intended to increase citizen capacity for implementing community greening and stormwater management projects (DPW, 2020). Similarly, DOEE offered outreach programs in the Watts Branch area (Department of Energy and Environment, n.d.) such as Anacostia Environmental Youth Summit, Anacostia River Explorers Program, Middle School Watershed Education, Watershed Stewards Academy, etc. Although faith-based organizations and universities were mentioned, they were not considered as the dominant groups.

Upon further probe into which they thought the best ways to reach people as part of the educational outreach activities were, respondents preferred modern technologies such as social media, mobile apps, flyers, emails/listservs, and many more ways. Table 3 details the responses of the respondents in each study watershed.

Under reflexive sphere, from the data presented in Sections 3.4.1 and 3.4.2 it can be seen that, of the six identified categories of barriers to GI adoption, the socio-cultural barrier is the dominant category across the stakeholder groups, followed by institutional, economic/financial, maintenance, environmental, and technological barriers. Almost all the respondents were equivocal that socio-cultural barriers need to be addressed to increase the adoption of GI among residents. As part of the government programs, the government agencies are required to carry out educational outreach activities in the residential areas. Most of the time, the agencies partnered with nonprofit organizations who already had established partnerships with the local communities. Our data suggest that more targeted educational outreach activities by the government is needed to be more collaborative to inform the residents on GI BMP adoptions.

3.5. Future and solutions for better GI BMPs adoptions

To gauge the respondents' prediction on the future, we asked them to describe what they think the future of GI is. The majority of them (about 55%) were optimistic and felt that the future of GI is bright and would have more green jobs in the future. At the same time, 14% of them were very pessimistic about the future and 31% not providing any response. Sixty-nine percent of the respondents suggested a total of 60 different types of qualitative solutions to achieve the green sustainability goals in the future (Table 4).

Below we quote several respondents to show the quality of the statements. One of the long time Baltimore residents thought that, rain is inevitable so as stormwater management:

Table 4

Solutions provided by the stakeholder groups to attain sustainability goals in Watershed 263, Baltimore, Maryland and Watts Branch, Prince George's County, Maryland and Washington, District of Columbia.

Stakeholder Groups	Solutions to attain sustainable transition goals in the future
Baltimore Residents	Change in policy level, collective actions, political willingness, positive media, social innovation, building future generation, government initiative/laws, changing the culture, push back from residents, resident involvement, system transparency, Role models from other states, GI, removing bureaucratic hiccups, making systems easier for residents for better implementation, more green jobs
Watts Branch Residents	Developers' interest, campaign, engagement, implementation, making things relevant to people that they can relate to, building upon the past and adapting in the future, interactive framework, resiliency framework, homeowners' involvement, community involvement, raising awareness, empowering/educating people, green jobs, solution-oriented, smarter approach, better knowledge, restoring nature, shrink built footprints
Baltimore GI Professionals	Community partnership, changing system, retrofits, changing management system, decentralized technologies, giving back to the community, environmental restoration, instilling environmental culture in next generation, fund to put in practices
Watts Branch GI Professionals	Retrofits, education and citizen engagement, continue monitoring of water quality, working on failures, stream restoration, changing mindset, environmental awareness, natural solutions, community engagement, political mindset, people's thinking, new innovation and new technology use

"Well stormwater's going to be here no matter what. Whether we manage it or not. I think it has the potential to grow into an industry."

One of the GI professionals working in the Baltimore 263 said:

"Whether the systems that we have are durable into the future, whether green infrastructures are durable into the future, but more substantially, is it even possible to create a new system out of retrofits, what are essentially piecemeal retrofit systems?."

The respondents were optimistic about the future of GI and felt that it will generate more green jobs for the future generations. They also provided several thought-provoking solutions to achieve future sustainability goals, which included community involvement/citizen partnership, changes in policy level, changing mind-set of people, reducing bureaucratic challenges, empowering the youth, etc. (Table 4).

4. Summary and conclusion

Our multi-disciplinary team utilized a transition management framework, in-depth interviews, and CBPR approach to better understand the existing knowledge and perceptions of the GI BMPs across diverse stakeholder groups in terms of sense of responsibility, barriers, community educational outreach activities, and the future of GI in two varying jurisdictional, physical, and socio-economically diverse watersheds in the Chesapeake Bay area. To our knowledge, this study is one of the first to apply Looorback's governance schema to characterize stormwater governance activities within four spheres (strategic, tactical, operational, and reflective) relevant to societal transitions, using data from 42 in-depth interviews and an assessment of the government GI policies. We found that strategic activities were largely driven and shaped by the overarching national policy that regulates water quality in the USA, the Clean Water Act, and resultant regulations at local levels, such as MS4 permit and TMDL limits in both the study watersheds. Tactical activities were carried out by several stakeholders including government agencies, nonprofit organizations, and community members. The Baltimore professionals (BGIP) did not mention about clean-up activities as a BMP compared to the residents (BR) of the same watershed. Outreach activities were popular among Watts Branch GI professionals and residents, whereas the Baltimore residents did not consider outreach as one of the BMPs.

As operational activities, we discussed BMPs that the respondents listed as prominent, and their perceptions of responsibility towards achieving sustainability goals. Residential scale was the most adopted BMPs presumably because majority of the properties in both the watersheds are privately owned. However, to meet water quality goals, there is still a substantial need remaining for more people to adopt GI BMPs. Our data suggested that stakeholders do realize their respective responsibilities and admitted that the responsibility lies both with the residents. Under the reflexive sphere,

we evaluated perceived barriers to GI BMPs adoption and community educational outreach activities. We identified five categories of perceived barriers, with socio-cultural being the dominant category across all stakeholder groups. Lack of maintenance and funding for that was another barrier, which needed to be addressed for long term sustainability planning. Despite considerable involvement by the government agencies, several community members, and nonprofit organizations, our study results indicated that educational outreach activities surrounding GI BMPs adoptions was inadequate, especially in Watershed 263.

Achieving the green sustainability goals is still challenging and a concerted effort among all the stakeholders is needed. Incorporating multi-stakeholders' perspectives at the inception of the sustainability planning process is warranted to make the process more efficient and trustworthy. Decision-making often involves constructive two-way open dialogue between government, policymakers, nonprofit organizations, residents, environmental professionals, and others. Residents' engagement and willingness is critical to achieve sustainability goals in the Chesapeake Bay area. Local communities must understand the benefits of GI adoptions, prioritize it, and be willing to participate.

We suggest several policy measures to improve water quality in the region. Along with long term planning, the policymakers should introduce different spheres of the transition management governance and be more inclusive, collaborative, and involve stakeholders from the beginning of any planning process. Government should take proactive measures to bring GI adoptions to the priority list of residents, at the same time not overwhelming people with excess-messaging. More meaningful outreach activities using modern technology such as smartphone applications and social media, are needed to build trust with the residents. This trust will increase the GI BMPs adoption rates. They need to address the socio-cultural barriers resulted from our study. At the same time, residents also need to take up more responsibility for collective action to help implement GI BMPs. More studies should use CBPR approach just like ours to gain in-depth insights and data to build meaningful partnership with the community and stakeholders. It would be interesting to explore the effectiveness of the rebate and incentives programs in both the study watersheds and evaluate the community educational outreach programs offered by different agencies. Urban stormwater can be a signature model and inform social transition management theory as well as coupled natural-human systems theory. With increasingly polluted watersheds and a realization that technical approaches to urban water management (i.e., regulatory requirements, monitoring, local ordinances, etc.) have been insufficient, better understanding of the adoption of GI BMPs at the residential scale presents a compelling societal transition. And there are important environmental reasons i.e., less flooding, cleaner water, development of vacant lots, for this too. Since we compared two watersheds with varying jurisdictional, physical and socio-economic characteristics, the results from this study can be applied in other cities within USA and elsewhere to understand the underlying socio-cultural factors affecting the adoption of GI to

reach sustainability goals.

CRediT authorship contribution statement

Debasmita Patra: Conceptualization, Methodology, Investigation, Data curation, Visualization, Formal analysis, Writing – original draft. **Victoria Chanse:** Funding acquisition, Methodology, Writing – review & editing. **Amanda Rockler:** Funding acquisition, Writing – review & editing. **Sacoby Wilson:** Funding acquisition, Writing – review & editing. **Hubert Montas:** Funding acquisition, Writing – review & editing. **Adel Shirmohammadi:** Funding acquisition, Writing – review & editing. **Paul T. Leisnham:** Funding acquisition, Project administration, Resources, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial

interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

This work was supported by the National Science Foundation (grant number- DEB 1824807). We thank our Community Advisory Board members for guiding us throughout our project. We thank our community partners Parks and People Foundation, Blue Water Baltimore, and Anacostia Watershed Society for providing all the help and support needed during the fieldwork. We would like to thank all the respondents for their overwhelming participation during the interviews offering different perspectives. We would like to thank Ms. Emma Lipsky for helping with transcriptions of several interview audio tapes and Zeshu Zhang for providing SES data and inset maps of two watersheds. Last but not least, we thank the anonymous reviewers for their incredible help to give a wonderful shape to our manuscript.

Appendix A. Socio-Economic Status of Baltimore and Washington, District of Columbia

The largest metropolitan regions in the Chesapeake Bay watersheds are Washington, DC and Baltimore, MD, which are located roughly 73 km apart and house 705,749 million people with a median household income of \$82,604, and 593,490 million people with a median household income of \$48,840, respectively (USA Census Bureau, 2019). Both cities are similar in geographic size, age, and population density. They lie in the Humid Subtropical climate zone. Precipitation occurs on average at a rate of 3-4 inches (76 to 102 mm) per month with the lower value in April and the high in September. They are both coastal cities with direct connections to the Chesapeake Bay. Both cities have new sustainability plans yet are in violation of air and water quality regulations; however, they each have established a 40% urban tree canopy goal. Washington, DC and Baltimore show clearly different social characteristics. The cities differ in recent population trajectories: while Baltimore recorded historically lowest number of population., under 600 million (1.2% decline from 2018) and has more than 30,000 vacant properties within the City limits (Baltimore Sustainability, 2019) and the Washington, DC population grew by 0.6% in the same time period and has less than one-eighth the vacant lots in Baltimore (4152). Baltimore and Washington, DC have 31.2% and 57.6% of residents over 25 years of age have attained a Bachelor's degree or higher, respectively (USA Census Bureau, 2019). Both cities have a high percentage of households subsisting below the poverty line (21.8% in Baltimore and 16.2% in Washington, DC with a nation-wide rate of 11.8%). Hence, both the cities have substantial socioeconomic variation among neighborhoods.

Appendix B. Qualitative analysis of popular BMPs as reported by respondents from Watershed 263, Baltimore, Maryland and Watts Branch, Prince George's County, Maryland and Washington, District of Columbia

Outreach	Residential scale practices	Clean-up activities	Large scale practices	Property-dependent
- community engagement	- rain barrel	- clean-up trash	- curve bump outs	- one should opt for a BMP depending upon the type of the property (public, private, right of way, industrial, vacant lot, etc.)
- following existing program models	- rain garden	- clean-up litter	- bio retention ponds	
- community partners	- permeable pavers	- clean-up gutter	- GI	
- educating people and kids	- impervious surface removal	- no dumping	- stream restoration	
- social media	- native plants	- dealing with vacant properties	- trees	
- App	- water reuse	- clean-up drains	- green roof	
- camps	- cistern	- clean-up debris	- dry well	
- marking drains	- pump	- clean-up dead leaves	- intercept or catch the rain where it falls	
- laws	- downspout-disconnect		- retrofit	
- regulations	- conservation landscape		- environmental site design	
- policy			- low impact development	
- better implementation			- environmental co-benefits	
- social acceptance				
- maintenance				

Appendix C. Qualitative analysis of barriers to adopting GI BMPs reported by stakeholder groups from two study watersheds: Watershed 263, Baltimore, Maryland and Watts Branch, Prince George's County, Maryland and Washington, District of Columbia

Population	Socio-cultural	Institutional	Economic/financial	Maintenance	Environmental	Technological
- BR	- community outreach is for politically active communities - exclusion by language/ethnicity - less responsibility from renters - lack of awareness and education - lack of youth education - vacant lots - not a priority - changing the mind-set of people is hard - legends to deal with recycle bins	- lack of government/institutional support - programs for residents like by BGE - delay in getting permits - no law enforcement - lack of support from city government - top-down approach of the city structure - other utility companies making mess	- water bill - financial constraints - lack of financial incentives - lack of funding - new developments should pay more attention to it - financial burden on residents	- lack of funding for maintenance	- trash	- abstract issues people can't relate to
- WBR	- lack of education - geriatric community - inconsistent messaging across the stakeholders - lack of youth education - bias toward poor people - people doing work on stormwater or environment have decent jobs and get time - not a priority - putting lot of burden on people is making them against environment - mistrust in outsiders - people skill is needed to understand communities - lack of making people understand the consequences of their action - lack of need-based solution to people - showing people how their action impacts the environment	- ineffective community engagement - lack of public awareness of government program - working to get MS4 permit rather than build healthy eco-systems	- cost associated with GI is huge	- lack of emphasis on maintenance - lack of proper maintenance guidelines		- scientific jargons detrimental to communication to general public - knowledge gap
- BGIP	- not a priority among people - conflicting expectations - push back from communities - bigger issues like crime and illegal dumping - lack of education	- illegal dumping - interference of utilities - permitting procedure takes a lot of time - interagency approval is difficult because of potential credit associated with their work - not enough land - underground conflicts	- costly projects and limited funding - stormwater fee	- no funding for maintenance - lack of maintenance - maintenance-intensiveness of the stormwater - reliance on the residents to volunteer to maintain (adopt-a-lot)	- trash - poor soil quality - showing people how their action impacts the environment	- desktop analysis and reality are different things - lack of technology and communication - retrofitting rather than having a new system - lack of making people understand the consequences of their action - lack of need-based solution to people - not feasible to put the facility in the ground

(continued on next page)

(continued)

	- lack of transparency might lead to projects being frozen	- vacant lots	- more centralized bureaucracy			
- WBGIP	- not much political support	- people's perception	- regulatory	- financial	- maintenance not funded	- topography not conductive
	- not a priority	- permit process takes time	- costly			- use of jargons by others that communities don't understand
	- time management is difficult	- installations should be subsidy-based				
	- lack of education among people on the topic	- people making decisions are not environmentally educated				
	- resistance from the public					
	- mistrust of public in government (historically underserved communities					
	- geriatric community					
	- disconnect between public agencies and people					
	- locals were not involved					
	- other barriers like crime, violence, infant mortality rate, low life expectancy					
	- people resisting sometimes like parking space removal					

References

- Andersson, E., Barthel, S., Borgström, S., Colding, J., Elmqvist, T., Folke, C., & Gren, Å. (2014). Reconnecting cities to the biosphere: Stewardship of green infrastructure and urban ecosystem services. *Ambio*, 43, 445–453. <https://doi.org/10.1007/s13280-014-0506-y>. <https://doi.org/>
- Balany, F., Ng, A. W., Muttill, N., Muthukumaran, S., & Wong, M. S. (2020). Green infrastructure as an urban heat island mitigation strategy—A review. *Water*, 12, 3577. <https://doi.org/10.3390/w12123577>. <https://doi.org/>
- Baltimore Office of Sustainability: Nature in the City Chapter: Sustainability Plan, 2019. https://www.baltimoresustainability.org/wp-content/uploads/2019/02/Sustainability-Plan_Ch5-4_Nature.pdf. (accessed October 20, 2020).
- BenDor, T. K., Shandas, V., Miles, B., Belt, K., & Olander, L. (2018). Ecosystem services and US stormwater planning: An approach for improving urban stormwater decisions. *Environmental Science & Policy*, 88, 92–103.
- Braun, V., & Clarke, V. (2013). *Successful qualitative research: A practical guide for beginners*. London: SAGE.
- Carballo-Penela, A., & Castromán-Diz, J. L. (2015). Environmental policies for sustainable development: An analysis of the drivers of proactive environmental strategies in the service sector. *Business Strategy and the Environment*, 24, 802–818. <https://doi.org/10.1002/bse.1847>. <https://doi.org/>
- Cettner, A., Ashley, R., Hedström, A., & Viklander, M. (2014). Sustainable development and urban stormwater practice. *Urban Water Journal*, 11, 185–197. <https://doi.org/10.1080/1573062X.2013.768683>. <https://doi.org/>
- Chaffin, B. C., Shuster, W. D., Garmestani, A. S., Furio, B., Albro, S. L., Gardiner, M., ... Green, O. O. (2016). A tale of two rain gardens: Barriers and bridges to adaptive management of urban stormwater in Cleveland, Ohio. *Journal of Environmental Management*, 183, 431–441. <https://doi.org/10.1016/j.jenvman.2016.06.025>. <https://doi.org/>
- Chanse, V., Mohammed, A., Wilson, S., Delamarre, L., Rockler, A., Leisnham, P. T., Shirmohammadi, A., & Montas, H. (2017). New approaches to facilitate learning from youth: Exploring the use of Photovoice in identifying local watershed issues. *Journal of Environmental Education*, 48, 109–120.
- Chesapeake Bay Partners, 2020. <https://www.chesapeakebay.net/who/partners>. (accessed October 20, 2020).
- Chesapeake Bay Partners, 2013. <http://ian.umces.edu/ecocheck/reportcards/chesapeake-bay/2013/> (accessed 05 January 2020).
- Chini, C. M., Canning, J. F., Schreiber, K. L., Peschel, J. M., & Stillwell, A. S. (2017). The green experiment: Cities, green stormwater infrastructure, and sustainability. *Sustainability*, 9, 1–21. <https://doi.org/10.3390/su9010105>. <https://doi.org/>
- Copeland, C. (2016). Green infrastructure and issues in managing urban stormwater. *Congressional Research Service report*. <https://fas.org/sfp/crs/misc/R43131.pdf>.
- Corburn, J. (2005). *Street science: Community Knowledge and Environmental Health Justice*. Cambridge, MA: MIT Press.
- Coutts, C., & Hahn, M. (2015). Green infrastructure, ecosystem services, and human health. *International Journal of Environmental Research and Public Health*, 12, 9768–9798. <https://doi.org/10.3390/ijerph120809768>. <https://doi.org/>
- De Haan, F. J., Rogers, B. C., Frantzeskaki, N., & Brown, R. R. (2015). Transitions through a lens of urban water. *Environmental Innovation and Societal Transitions*, 15, 1–10. <https://doi.org/10.1016/j.eist.2014.11.005>. <https://doi.org/>
- Department of Public Works, Baltimore City, 2019. <https://publicworks.baltimorecity.gov/pw-bureaus/water-wastewater/stormwater>. (accessed October 20, 2020).
- Department of Public Works (DPW), GROW Centers, 2020. <https://publicworks.baltimorecity.gov/grow-center>. (accessed July 02, 2021).
- Dernoga, M. A., Wilson, S., Jiang, C., & Tutman, F. (2015). Environmental justice disparities in Maryland's watershed restoration programs. *Environmental Science & Policy*, 45, 67–78. <https://doi.org/10.1016/j.envsci.2014.08.007>. <https://doi.org/>
- Dhakal, K. P., & Chevalier, L. R. (2016). Urban stormwater governance: The need for a paradigm shift. *Environmental Management*, 57, 1112–1124. <https://doi.org/10.1007/s00267-016-0667-5>. <https://doi.org/>
- Dhakal, K. P., & Chevalier, L. R. (2017). Managing urban stormwater for urban sustainability: Barriers and policy solutions for green infrastructure application. *Journal of Environmental Management*, 203, 171–181. <https://doi.org/10.1016/j.jenvman.2017.07.065>. <https://doi.org/>
- Department of Energy and Environment (DOEE). N.d. <https://doee.dc.gov/education>. (accessed June 30, 2021).
- Environmental Protection Agency (EPA): Overview of Total Maximum Daily Loads. 2020. <https://www.epa.gov/tmdl/overview-total-maximum-daily-loads-tmdls>. (accessed October 20, 2020).
- Environmental Protection Agency (EPA): Stormwater Phase II Final Rule Public Education and Outreach Minimum Control Measure. 2020. <https://www.epa.gov/sites/production/files/2015-11/documents/fact2-3.pdf>. (accessed October 20, 2020).
- Geels, F. W. (2005). Processes and patterns in transitions and system innovations: Refining the co-evolutionary multi-level perspective. *Technological Forecasting and Social Change*, 72, 681–696. <https://doi.org/10.1016/j.techfore.2004.08.014>. <https://doi.org/>

- Guest, G., MacQueen, K. M., & Namey, E. E. (2012). *Applied thematic analysis*. Los Angeles: Sage Publications.
- Hester, E. T., & Little, J. C. (2013). Measuring environmental sustainability of water in watersheds. *Environmental Science & Technology*, 47, 8083–8090. <https://doi.org/10.1021/es400513f>. <https://doi.org/>
- Huang, L., Zheng, W., Hong, J., Liu, Y., & Liu, G. (2020). Paths and strategies for sustainable urban renewal at the neighbourhood level: A framework for decision-making. *Sustainable Cities and Society*, 55, Article 102074. <https://doi.org/10.1016/j.scs.2020.102074>. <https://doi.org/>
- JMP version 14, SAS Institute Inc., Cary, NC.
- Kates, R. W., Clark, W. C., Corell, R., Hall, J. M., Jaeger, C. C., Lowe, I., ... Svedin, U. (2001). Sustainability science of local communities. *Science*, 292, 641–642.
- Kim, G. (2018). An integrated system of urban green infrastructure on different types of vacant land to provide multiple benefits for local communities. *Sustainable Cities and Society*, 36, 116–130. <https://doi.org/10.1016/j.scs.2017.10.022>. <https://doi.org/>
- Legard, R., Keegan, J., & Ward, K. (2003). In-depth Interviews. In J. Richie, & J. Lewis (Eds.), *Qualitative Research Practice* (pp. 139–168). London: Sage.
- Liu, O. Y., & Russo, A. (2021). Assessing the contribution of urban green spaces in green infrastructure planning for urban ecosystem conditions and services. *Sustainable Cities and Society*, 68, Article 102772. <https://doi.org/10.1016/j.scs.2021.102772>. <https://doi.org/>
- Liu, Y., Engel, B. A., Flanagan, D. C., Gitau, M. W., McMillan, S. K., & Chaubey, I. (2017). A review on effectiveness of best management practices in improving hydrology and water quality: Needs and opportunities. *The Science of the Total Environment*, 601–602. <https://doi.org/10.1016/j.scitotenv.2017.05.212>, 580–593 <https://doi.org/>
- Loorbach, D. (2010). Transition management for sustainable development. *Gov. an Int. J. policy*, 23, 161–183. Adm. institutions.
- Loorbach, D., Frantzeskaki, N., & Avelino, F. (2017). Sustainability transitions research: Transforming science and practice for societal change. *Annual Review of Environment and Resources*, 42, 599–626. <https://doi.org/10.1146/annurev-environ-102014-021340>. <https://doi.org/>
- Loorbach, D., & Rotmans, J. (2006). Managing transitions for sustainable development. In X. Olsthoorn, & A. J. Wicorek (Eds.), *Understanding Industrial Transformation: Views from Different Disciplines*. Dordrecht: Springer. X. Olsthoorn.
- Lovell, S. T., & Taylor, J. R. (2013). Supplying urban ecosystem services through multifunctional green infrastructure in the United States. *Landscape Ecology*, 28, 1447–1463. <https://doi.org/10.1007/s10980-013-9912-y>. <https://doi.org/>
- Maeda, P. K., Shirmohammadi, A., Leisnham, P. T., Chanse, V., Rockler, A., Montas, H., & Wilson, S. (2018). Linking stormwater best management practices to social factors in two suburban watersheds. *Plos One*, 1–23.
- Maryland Department of Environment, 2020. https://mde.maryland.gov/programs/water/stormwatermanagementprogram/pages/npdes_ms4_new.aspx. (accessed October 20, 2020).
- Mayer, A. L., Shuster, W. D., Beaulieu, J. J., Hopton, M. E., Rhea, L. K., Roy, A. H., & Thurston, H. W. (2012). Building green infrastructure via citizen participation: A six-year study in the Shepherd Creek (Ohio). *Environmental Practice*, 14, 57–67. <https://doi.org/10.1017/S1466046611000494>. <https://doi.org/>
- Millennium Ecosystem Assessment Board. (2005). *Ecosystems and human well-being: Current state and trends. Findings of the Condition and Trends Working Group. Millennium ecosystem assessment series (report)*. Washington, DC: Island Press.
- Nassauer, J. I., Wang, Z., & Dayrell, E. (2009). What will the neighbors think? Cultural norms and ecological design. *Landscape and Urban Planning*, 92(3), 282–292.
- National Research Council (NRC). (2009). *Urban Stormwater Management in the United States*. Washington, DC: National Academies Press. <https://www.nap.edu/catalog/12465/urban-stormwater-management-in-the-united-states>.
- Patton, M. Q. (2002). *Qualitative research & evaluation methods* (3rd ed.). Thousand Oaks, CA: Sage.
- Committee Members Reckhow, K. H., Norris, P. E., Budell, R. J., Di Toro, D. M., Galloway, J. N., Greening, H., Sharply, A. N., Shirmohammadi, A., Stacey, P. E., Johnson, S. E., & Stoeber, M. J. (2011). *Achieving nutrient and sediment reduction goals in the Chesapeake Bay: An evaluation of program strategies and implementation* (p. 246p). Washington, DC: National Research Council (NRC) of National Academies, The National Academies Press.
- Rendon, C., Osman, K. K., & Faust, K. M. (2021). Path towards community resilience: Examining stakeholders' coordination at the intersection of the built, natural, and social systems. *Sustainable Cities and Society*, 68, Article 102774. <https://doi.org/10.1016/j.scs.2021.102774>. <https://doi.org/>
- Rickenbacker, H., Brown, F., & Bilec, M. (2019). Creating environmental consciousness in underserved communities: Implementation and outcomes of community-based environmental justice and air pollution research. *Sustainable Cities and Society*, 47, Article 101473. <https://doi.org/10.1016/j.scs.2019.101473>. <https://doi.org/>
- Rotmans, J., & Kemp, R. R. (2003). Managing societal transitions: Dilemmas and uncertainties: The Dutch energy case study. *OECD Workshop on the Benefits of Climate Policy: Improving Information for Policy Makers*. <http://www.oecd.org/environment/cc/2483769.pdf> accessed October 20, 2020.
- Roy, A. H., Wenger, S. J., Fletcher, T. D., Walsh, C. J., Ladson, A. R., Shuster, W. D., ... Brown, R. R. (2008). Impediments and solutions to sustainable, watershed-scale urban stormwater management: Lessons from Australia and the United States. *Environmental Management*, 42, 344–359. <https://doi.org/10.1007/s00267-008-9119-1>. <https://doi.org/>
- Schifman, L. A., Tryby, M. E., Berner, J., & Shuster, W. D. (2018). Managing uncertainty in runoff estimation with the U.S. Environmental protection agency national stormwater calculator. *Journal of the American Water Resources Association*, 54, 148–159. <https://doi.org/10.1111/1752-1688.12599>. <https://doi.org/>
- Söderberg, H., & Aberg, H. (2002). Assessing socio-cultural aspects of sustainable urban water systems - the case of Hammarby Sjöstad. *Water Science and Technology-Water Supply*, 2, 203–210.
- Srinivasan, S., & Collman, G. W. (2005). Evolving partnerships in community. *Environmental Health Perspectives*, 113(2), 1814–1816.
- Rain Check Rebate, 2019. <https://www.princegeorgescountymd.gov/313/Rebates> Accessed October 20, 2020.
- Sustainable Development Goals, 2020. <https://www.un.org/sustainabledevelopment/cities/>. (accessed October 20, 2020).
- The Clean Watershed Partnership, 2020. Available at: <https://thecleanwaterpartnership.com/about-the-project/>. Accessed October 20, 2020.
- Tzoulas, K., Korpela, K., Venn, S., Yli-Pelkonen, V., Kąrmierczak, A., Niemela, J., & James, P. (2007). Promoting ecosystem and human health in urban areas using Green Infrastructure: A literature review. *Landscape Urban Planning*, 81, 167–178. <https://doi.org/10.1016/j.landurbplan.2007.02.001>. <https://doi.org/>
- UNESCO World Water Assessment Programme, 2018. The United Nations world water development report: nature-based solutions for water. <https://unesdoc.unesco.org/ark:/48223/pf0000261424>. (accessed October 20, 2020).
- Ureta, J., Motallebi, M., Scaroni, A. E., Lovelace, S., & Ureta, J. C. (2021). Understanding the public's behavior in adopting green stormwater infrastructure. *Sustainable Cities and Society*, 69, Article 102815. <https://doi.org/10.1016/j.scs.2021.102815>. <https://doi.org/>
- US Census Bureau, 2019. <https://www.census.gov/quickfacts/fact/table/baltimorecitymaryland,US/PST045219>; <https://www.census.gov/quickfacts/DC>. (accessed October 20, 2020).
- US Congress, 2019. <https://www.congress.gov/bill/115th-congress/house-bill/7279> (accessed August 05, 2021).
- Van der Brugge, R., 2009. Transition Dynamics in Social-Ecological System - The Case of Dutch Water Management. <https://repub.eur.nl/pub/16186/VanderBrugge2009dissertatie.pdf>. (accessed December 17, 2020).
- Yin, R. K. (2014). *Case Study Research: Design and Methods* (fifth ed). Los Angeles: Sage.