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Green Infrastructure through Citizen Stormwater Management: Policy Instruments, Participation and Engagement

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Abstract: As in other industrialized countries, many urban water social-ecological systems in the United States are characterized by frequent discharges of contaminated runoff, catastrophic flooding, and near-complete severance of the hydrologic cycle. Recent advancements in stormwater best management practices aim to push urban water social-ecological systems into a more sustainable regime that reconnects the hydrologic cycle and utilizes ecosystem services, such as infiltration and evapotranspiration, to improve the quality of urban and suburban water bodies. Collectively, these approaches are termed green infrastructure. As a decentralized approach, green infrastructure requires implementation on, as well as access to, property throughout a watershed, which poses particular governance challenges for watersheds where most land is held privately. We argue that green infrastructure on private property has a strong potential for creating a more sustainable regime through Citizen Stormwater Management, a participatory form of governance with strong citizen influence and engagement. We develop a classification scheme to assess policy instruments' degree of government intervention, citizen participation, and engagement. The paper explores how various policy instruments encourage Citizen Stormwater Management across the United States on both public and private property. We then conduct a textual analysis of ten years of publicly available data from Onondaga County, New York (USA) to assess the implementation of applicable policy instruments. Findings indicate that incentive-based (carrots) along with outreach (sermon) policies can play an important role when regulatory instruments (sticks) are lacking.

Keywords: green infrastructure; urban water management; policy instruments; participation; engagement; Citizen Stormwater Management

1. Introduction

In industrialized countries like the United States, the existing paradigm for managing stormwater in urban areas has been to capture stormwater and move it away from population centers as quickly as possible [1]. Water infrastructure in urban and suburban cities, i.e., social-ecological systems, virtually severed the hydrologic cycle through a series of impervious surfaces, storm drains, tunnels, pipes, and, in some cases, wastewater treatment facilities [2]. Urban water social-ecological systems function in a highly degraded and unsustainable regime, with frequent disturbances ranging in scale from localized discharges of contaminated stormwater to catastrophic flooding events (e.g., Superstorm Sandy).

In the past decade, a new approach, termed “green infrastructure”, has gained ground in modern stormwater management, one that makes use of and invests in ecosystem services to manage stormwater where it falls; this is accomplished by reconnecting the hydrologic cycle, i.e., precipitation, infiltration, evapotranspiration [3,4]. Green infrastructure has the capacity to provide social and

ecological ancillary benefits, such as increased access to green space [5], public health improvements, heat island abatement [6], and habitat for beneficial arthropods [6]. Accordingly, green infrastructure has the potential to catalyze a shift toward a more hydrologically and ecologically functioning system, contributing to a comprehensively more sustainable regime in the integrative sense of sustainable development, i.e., linking ecological aspects with economic and societal elements [7].

The green infrastructure approach requires a paradigm shift from physical capital investments in centralized, pipe-bound conveyance systems that capture stormwater; instead, it focuses on reducing the burden on the traditional engineered system by keeping stormwater out of it [3]. The green infrastructure approach can be linked to a modularization trend in urban water management [8] and takes many forms, such as rain gardens, permeable pavement, green roofs, and rain barrels, which disconnect impervious surfaces from the traditional grey infrastructure and builds detention capacity, restores natural hydrology, and subtracts runoff volume from overburdened, aging grey infrastructure. The decentralized nature of green infrastructure poses property access obstacles for stormwater managers and city planners [9]. In the United States, there is a regulatory vacuum at the national level for stormwater management on the majority of existing private property [10]. Clean Water Act regulations, for instance, generally only apply to new developments or significant redevelopments of multi-family residential, commercial, or industrial properties and not to single-family residences.

However, a range of policy instruments exists in environmental policy, which extends beyond regulations like the Clean Water Act to include more participatory aspects such as public outreach [11]. Sustainability studies indicate that participatory aspects are key in the creation of change toward a more sustainable regime [12–15]. Recent research has also pushed for participatory approaches in relation to green infrastructure in the facilitation of local projects on public and private property [16]. The idea is to engage citizens and extend the coverage of green infrastructure by decentralizing the application across a larger area [15]. To affect long-term change, actors' behavior at the local level, i.e., citizens, can play a crucial role and such behavior has been promoted in the quest for sustainable development [17]. Hence, integrating stormwater management into people's everyday lives could help move social-ecological systems to become more sustainable regimes through more engaged and aware citizens [9].

This paper takes stock of how various policy instruments have been employed to grant access for green infrastructure particularly on private as well as public property and to stimulate participatory stormwater governance, what we call Citizen Stormwater Management. To address policy instruments, we draw on Vedung's [18] classic terminology of sticks, carrots, and sermons (see also Metz and Ingold [7]): Sticks or regulatory instruments include control mechanisms such as standards, licenses, permits, and sanctions as well as planning tools [7]. *Carrots*, or financial instruments either have an incentive or disincentive function; through a change in price or quantity allowances, it is assumed that target groups will adjust their behavior [7]. Finally, *sermons*, also known "soft" instruments, encourage the target group to change their behavior, such as adopting environmentally friendly behavior. Sermons involve outreach, knowledge exchange, and consultation.

To further address the public's ability to participate and engage in stormwater management policy, we use Arnstein's [19] seminal ladder of participation and recent developments by Rau et al. [20]. The lowest level of participation is termed "information" whereby citizens have an ear, but no voice. On the second rung of "consultation", citizens not only have an ear but also a voice (for example, through public hearings). Arnstein describes both latter participatory means as "token", in that they do not give the citizens decision-making power. In contrast, on the next rung, "cooperation", citizens can co-decide and have delegated power (such as having dominant authority over a specific plan, program or subcontracts). Finally, on the highest rung of participation, "citizen control", the citizens have full decision rights by gaining "the majority of decision-making seats, or full managerial power" [19] (p. 218).

In the next section, this paper draws on both the policy instruments and the ladder of participation to develop a classification scheme for how differing policy instruments can foster Citizen Stormwater Management. We then describe the methods and materials before assessing US stormwater policy and identify sticks, carrots, and sermons in the promotion of green infrastructure and Citizen Stormwater Management. Finally, the analysis focuses on a case study of Onondaga County, New York to analyze the implementation of various policy tools as a means of public engagement and water quality improvement.

2. Classification Scheme

Drawing on the policy instrument approach, we first differentiated the instruments based on the degree of government intervention. Such a differentiation is widely established in the literature [11,18,21]: sticks typically involve high governmental intervention, as they entail stringent guidelines and legally binding requirements for target groups which have been defined by governments [18]. Carrots have a moderate degree of government intervention, as they are not legally binding; the target groups are free to react (or not) to the instruments [22]. If an actor decides to react, typically a contractual agreement is then made, with rights and obligations that are similar to regulatory instruments [23]. Finally, sermons entail a low degree of government intervention, as the focus is on a transfer of knowledge between actors without a governmental mandate [18].

Parsing the policy instruments based on participation and engagement is less widely established in the literature. Our typology is thus exploratory in this regard. We explain below how we combined aspects of the sticks, carrots, and sermons typology with elements of Arnstein's participation rungs. In the following, we classify policy instruments based on a metric calibrated from low (1) to high (3) to assess the degree to which instruments involve government intervention and foster participation and engagement. Many of the instruments cannot definitively be categorized as high or low but often involve a range.

We find that both Arnstein's ladder and Rau et al.'s [20] further development of the ladder fail to distinguish between participation in terms of decision-making influence and the degree to which citizens *engage* with the policy once it is established. For example, top-down mandates may force high degrees of compliance. Accordingly, we add the dimension of engagement to our analysis. Citizen engagement arguably goes a step further than participation, as "citizen engagement may actually be leveraged to encourage individuals to act as managers" [9] (p. 1671). That is, citizens become actively involved in employing policy instruments, leading to not only a behavioral change but also (positively) impacting the environment

Sticks are hierarchical in nature in which citizens have no active decision-making role but passively receive information through, for example, regulations. Hence, they could be related to low participation on Arnstein's ladder [19,20]. However, citizens may have a nominal role in the "notice and comment process", whereby regulations must be published and open for comment for a certain amount of time before a rule is finalized. The comments must be addressed, even if to just a nominal degree. Furthermore, citizen lawsuits provide the public with an active means to influence decision making. Although not an "active decision-making role", it is a chance to receive citizen input on the record. Therefore, we argue that participation can range from low to moderate. Conversely, engagement would typically be high, as top-down mandates may force high degrees of compliance and, accordingly, a degree of "forced" engagement. However, in the case that the stick lacks legally binding elements to force change, engagement would be low.

Carrots can be seen as enablers of limited (low to moderate) participation, as they rely on formalized mechanisms in which the emphasis is on financial aspects rather than on citizens' access to decision-making rights [19]. As with sticks, they may involve a degree of information transmission; however, this is geared to persuade citizens with carrots. In terms of engagement, carrots can encourage behavioral change in the form of compliance, but negative incentives may not spur citizens to activate this instrument, which is why we argue for high to moderate engagement.

Finally, the nature of sermons may enable a higher degree of citizen participation than the other two instrument types, as the means underlying it, i.e., knowledge transfer, is conducive to encouraging interaction. However, according to Arnstein [19], sermons would not fulfill the criteria of “citizen control” in terms of decision-making rights or managerial power. However, sermons can involve a degree of co-decision-making, as the citizens can engage in round tables or dialogue forums with other actors that may lead to projects or influence policy decisions. As such, they would fall under “cooperation” [20]. We argue that sermons entail a moderate to high degree of participation. In terms of engagement, sermons can encourage voluntary behavioral change and thus lead citizens to employ the instruments. As these actions are voluntary and highly dependent on the appeal that the sermon has on the target group, we argue that this could constitute moderate to high engagement.

Table 1 summarizes our exploratory classification of policy instruments based on the degree to which instruments involve government intervention as well as foster participation and engagement. Government intervention is considered high when state actors have legally binding tools, with means of sanctions (in the sticks/government intervention box). Low intervention entails governmental use of voluntary or persuasive tools such as education programs (sermons/government intervention box). In contrast, participation is considered low when the tools do not enable citizen influence, moderate when they are consultation-based, and high when they enable citizen control through decision making. Finally, engagement is considered low if tools fail to mobilize citizens to utilize them; in contrast, high engagement occurs when tools encourage, either voluntarily or involuntarily (force), citizens to employ the instruments. We argue that policy instruments with moderate to high government intervention, citizen participation, and engagement encourage Citizen Stormwater Management.

Table 1. Summary of instrument types, government intervention, participation, and engagement.

	Stick	Carrot	Sermon
Government Intervention	3—high intervention Governmentally defined programs	2—moderate intervention voluntary mechanisms but, once engaged, become binding (e.g., contracts)	1—low intervention voluntary, based on information, outreach and consultation
Participation	1–2—low to moderate participation hierarchical nature leaves little room for horizontal citizen participation, but citizens can influence policy through lawsuits	1–2—low to moderate participation focus on (financial) incentives and disincentives rather than participation	2—moderate to high participation co-decision-making, enables influence through knowledge exchange and consultation
Engagement	3—high engagement , if can force high degree of engagement through legally binding requirements 1—low engagement , if not legally binding and not affecting behavior change	3–2—high to moderate engagement can incentivize compliance but disincentives may deter engagement	2–3—moderate to high engagement encourage voluntary behavior change (high if change occurs)

Legend 1 = low; 2 = moderate; 3 = high. Source: Own representation.

3. Methods and Materials

In the empirical analysis, we first assessed US stormwater policy in terms of the sticks, carrots, and sermons typology and provided examples of policy instruments in each category for how they enable or encourage Citizen Stormwater Management. A textual analysis, which screened for the mechanisms of government intervention, participation, and engagement, was conducted of the following materials: Clean Water Act, US Environmental Protection Agency guidance documents, federal regulations, and various state water protection laws.

Next, we focused on a case study of Onondaga County, located in Central New York State in the United States, and applied our exploratory typology (Table 1). We selected Onondaga County as a “crucial case” because of the county’s comprehensive stormwater management program—Save the Rain—which has received national recognition for its green infrastructure alternatives to its combined sewer system upgrades. The county has pursued this program as a part of its Clean Water Act agreement. Furthermore, the county is the site of Onondaga Lake, once deemed the most polluted

water body in the United States due to industrial and municipal wastewater contamination. Decades of investment in remediation and sewer system upgrades have resulted in a much cleaner lake, one that has recently been deemed “swimmable” by state authorities.

We analyzed ten years of data from stormwater management reports from Onondaga County, New York (US). Data included hydrological monitoring, modeling results, and participation counts in green infrastructure projects. Data were parsed by policy instrument, participation, and engagement and then collated. We qualified the results using the metric summarized in Table 1. The analysis followed these definitions: projects required by the county were sticks; projects constructed on private property with financial incentives from the county were carrots (Green Improvement Fund); projects that are intended to educate or involve outreach were sermons.

We then assessed the performance of green infrastructure projects in the case study. Runoff capture is the county’s chosen means of reducing runoff and is therefore the metric used to measure success of actual green infrastructure installations. It is also the metric by which the state and federal regulators measure success. Thus, it was an appropriate metric to use in our analysis. Runoff reduction of the project categories was related to sticks, carrots, and sermons. However, making a causal link between many of the projects related to sermons and hydrologic results presented a challenge. On the one hand, we distinguished between projects which exhibited sermon-like elements on public property with high outreach potential and compared these to green infrastructure projects on public property *without* high outreach potential. On the other hand, we separately assessed the number of people who became engaged through sermons without making a link to runoff.

4. Results and Discussion

The instrument types are illustrated by drawing on stormwater management examples from across the United States and assessed as to how they enable or encourage Citizen Stormwater Management.

4.1. Sticks

Regulatory instruments are hierarchical and involve high governmental intervention with legally binding requirements. In the United States, there are no regulatory sticks that mandate onsite stormwater control for most private properties, especially residential properties, at the federal level. New construction of multi-family residential developments or significant redevelopment may be subject to stormwater regulation, depending on the size of the property or its impervious area. Despite the lack of sticks for onsite stormwater management, the Federal Clean Water Act is a very powerful mandate, which has trickle-down effects to the citizen scale. Therefore, brief discussion of the most stormwater relevant rules that may impact the public follows.

4.1.1. Clean Water Act Stormwater Rules for Construction and Post-Construction

Large and medium municipal separated storm sewer systems have been subject to Phase I of the National Pollutant Discharge Elimination System program since 1990; additional, smaller separated storm sewer systems are now subject to Phase II of the program. Once a separated storm sewer system obtains a National Pollutant Discharge Elimination System discharge permit, the managing authority must fully implement all stormwater runoff control practices identified in the permit. The control practices include a stormwater management program designed to reduce the discharge of pollutants to the maximum extent practicable, which must include six minimum control measures: public education and outreach; public participation/involvement; illicit discharge detection and elimination; construction site runoff control; post-construction runoff control; and pollution prevention/good housekeeping [24].

4.1.2. Clean Water Act Combined Sewer Overflows Enforcement

For combined sewer systems, combined sewer overflows constitute violations of the Clean Water Act; significant litigation has arisen and been settled regarding combined sewer overflows in recent

years. Settlements typically result in consent decrees and control plans that last decades and can cost billions of dollars. Control plans are increasingly inclusive of green infrastructure components as municipalities seek more cost effective and publicly acceptable combined sewer overflows solutions (e.g., Cleveland, OH, USA [25]; Onondaga County, NY, USA). Although Clean Water Act combined sewer overflow enforcement pertains to the duties of the sewer system owner, there are implications for Citizen Stormwater Management. The US Environmental Protection Agency defends its practice of seeking relief through judicial, as opposed to administrative, process by claiming that a judicial consent decree shields against citizen suits (*Starkist Caribe* [26]), which arguably provides for even less citizen participation in the abatement of combined sewer systems.

4.2. Carrots

Carrots have either an incentive or disincentive function and, once activated, they become legally binding. In contrast to sticks, we found numerous examples of carrot instruments in stormwater policy across the United States.

4.2.1. Direct Provision

Perhaps the most popular form of engaging citizens in residential stormwater management is via direct provision of a rain barrel [27]. Rain barrels connect to a home's gutter downspout to harvest and store stormwater, either for residential landscape use (irrigation) or for delayed release after a storm has passed [28].

The popularity of rain barrel giveaways stems from their high visibility and ease of use. Rain barrels sit prominently below a downspout, leading to increased awareness of their use in a neighborhood; such awareness can lead to greater adoption through the spread of social capital [9]. Promotions such as rain barrel art contests, whereby contestants submit decorated barrels to be either given away or auctioned off, boost their visibility. Rain barrels workshops engage the public in installation and proper maintenance. Rain barrels are also popular tools for engaging citizens from the perspective of a stormwater manager because they can be given away at a central location, can be easily branded, are relatively low cost, and require no oversight for operation or maintenance.

4.2.2. Rebates and Cost Shares

Rebates and cost shares are direct economic incentives to purchase and install green infrastructure on private property and are, in practice, essentially synonymous. Rebates and cost sharing programs subsidize, generally retroactively (reimbursement), costs associated with the engineering design, purchase, and/or construction of eligible green infrastructure practices, such as installing rain gardens or green roofs [29]. Programs range from a portion of to total costs borne by the agency. At the national level, the US Environmental Protection Agency provides a broad palette of such green infrastructure funding support for cities and states to incentivize implementation on both public and private properties [30]. At the city level, Seattle Public Utilities provides large rebates (on average, \$4800) for rain garden installations. To be eligible in residential properties, the rain gardens must be located in a priority area. The rebates are based on the square footage of roof area that is devoted to the rain garden [31,32]. Rebate and cost share programs are relatively straightforward to administer and are popular policy mechanisms in the United States. However, in a survey of rebate program participants in Washington D.C., participants stated a preference for upfront payment assistance rather than a delayed rebate program [33].

4.2.3. Stormwater Fee Credits

As regulatory pressure to reduce the environmental impact of urban stormwater intensifies, municipalities increasingly seek a dedicated source of funding for stormwater management programs, such as a public stormwater utility [34]. Stormwater utilities appeal because they are more fair and equitable than funding stormwater systems from tax revenue. Generally, the fee is based on a

property's contribution to the problem (amount of impervious surface, a proxy for runoff discharged from property), which can be objectively determined, and is not based on assessed value. It also applies to all properties, including tax exempt properties such as nonprofits and faith-based organizations.

Because residential fees are generally low (\$50–100/year), financial incentives, such as utility credits, may be insufficient price signals to motivate mass decentralization of stormwater management on private property [10]. However, social contagion [35], coupled with economic incentives [9], may prove sufficient to motivate the installation of these highly visible best management practices. In a survey of credit program participants in Washington D.C., even small stormwater utility credits were valued by participants [36].

4.3. Sermons

Sermons are often the predecessors or supporters of the “harder” instruments, such as sticks and, to a degree, carrots. The underlying logic is the assumption that self-accountable and environmental friendly behavior is only possible if there is an active exchange with citizens [37]. We found several examples of sermons in US stormwater policy.

4.3.1. Linking Outreach with Direct Provision

Drawing on the rain barrel example above, previous research has shown that sermons (education and outreach) can foster citizens' willingness to manage stormwater on their private residential property with minimal financial incentives [29]. In the Shepherd Creek watershed in suburban Cincinnati, private property owners were offered free rain barrels and rain gardens, inclusive of three years of maintenance, in addition to education as well as reasonable financial payouts determined by bidding in an anonymous, reverse auction. Results show that more than half of the homeowners requested \$0 to provide this onsite ecosystem service and that the offer of a rain barrel or garden combined with education was sufficient to incentivize behavioral change among property owners who were willing to convert their private property into a stormwater management feature for the public good [29]. Results also show that social contagion occurs over time, as neighbors share good experiences with one another and more residents are willing to participate [9]. The Shepherd Creek watershed demonstration project shows that education campaigns, minimal financial incentives, and time allowances for new ideas to catch on were effective in turning everyday suburban residents into onsite stormwater managers.

4.3.2. Clean Water Act's Stormwater Rules for Outreach and Public Education

One of the minimum control measures for compliance with the Clean Water Act requires municipal stormwater programs to include public outreach campaigns. There is a wide degree of flexibility with respect to this requirement, with the only true condition being that an outreach plan is in place. Despite this leeway, many municipalities have robust outreach campaigns and take citizen engagement very seriously [9]. Programs include hosting clean water festivals, labeling storm drains and watershed boundaries, organizing media campaigns, and developing relevant curricula for primary and secondary schoolchildren. The goal is to invest in human capital through individual outreach, encourage the spreading of social capital through community building around stormwater management, and promote multi-generational cultural capital through the education of children and the long-term promotion of Citizen Stormwater Management [9]. Washington D.C. survey participants indicated that listservs, forums, and Facebook groups were more effective than promotions in newspapers or on television or radio as a means to engage them in residential stormwater management [36].

4.3.3. Environmental Protection Agency Watershed Academy (and other) Webinars

Online seminars (e.g., webcasts, webinars) are popular venues to provide technical assistance to large audiences. The Environmental Protection Agency hosts numerous webinar series that range in target audience from expert (e.g., water quality modeling training) to basic homeowners

(e.g., introduction to rain gardens). Regional and local watershed groups as well as university extension agencies also sponsor similar programs. In a survey of participants regarding various forms of Citizen Stormwater Management in Washington D.C., participants indicated that technical assistance, especially with native plant care, was more important than financial assistance [36].

4.3.4. “Green Sermons” and “Green Ministries”

In the Chesapeake Bay watershed, the Alliance for Chesapeake Bay includes actual sermons in their policy toolkit. Through the RiverWise Congregations partnership with Anne Arundel County (Maryland, USA), religious institutions commit to measurable stormwater management practices on their property in exchange for financial and educational resources. Although this comprises a carrot-sermon combination, we find the former aspect (i.e., the carrot) to dominate. Beyond physical upgrades, congregation leaders attend training workshops through a county-wide watershed stewardship academy, which requires that they deliver an educational workshop to congregation members on environmental stewardship and the theological underpinnings of environmentalism. At least 25 houses of worship have participated in the program thus far [38].

Similarly, the neighboring Prince George’s County (Maryland, USA) also encourages onsite stormwater management and environmentally focused worship services (“green ministries”) by reducing the stormwater utility fee on church properties that enroll in the Prince George’s Stormwater Stewardship Grant Program. Such a program comprises a combination of stick, carrot, and sermon, with the primary focus on outreach. Accordingly, we place such a program under sermons. Church properties, which typically feature large parking lots, are some of the largest impervious surfaces in the county. When Maryland initiated the stormwater remediation fee, congregation leaders opposed the measure, as it could cost each property hundreds to thousands of dollars annually [36]. To curb opposition and take advantage of the significant outreach potential of church congregations, county officials negotiated a fee rebate program for the churches. In addition, the government covers a significant portion of the cost to install the stormwater best management practices. Thus far, at least 30 houses of worship have applied to the program [39].

4.4. Case Study: Onondaga County’s Save the Rain Program

Onondaga County agreed to pursue green infrastructure alternatives to its combined sewer system upgrades under its Clean Water Act settlement agreement. A key outcome is the county’s comprehensive stormwater management program, Save the Rain (stick). The green components arose in large part because of public protest against the county’s grey plans, which largely ignored public input. After a regional wastewater treatment facility was constructed which displaced 45 families, the political winds in the county changed [40]. A new County Commissioner was elected following a campaign which promised greener approaches and increased public engagement in the stormwater management process [41].

The county’s Save the Rain program is a stick, as it provides mandates on how to improve stormwater management. However, the County has no local regulations in place to require green infrastructure on the ground. In terms of Citizen Stormwater Management, Save the Rain directly engages residents; the program provides free rain barrels and residential trees for enhanced stormwater evapotranspiration (carrots) in the portions of the county that have the highest priority for stormwater mitigation. Further, the County provides funding via public-private partnerships through a Green Improvement Fund for private commercial developments (carrot). Save the Rain also administers public outreach and education through a Clean Water Festival and curriculum development (sermons). The County has constructed hundreds of highly visible green infrastructure installations on public property (e.g., parks, roads, public rights-of-way) throughout the watershed, including a comprehensive transportation and green infrastructure project known as the Connective Corridor. These projects are highly visible and include public outreach components,

including stakeholder engagement at the planning stage and educational signage at completed projects (sermon-like elements).

The County also supports the work of citizen groups engaged in green infrastructure. For example, the Atlantic States Legal Foundation, a New York chartered non-profit organization, plants trees on private property and repurposes brownfields for stormwater mitigation. Likewise, the Cornell University Cooperative Extension and the Onondaga Earth Corps, a non-profit organization to engage youth in environmental work, also plants street trees in the public rights-of-way for enhanced evapotranspiration. The County hosts tree-planting events at public schools in collaboration with the latter organizations and with the assistance of volunteers (sermons).

As a continuation from Table 1, Table 2 summarizes the Onondaga County case in terms of the degree to which the differing policy instruments can be linked to government intervention and citizen participation as well as engagement and encouragement of Citizen Stormwater Management using three examples from Onondaga's Save the Rain program (in italics).

Table 2. Summary of Onondaga County case study green infrastructure project examples according to instrument.

	Stick	Carrot	Sermon
<i>Example</i>	<i>County's stormwater management program—Save the Rain</i>	<i>Green Improvement Fund Projects—subsidized green infrastructure construction projects</i>	<i>Rain barrel painting contest, winner determined by popular vote</i>
Government Intervention	3—high county defined the program	2—moderate county approves plan, oversees operation and maintenance, but target group free to engage or not	1—low voluntary participation
Participation	1—low initially lacked citizen input	2—moderate citizens influenced establishment of fund and property owners request cost share for construction	2—moderate co-designing of event, outreach
Engagement	1—low no legally binding local legislation to change behavior	3—high behavior change; green infrastructure constructed on private property	3—moderate volunteers engage in behavior changing activity

Legend 1 = low; 2 = moderate; 3 = high. Source: Own representation.

How do the above policy instruments link to actual green infrastructure installations and what does this mean for hydrologic results in terms of runoff capture? Publicly available data indicate that Onondaga County manages over 10 million square feet of impervious area and 122 million gallons of stormwater runoff annually through green infrastructure instruments [42]. As shown in Table 3, a carrot (the Green Improvement Fund) accounts for over 32 million gallons of stormwater runoff capture (Table 3) [42]. Projects on public property with high outreach and education potential (sermon-like elements), as defined by interpretative signage requirements and visibility (i.e., those on school grounds, public parks, and public centers), account for over 30 million gallons of stormwater runoff capture [42]. Conversely, approximately 60 million gallons of stormwater runoff is captured via infrastructure projects on public property with little to no outreach potential (e.g., complete separation of a combined sewer, road reconstruction projects) [42]. Notably, such projects account for a large proportion of runoff capture; they tend to be large scale yet not highly visible in terms of outreach potential to the public, for example, the greening of a wastewater treatment facility parking lot. The County has no stick-type instruments to utilize within the program that can be linked to a hydrologic result. In addition, sermons cannot directly be linked to hydrologic results and are addressed separately below.

Table 3. Results: Hydrologic results of Onondaga County green infrastructure projects.

Policy Instrument	Number of Projects	Annual Runoff Capture (Million Gallons)
Stick	0	0
Carrot	81	32
Sermon	0	0
Public property with outreach	49	30
Public Property without outreach	38	60

Source: own representation based on Mahoney [42].

Results show that Onondaga County utilizes carrots and public projects with outreach and education potential (sermon-like elements) to capture approximately 62 million gallons of stormwater runoff in green infrastructure annually; in comparison, 60 million gallons are captured via the county's installation of green infrastructure on public property with little potential for any public engagement.

Many sermons may not necessarily result directly in hydrologic results. However, they have reached people through local and digital campaigns, encouraging behavior that might lead to hydrologic results (see Table 4). We noted that social media may have high results in terms of “likes” or video views, but engagement from social media campaigns resulted in relatively less pledged behavior changes (653 pledges to “block litter” from over 63,600 Facebook video views to 281,197 YouTube video views encouraging behavioral change). Further, the engagement resulted in a pledge to change behavior, with no data to determine any actual behavior change.

Table 4. Results: Sermon policy instruments and metrics for Onondaga County, New York.

Sermon	Projects
Social media	3016 Facebook likes 1105 Twitter followers 63,600 Facebook video views 281,197 YouTube video views 653 “Block Litter” pledges
Tree plantings	230 volunteers 58 trees “adopted” 651 doors reached in “door-to-door” outreach
Rain barrel art contest	14 finalist entrees
Clean Water Fair	350 est. attendees
Public school curriculum	1600+ students reached

Source: Mahoney [43].

According to our typology, carrots and elements of sermon-type instruments play an important role when sticks are lacking. However, it is difficult to identify direct results in terms of behavior change or hydrologic results, particularly with sermons. However, sermons appear to play an important supportive role, as they are often linked to carrots or sticks.

5. Conclusions

Recent advancements in stormwater best management practices aim to push urban water social-ecological systems into a more sustainable regime that reconnects the hydrologic cycle and utilizes ecosystem services to improve the quality of urban and suburban water bodies while also providing ancillary benefits through green infrastructure. We argue that green infrastructure on both public and private property is critical to increase the sustainability of urban water social-ecological systems and has a strong potential for reconnecting citizens to their own ecological footprint through Citizen Stormwater Management, a participatory form of governance with strong citizen influence and engagement.

This paper has developed an exploratory classification scheme by drawing on a policy instruments approach in terms of a carrots, sticks, and sermons typology [18] in combination with a citizen

participation perspective [19,20] and the concept of citizen engagement [9] (p. 1671). Such a scheme is innovative as it goes beyond the widespread classification of policy instruments based only on the degree of state involvement to include both participation and engagement. Our classification scheme enables an analysis of policy options to encourage green infrastructure on the citizen scale and, accordingly, Citizen Stormwater Management. We assessed policy instruments as applied in urban areas across the United States as well as a specific case study of Onondaga County in New York. We looked at differing policy instruments' capacity to foster Citizen Stormwater Management through intervention, citizen participation, and engagement in stormwater management.

We have found that there are no regulatory sticks which mandate onsite stormwater control for most private property in the United States at the national level. However, within the Federal Clean Water Act, we found trickle-down effects to the citizen scale. Conversely, we identified many carrots and some sermons to encourage Citizen Stormwater Management across the United States. In our case study of Onondaga County, the Save the Rain Program exhibits the characteristics of a stick but lacks legally binding sticks within the program, as no local regulations are in place to require green infrastructure. In the absence of such governmental intervention, we found that the public can still engage and participate in green infrastructure stormwater management via carrots and sermons. We also indicated how carrots can contribute to the achievement of hydrologic effectiveness (annual runoff capture) in the case study of Onondaga County's Save the Rain Program. Although causally linking sermons directly to hydrologic effectiveness is a challenge, these outreach-type instruments can play a supportive function for carrots (and sticks).

By focusing on the citizen scale, this paper contributes to sustainability studies that address how participatory aspects are key in changes toward a more sustainable regime [12–14]. Indeed, since the 1990s United Nation conventions, numerous declarations (such as the Rio Declaration on Environment and Development) or statements have emphasized the participation of individuals as a means to improve natural resource management [17]. Our in-depth case study results has shed light on the integrative dimension of sustainable development by linking ecological aspects with economic and societal elements [7].

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