



Green Stormwater Infrastructure:

Maintaining Equitable Systems

Statement of Authorship

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Abbreviations

aBMP – Alternative Best Management Practice
DHCD – Department of Housing and Community Development
DPW – Department of Public Works
DOT – Department of Transportation
GI – Green Infrastructure
GSI – Green Stormwater Infrastructure
MOU – Memorandum of Understanding
NGO – Not-for-Profit or Non-governmental Organization

Cover photograph: Henrietta Lacks Educational Park, Baltimore, MD.

Definitions

Green Infrastructure and Green Stormwater Infrastructure

The definition of and distinctions between Green Infrastructure (GI) and Green Stormwater Infrastructure (GSI) are widely debated amongst practitioners, academics, and other stakeholders. For the purposes of this report we maintain a distinction between these two terms. GI, when mentioned in this document, refers to interconnected green spaces that serve multiple functions.

GSI, on the other hand, refers to site specific facilities that manage the impacts of stormwater runoff. In our study city of Baltimore, these facilities are built to address stormwater quality. We recognize that other cities may construct GSI to address issues pertaining to the quantity of stormwater runoff.

Equity

Equity is an oft mentioned, but ill defined, characteristic of contemporary environmental and sustainability plans. This report defines equity as fairness in the context of needs, choices, and merit of decisions, pertaining to environmental benefits and burdens.

Equity can have multiple dimensions including:

- **Distributional** - Where are benefits and burdens located?
- **Procedural** - How are decisions that shape benefits and burdens made?
- **Structural** - What historical benefits and burdens have shaped social structures?
- **Transgenerational** - How will future generations be influenced by benefits and burdens?

For equity to be an outcome of a project, these multiple, and often intersecting dimensions, must be considered.

1.1 - Project description

A recent project led by Cary Institute of Ecosystem Studies with researchers from The New School, University of California - Davis, and the USDA Forest Service - Baltimore Field Station investigated the question, *Is Green Infrastructure (GI) a Universal Good?* Researchers addressed this question through three separate, but interrelated inquiries:

- **Objective I** - To map the spatial context of green stormwater infrastructure (GSI) relative to the social and demographic contexts of different neighborhoods in Baltimore.
- **Objective II** - To identify positive and negative perceptions residents and institutional stakeholders hold about GSI in these neighborhoods.
- **Objective III** - To evaluate whether sustainability plans from 20 US cities acknowledge a potentially different relationship of green infrastructure among underserved neighborhoods.

1.2 - Summary of overall recommendations

In conducting this research, we identified governance challenges in Baltimore that we suspect are broadly applicable to US cities as they work to expand the use, efficacy, and impact of GSI. To test whether a broad level of generality between cities is possible, we propose conducting interviews and surveys to learn more about governance networks and strategies in six US cities working to expand the use of GSI. The synthesis of this research will form the basis of a toolkit to improve governance practices, protocols, and shared standards related to GSI. This toolkit will offer a variety of resources tailored for city agencies, institutions, and residents.



Inlet and vegetation in curb bump-out, Baltimore, MD.

1.3 - What can our recommendations achieve?

Our GSI governance toolkit will provide a suite of activities and practices that allow cities to achieve equitable outcomes through the development of collaborative procedures, protocols, and systems. We define governance as “processes involving collective action and resource allocation and use across multiple societal actors.”¹ Another way to think about governance is the practices groups and actors use to manage systems collaboratively. City, institutional, and residential stakeholders who utilize the toolkit will be able to identify the network of roles and responsibilities of those working to implement GSI in their cities. They will also be able to suggest concrete strategies for improving how these actors work together to achieve just environmental outcomes.

This toolkit considers GSI as a system that complements existing strategies emphasizing hydrologic or functional outcomes of specific installations. The resources provided in the toolkit will cultivate the development of broadly conceived maintenance procedures that can involve multiple stakeholders. We understand maintenance as the critical, and often hidden work, that allows technologies, communities, and institutions to keep going. Developing clear and accessible maintenance interventions is essential to ensure that GSI is supported economically, socially, politically, ecologically, and institutionally. Emphasizing the development of cross-disciplinary maintenance protocols ensures that GSI emerges as a durable system that will persist into the future.

1.4 - Existing GSI toolkits

Existing GI or GSI toolkits are primarily written for cities and people working within governmental institutions. These resources provide important information about how to install GI, where to acquire funding, or how to design projects that include community feedback.

Additionally, these kits are often written for municipalities looking to build GSI for the first time.

Fewer, if any, toolkits address the challenges of developing actionable and attainable procedures, regulations, and permissions among diverse communities of participants. We frame this issue

as one of ‘stakeholder governance’. The need for developing strategies for stakeholder governance emerges with increased uptake of GSI beyond pilot projects. Because GSI projects often involve collaboration among cities, residents, and institutional actors, a need exists to codify strategies for collaboration.

Maintenance is the critical, and often hidden, work that allows technologies, communities, and institutions to keep going.

With this in mind, we propose developing a toolkit that guides processes for the management and maintenance of GSI as a system of socially responsible environmental interventions. This toolkit will be a best fit for urban areas that are working to implement GSI, yet are experiencing growing pains as projects scale, involved stakeholders become more numerous, and actors grapple with the fair distribution and allocation of facilities.

¹Muñoz-Erickson, Tischa A., Lindsay K. Campbell, Daniel L. Childers, J. Morgan Grove, David M. Iwaniec, Steward T.A. Pickett, Michele Romolini, and Erika S. Svendsen. 2016. “Demystifying Governance and Its Role for Transitions in Urban Social-Ecological Systems.” *Ecosphere* 7 (11): 1–11. <https://doi.org/10.1002/ecs2.1564>.

The scaling of GSI projects presents a conundrum for stakeholders. Unlike other municipal infrastructure, like sewer or electrical systems, individual facilities are not directly networked together. If one ‘node’ fails, the system is generally unaffected. Yet, the cumulative benefits of GSI are often presented as a desired outcome. There is a disconnect between the discrete facility and the system it is envisioned to contribute to. We understand this problem as one of momentum – as facilities multiply, intended effects and goals span across the whole system.² Thus, there is a need to develop community protocols, practices, and standards that can support this growth to achieve both localized and system-spanning effects.

1.5 - What is required to make this recommendation successful?

Our research efforts in Baltimore were the product of two years of community cultivation and engagement. We recognize that this specific form of place-based outreach is unfeasible for multi-city, comparative research. In order to better understand the shared challenges of stakeholder governance between cities, we will draw from tested community engagement strategies. Successful outreach requires building responsive relationships between researchers and informants. The success of our recommendations are tied to our ability to cultivate trust while engaging with knowledgeable stakeholders. The creation of a toolkit will serve as one measure of this trust through the open sharing of results that emerge from our research.

A need exists to develop community protocols, practices, and standards to support the growth of green stormwater infrastructure as a system.



A community run green space with green stormwater infrastructure.

1.6 - Key recommendations for constructing a toolkit:

- Locate six cities at similar stages of GSI system building as Baltimore.
- Identify active organizational and community stakeholders involved in GSI governance.
- Develop and pilot interview protocols, tools, and survey instruments to assess governance structures and relationships currently in place.
- Synthesize findings across study sites into a ‘governance toolkit’.
- Develop use cases of the toolkit.

² Hughes, Thomas P 1994. “Technological Momentum.” In Does Technology Drive History? The Dilemma of Technological Determinism, 101–13. Cambridge, MA: MIT Press.

II: Case Study: Observed Roadblocks to the Uptake of GSI in Baltimore

2.1 - Problem context

The management of urban environments has long been a process involving many stakeholders including public works officials, non-profit organizations (NGOs), citizen-led advocacy coalitions, parks professionals, and others. The number of actors who contribute expertise to matters of environmental concern has only grown in recent years as cities implement green technologies, resilience initiatives, and sustainability plans. This growing number of participants, combined with the need to assess multiple measures of fairness, means that many cities are grappling with questions of how to best govern for equitable environmental change.

One initiative at the helm of this transition is the use of GSI to decrease impervious surface area, improve water quality, reduce strain on existing grey infrastructure, and provide a suite of beneficial ecosystem services. For the past 15 years, many stakeholders within Baltimore City have designed, constructed, and maintained GSI with variable success. Some GSI within the city remain in excellent condition, while others sit abandoned. Explanations for this divide can be traced to variable priorities, regulatory constraints, and divergent goals across stakeholder positions. Addressing this changing terrain between groups requires a reassessment of existing governance strategies and networks.

2.2 - Identified stakeholders

Baltimore's supporters of GSI often emerge from three distinct stakeholder positions—City, NGO, and Resident. While the knowledge systems within these positions are not unified, these categories offer an index for how stakeholders are able to articulate and assert power within the sustainable city.

For instance, many city departments including Public Works (DPW), Transportation (DOT), and Housing and Community Development (DHCD) want to pursue GSI

projects. Yet, only some departments have the funding mandate required for implementation. While city stakeholders share positions as institutional actors, individual agency directives dictate how, and whether, GSI is prioritized. Importantly, this highlights how occupying a position as a governmental stakeholder does not automatically equate to the ability to build or contribute to the system.

On the other hand, NGOs that implement GSI are driven by institutional, rather than public, missions. These organizations often leverage state, federal, and private grants to construct GSI within their organization's operational focus. Subsequently, NGOs are accountable to board members, donors, and institutional constituencies to act in service and stewardship of the defined mission. In Baltimore, such missions can include improving water quality or restoring city parks. These organizations often have more latitude than city agencies in approving, implementing, and constructing projects. Yet, NGO stakeholders are also constrained in action by bureaucratic procedures like the review of engineering plans by city agencies or the inability to provide funding for facility maintenance through grants.

Residents often play an important role in the planning and continued maintenance of GSI. Structurally, these stakeholders may lack procedural or administrative knowledge, but are interested in reducing neighborhood pollution, greening their community, and improving the environment. Importantly, residents are the stakeholders who live with GSI, and are most impacted by its day-to-day presence in the environment. Individual residents and community groups are most often engaged in GSI during the initial planning phases. Yet, their place-based knowledge is an untapped resource beyond this phase. Residents possess place-based knowledge about their surroundings, such as where storm drain backups are most common, that might inform the success of a facility.

2.3 - Observed governance challenges

Stakeholders face challenges, of differing degrees, as the use of GSI continues to grow. Fundamentally, city agencies, NGOs, and residents struggle to agree on what counts as GSI. Differing definitions cause confusion and conflict among stakeholders. Our systematic review of planning documents reveals that definitional ambiguity is nearly universal within US cities.

Furthermore, regulatory requirements mean that some city stakeholders have a greater role in supporting some definitions and functions than others. For instance, DPW is required, through a federal permitting process, to reduce the total amount of nutrients carried into receiving water bodies by stormwater runoff. Due to these regulatory constraints, DPW funds GSI and alternative best management practices (aBMPs) through a stormwater management fee assessed to all properties in the city.

Conversely, the Office of Sustainability, located within the Department of Planning, has released a Green Network Plan as well as a Sustainability Plan. These documents, while presenting a comprehensive vision for urban environmental transformation, lack a dedicated funding source. Thus, the distribution of the power to act and implement governance decisions within stakeholder types is not unified.

The shift to GSI as a municipal strategy for stormwater management also marks a major change to who gets a say in the deployment of municipal systems. As stormwater management moves above ground and into public spaces, a new cohort of professionals including landscape architects, community organizers, and environmental scientists are interested in implementing and contributing to projects. This growing intrigue presents an exciting opportunity for

collaboration, but our findings indicate that practitioners rarely agree on the problem being addressed. This issue coalesces around practices relating to the functional and aesthetic maintenance of facilities. In many cases, the responsibility of maintaining NGO-constructed GSI falls to community groups who sign a memorandum of understanding (MOU). The practice of utilizing MOUs fails to recognize the differential capacities of residential organizations at work in the city. In some instances, solving a stormwater problem inadvertently leads to the predicament of neglect. Emerging procedural relationships

must be attentive to these uneven social relationships.

Failure to conceptualize GSI as a system makes it challenging to understand patterns of development, intentional or otherwise, that point to questions of social, economic, or procedural equity.

Finally, GSI in Baltimore City is not currently catalogued or tracked in any central or public repository. Documentation of existing installations built by the city and NGOs, if tracked, is often incomplete.

The consequences of missing data impact stakeholders directly. City agencies, particularly those concerned with stormwater permitting, worry that existing projects that could count towards meeting credit requirements are going untracked. Furthermore, minimal documentation means that there is no way to regularly inspect facilities to ensure proper function. Similarly, NGOs lack actionable data to understand the scope of existing projects, or what areas of the city might be neglected in outreach efforts. Additionally, residents are often unsure of who to contact if a site requires maintenance and struggle to engage city services that might be necessary to make repairs.

Fundamentally, the absence of complete record keeping demonstrates that green stormwater infrastructure, despite its namesake, has not been deployed as a system. Failure to conceptualize GSI as a system also

means that it is more difficult to understand patterns of development, intentional or otherwise, that point to questions of social, economic, and procedural equity.

2.4 - Despite challenges

Despite persistent challenges, interviews with stakeholders reveal broad support for GSI. Many view greening strategies, broadly defined, as necessary steps to improve the quality of urban life and the health of the people who live there.

Residents involved in the planning, construction, or maintenance of GSI view their interactions positively and believe these facilities are beneficial neighborhood assets that catalyze positive environmental change. For instance, some residents observed an increase in desirable wildlife, such as birds and pollinators, following the introduction of GSI. Another drew a connection

between a park with stormwater management features and the reduction of the neighborhood's rat population. The park had previously been a vacant lot that often experienced illegal dumping. The transition in land use from abandonment to stewardship, as this interviewee observed, possibly reduced a regular rodent food source. These positive experiences with GSI demonstrate tangible benefits observed by local communities.

Additionally, the cause of advocating for improved and expanded GI has inspired new avenues of citizen participation. **Baltimore Blue+Green+Just**, a recently formed coalition organization, advocates for investment in green infrastructure to achieve regulatory goals while also “enhancing neighborhoods, mitigating the impacts of climate change, and improving public health.” While the invocation of multiple co-benefits associated with GSI is not novel, increased pressure to achieve and be accountable for these benchmarks signals a step forward.



2.5 - Thinking systemically about GSI

The initial steps to developing a governance toolkit in support of GSI are identifying existing stakeholder groups, defining the roles and responsibilities of actors within those groups, and articulating the relative capacities of actors within the network. All stakeholders have agency, but not all stakeholders operate within the same spheres of power and influence. Tracing a network with respect to the capacity of stakeholders is an important step towards a broader recognition of differential needs, abilities, and goals.

This work must begin with the identification of network stakeholders as the starting point of a system. Through this process, actors have the ability to describe how institutional missions or individual commitments shape project goals, functions, and desired outcomes. Identifying the network is a necessary step in understanding the scope and quality of constructed facilities. Locating the existing technological system can lead to the prioritization of resources to under maintained facilities or provoke a project assessment.

Ideally, conceptualizing GSI as supported by a system of the work of actors brings to the surface intersecting challenges that can be addressed through the facilitation of community-supported standards, practices, and investments. By thinking through these problems as pertaining to maintenance, we draw attention to questions that need answers in order for the system to persist. We identify five domains where maintenance concerns must be addressed through stakeholder governance: economic, political, ecological, institutional, and social.

2.6 - Significance

Improving governance is a crucial and necessary step towards the creation of a greener and more equitable city. By supporting the development of community maintenance procedures that sustain just and collaborative knowledge production, we can work towards achieving these ends. While these goals are certainly ambitious, creating tools that consider the system-wide impacts and effects of GSI offers a concrete step towards obtaining these outcomes.

Maintenance Domains of Green Infrastructure	Questions to Improve Governance Practices
Economic	Who financially supports green infrastructure over time? What expenses are required beyond initial project costs? Whose labor is used to ensure facilities provide proposed benefits over time?
Political	Who has the power to make decisions and enforce rules? Who are institutions accountable to and over what timeframes? How are conflicts resolved?
Ecological	How are ecological assets cared for? How is function measured and monitored over time?
Institutional	How are relationships between stakeholders fostered? How are resources shared between institutions? Are some stakeholders burdened if processes, or procedures are unclear?
Social	How are different needs and capacities acknowledged? What processes are in place to guarantee equity in the distribution of assets? How are outcomes measured?

III: Key Recommendations for Constructing a Toolkit

The recommendations that follow explore whether identified governance challenges specific to Baltimore are applicable to US cities working to widely implement GSI. If governance challenges are shared by other cities, then specific strategies can be shared in the form of a toolkit to help cities and stakeholders as they scale their GSI portfolio.

3.1 - Locate six cities at similar stages of GSI system building as Baltimore

Cities across the US face different roadblocks when implementing GSI. Some areas are just beginning to construct these assets while others have built up a sizable portfolio of facilities over the last two decades. Many existing toolkits specifically target cities or municipalities unfamiliar with GSI.

Therefore, resources are needed that address stakeholders who are experienced with GSI, but face obstacles as systems scale to accommodate more facilities, participants, and practices. In this context GSI gains momentum when facilities multiply with the outcome of achieving goals across the various nodes of the system. Within Baltimore, stakeholders have stated proposed goals that include improving water quality, decreasing total impervious surface area, increasing community cohesion, and enhancing the overall environmental quality of the city.

Plans that we have previously identified and coded offer one mechanism of identifying cities at similar stages of system building. These cities are identifiable by the number of constructed installations, the presence of existing partnerships, proposed outcomes, and descriptions of community involvement. Furthermore, our prior research identified funding agencies and philanthropic organizations that often support GI/GSI projects. Referencing grant reports may also identify cities at similar stages of system building.

3.2 - Identify active governmental, organizational, and community stakeholders involved in GI governance

Stakeholder identification within the selected cities is the first step towards tracing existing governance networks, defining roles and responsibilities, and describing the capacities of system actors.

One resource at our disposal in this identification is the ‘Stewardship Mapping and Assessment Project’ (STEW-MAP), led by the USDA Forest Service – Northern Research Station. This publicly available database identifies environmental stewardship organizations in New York, Baltimore, Philadelphia, Chicago, Denver, Los Angeles, San Juan, PR, and Hilo, HI. Significant overlap exists between STEW-MAP cities and those identified in our plans analysis.

Additionally, in gathering contextual information about existing installations in Baltimore, we identified major funders of GSI nationally. Annual reports, grant summaries, and other public reporting documents can be used to identify relevant stakeholders working with GSI in cities.

3.3 - Develop and pilot interview protocols, tools, and survey instruments to assess governance structures and relationships currently in place

For each of the identified six cities, we plan to conduct three to five, 30 minute long interviews with city stakeholders. Other stakeholder positions, including NGOs and residents, will be invited to complete an emailed survey. We aim to receive about 10 completed surveys for each city. Both instruments (interview and survey) will address the five maintenance domains discussed in Section 2.5. In utilizing both types of instruments, we aim to overcome obstacles we faced in Baltimore pertaining to the time commitment required to participate in recorded interviews.

3.4 - Synthesize findings across study sites into a ‘governance toolkit’

Contents of the toolkit will evolve based on the stated needs, desires, and findings from our research in the six selected cities. Our toolkit will also include assessments, screenings, and glossaries developed during the initial stage of our research in Baltimore. The items below describe some of the possible resources to be included in the toolkit.

- **Stakeholder Network Identification** - We will provide instruction on how to identify roles, responsibilities, and capacities of GSI stakeholder groups in cities.
- **Data Management** - We will identify best practices for the management of GSI data for multiple stakeholder groups.
- **Term Glossary** - We will provide a term glossary that provides detail about city-specific and nationwide definitions of GSI.
- **Rapid Maintenance Field Assessment** - We will provide a tool that stakeholders can use to rapidly assess how well a GSI facility is being maintained.
- **Equity Screening** - We will provide an equity screening tool that addresses how, and to what degree, city plans address equity within GI plans.



Recently installed bioswale in a parking lot.



Educational sign in front of a rain garden.

3.5 - Develop use cases of toolkit

Following the finalization and distribution of the toolkit we will follow up with participating cities to understand how the toolkit was used, in what capacities, and where improvements need to be made. Recommendations will inform edits and adaptations of the toolkit. Use cases will be anonymized and added to provided toolkit resources.



Bioswale. Credit: Dylan Passmore.

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