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Article

## Identification and Induction of Human, Social, and Cultural Capitals through an Experimental Approach to Stormwater Management

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**Abstract:** Decentralized stormwater management is based on the dispersal of stormwater management practices (SWMP) throughout a watershed to manage stormwater runoff volume and potentially restore natural hydrologic processes. This approach to stormwater management is increasingly popular but faces constraints related to land access and citizen engagement. We tested a novel method of environmental management through citizen-based stormwater management on suburban private land. After a nominal induction of human capital through an education campaign, two successive (2007, 2008) reverse auctions engaged residents to voluntarily bid on installation of SWMPs on their property. Cumulatively, 81 rain gardens and 165 rain barrels were installed on approximately one-third of the 350 eligible residential properties in the watershed, resulting in an estimated 360 m<sup>3</sup> increase in stormwater detention capacity. One surprising result was the abundance of zero dollar bids, indicating even a limited-effort human capital campaign was sufficient to enroll many participants. In addition, we used statistical methods to illustrate the significant role of social capital in forming clusters of adjacent properties that participated in bidding. This indicated that as participants shared their experiences, neighbors may have become more willing to trust the program and enroll. Significant agglomerations of participating properties may indicate a shift in neighborhood

culture regarding stormwater management with positive implications for watershed health through the sustained induction of alternate capitals.

**Keywords:** urban stormwater management; green infrastructure; resilience; human capital; social capital; cultural capital; best management practices; private property; combined sewer overflow; economic incentive

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## 1. Introduction

### 1.1. Stormwater and Urbanization in the United States

After running off impervious areas in the urban landscape, rainfall is either captured, conveyed, and discharged untreated into receiving water bodies through a municipal separate storm sewer system (MS4) or, in older communities, captured, combined with sanitary sewage, conveyed to a wastewater treatment facility, treated, and discharged into receiving bodies through a combined sewer system. Traditional centralization of water resources services provides a high degree of reliability, though by capturing, piping, and discharging untreated stormwater, MS4s externalize many costs to the environment-at-large. In essence, urban streams often function more as stormwater conveyances (*i.e.*, pipes, ditches) rather than healthy ecosystems and exhibit symptoms of urban stream syndrome, which can include streambeds becoming incised to bedrock followed by pronounced lateral widening of the stream channel [1]. Urban development and suburban sprawl reduce the amount of vegetated, permeable land area available for stormwater infiltration and groundwater recharge. The lack of infiltration opportunities can result in reduced stream baseflow, flashier pulses in urban streams, increased stream bank erosion, and loss of aquatic wildlife and benthic habitat [2,3]. In addition, runoff from urban impervious surfaces often carries contaminants, sediments, and nutrients from the surface upon which it falls or flows that can degrade stream quality (e.g., vehicle oil from parking lots, grass clippings from lawns). Further, municipalities on centralized wastewater management systems are inadvertently cut off from infiltration and other ecosystem services such as removal of pathogens through filtration in soils [1,4,5].

Beyond the actual mechanisms of wastewater management that affect environmental quality, current regulatory policy does not adequately address the diffuse nature of stormwater runoff. In the United States, water quality is regulated at the state and federal level through a system of cooperative federalism whereby states implement the federal Clean Water Act under supervision of the U.S. Environmental Protection Agency (USEPA). For the most part, state environmental agencies issue National Pollution Discharge Elimination System (NPDES) permits to local entities that discharge water into receiving bodies, including municipal stormwater agencies and sewer districts. The NPDES program has been successful at reducing contamination of U.S. water bodies from point sources [6]. However, regulating more diffuse, nonpoint sources, such as stormwater quality and quantity has proven much more challenging. In 1999, the USEPA announced rules requiring municipalities that convey stormwater directly into receiving water bodies (*i.e.*, municipal separate storm sewer systems—MS4) to reduce the discharge of polluted stormwater to the maximum extent

practicable through a minimum of six control measures, two of which concern community engagement—public education and outreach and public participation and involvement [7]. Community engagement is an essential aspect in stormwater management because of the dispersed nature of the problem, and citizen engagement may actually be leveraged to encourage individuals to act as managers of stormwater runoff on their land. Since private lawns and impervious surfaces contribute to stormwater quantity and contaminant loads, mitigation of runoff from private parcels can play a vital role in the solution.

In light of a recent ruling from the Ninth Circuit Court of Appeals of the United States (*certiorari* granted), municipalities face potential liability for the degraded quality of discharged stormwater, regardless of the source of the pollution [8]. In addition, the USEPA and several state departments of environmental quality have recently begun to emphasize enforcement efforts for stormwater-related violations of the Clean Water Act, particularly those relating to combined sewer systems that have frequent combined sewer overflow (CSO) events (*i.e.*, raw sewage and stormwater discharged directly into receiving bodies during wet weather). Enforcement actions often result in negotiated consent orders that mandate new investments to upgrade wastewater conveyance systems that can range into the billions of U.S. dollars (e.g., Cleveland, Ohio committed to spend over \$ 3 billion on system improvements over 25 years [9]). With this much at stake, municipalities seek reliable, cost-effective methods to reduce the amount of stormwater that enters both separate and combined sewer systems and presumably reduce overflows. In turn, decentralized management approaches that incorporate both gray (underground conveyance and transfer of wastewater) and green (distributes runoff between above and below-ground plant-soil systems and engineered rainfall capture) infrastructures are a part of these negotiated settlements with greater frequency (see e.g., Cleveland [9], Philadelphia [10], Nashville [11], New York City [12]).

### *1.2. Decentralized Stormwater Management Practices*

Recent trends in water resources management highlight decentralized solutions at the community scale to restore natural processes [13–15]. In the stormwater context, one approach involves installation of stormwater management practices (SWMPs) throughout a drainage basin via investments in natural capital. Such investments aim to restore hydrologic processes and manage stormwater as a resource rather than a waste stream. This is in contrast to traditional, centralized, pipe-bound approaches such as wastewater treatment plants and high volume storage tunnels [16–18]. Decentralized approaches have been shown to remedy the negative consequences of stormwater runoff more cost effectively than upgrading traditional centralized systems [19]. Collectively, stormwater management practices that use soil and vegetation or engineered capture technologies to manage rainwater where it falls by replicating natural drainage systems are referred to as green infrastructure (GI), also referred to as low impact development, environmental site design, or sustainable drainage systems. Examples include rain gardens, bioswales, constructed wetlands, daylighting piped streams, permeable paving, and green roofs.

Although pipes and other gray infrastructure provide an efficient thoroughfare for the conveyance of runoff quantity, soil pore space is an alternative volume for storage of infiltrated runoff. Since managed plant-soil systems have their own interactive ecosystem dynamic, they are by design inherently capable of responding to a range of climate conditions and may therefore exhibit the

ecosystem attribute of resilience. For example, a rain garden incorporates soil amendments, careful tillage, and a community of adapted plant species (*i.e.*, well-suited to extreme conditions, such as saturation or drought) to maximize volume for temporary surface detention, enhances soil porosity for storage of excess stormwater runoff, and facilitates drainage. Soil ecosystem processes can induce positive feedbacks that improve both plant vigor and soil structure. Nutrient cycling and food web development are outcomes of soil macrofaunal activity, which can create large biopores (*i.e.*, macropores through which water can flow more freely than in smaller pores). Along with structural macroporosity from seasonal soil heaving and root penetration, biopores improve rainwater detention features [20], leading to ongoing improvement in drainage characteristics and enhanced ability to infiltrate a broader range of rainfall depths and frequencies. Hence, the system exhibits increased resilience that may counter changes in disturbance patterns.

Recent work at the USEPA emphasizes the role of GI in bringing communities into compliance with the Clean Water Act while also providing co-benefits such as increased green space, improved aesthetics, and community redevelopment [21]. Green infrastructure can be widely distributed throughout a community and watershed, and the role of citizen landowners in restoring natural drainage processes should not be underestimated. In order to achieve the full suite of GI co-benefits, communities must be engaged. This is particularly true in decentralized programs where issues of private property rights, land access, and community acceptance of an unfamiliar technology pose significant obstacles to implementation and long-term success. Further, when linking stormwater solutions to socio-economic issues, investments in human and social capitals play a vital role in GI implementation and have the potential to shift culture toward a more sustainable future.

### 1.3. Forms of Capital beyond Physical

The crumbling water infrastructure of many U.S. cities exemplifies the pitfalls of relying on physical capital alone when managing stormwater [22]. If physical capital (*i.e.*, actual infrastructure) is used by more than a single individual, investment in human and social capitals is necessary to maintain productivity in the long term [22]. Knowledge, skill, and experience are forms of human capital. Individuals bring their human capital with them to any activity, and it can be built consciously (e.g., attending college) or through unconscious investment (e.g., taking a walk for pleasure is also an investment in maintaining physical health). Either way, human capital is built by acquiring new capabilities or learning constraints [22]. For example, individuals invest in their own human capital by learning a new language or realizing they struggle with math.

A collective forum for human capital is social capital, which is the knowledge, skills, and experiences that individuals share and bring to a recurrent, coordinated activity [23]. It is derived from relationships that form social structures which can be formal (e.g., teacher student relationships) or more loosely defined (e.g., neighbors) [24]. From a functional perspective, social structures become social capital when an actor (*i.e.*, an engaged individual) can appropriate the relationship for effective use in furtherance of their own interest [24]. One benefit that social capital may confer is the ability to influence and control a member of one's social network [25]. For example, when a friend utilizes the stock of trust or goodwill established with another friend to encourage a voluntary act [26]. This is the premise behind the commercial value of social networking websites; when friend

A endorses (*i.e.*, “likes”) a product on a social networking site, this action may influence friend B to purchase the product. Thus, friend A appropriated their social capital to influence the purchasing behavior of friend B. Social capital is difficult to measure and even identify and often difficult to communicate in precise language. In the example above, there may be many reasons why friend B was influenced by friend A: perhaps friend A is trusted with good taste or perhaps friend B seeks admiration of friend A by mimicking A’s behavior.

Social capital can take time to cultivate, so short-term projects may not cultivate nor detect increased social capital [22]. Likewise, once social capital is accumulated, it can deteriorate quickly with dormancy (e.g., classmates may not interact over summer break and thus have less opportunity to influence each other’s behavior) or personnel turnover (e.g., a leader retires). Government institutions play a large role in facilitating or hindering social capital to solve collective action problems, but establishing social capital is difficult from the outside [22,27]. If governments give citizens space for self-organization, social capital has room to grow [22].

With sufficient investment in human and social capital, community culture may shift toward a more environmentally conscious populace, resulting in cultural capital that influences the behavior of all residents. Cultural habits and dispositions, such as emphasis on respecting elders or performing well in school, comprise a resource—cultural capital—capable of generating profits and are potentially subject to appropriation by individuals and groups [28]. Inherited habits and dispositions are fundamental to success in various social and institutional arenas, such as success in schooling [28]. With reinforcement and daily practice or familiarity, environmental management values can be transmitted from one generation to the next [29]. Furthermore, engagement of citizens can develop and provide a source of social and cultural capital toward environmental management of stormwater, which may effectively substitute for the presently dominant technological and physical capitals of gray infrastructure that emphasizes pipes and other capital infrastructure for conveyance and control [30].

By recruiting average individuals that typically act as passive producers of stormwater runoff into becoming stormwater managers, citizens aid and abet the effort of stormwater management agencies (e.g., USEPA, state environmental agencies, municipal storm, sewer and sanitation districts) by making stormwater management a part of their everyday business. Dispersed GI practices manage the root of the problem with source controls that, in the aggregate, have the capacity to substantially reduce the urban stormwater problem. In this sense, social and cultural capitals may prove to be adequate substitutes for the traditional, dominant approach of technological and natural-resource intense physical capital as this approach increases the ecological knowledge of society, not just individuals (human capital), and fosters an environmental worldview [31].

## 2. Methods

Our experimental work centered on a small urbanized watershed where economic incentives administered as an experimental reverse auction could effectively spur public acceptance and installation of on-lot, retrofit stormwater detention practices (e.g., rain gardens, rain barrels) on private property. Specifically, we asked whether this would lead to a sufficient number of installations that would potentially decrease stormwater runoff quantity and improve other metrics of environmental quality. The specific objectives of this paper are to interpret outcomes of this participatory

environmental management study in the context of the role of human, social, and cultural capitals and to discuss how these capitals might be best applied in the larger arena of environmental management.

We developed and applied this methodology to distribute rain gardens and rain barrels to homeowners and maintain them for three years. To engage homeowners we invested in a human capital campaign (*i.e.*, education and outreach) and conducted voluntary reverse auctions in 2007 and 2008. To our knowledge, this is the first project to use economic incentives to retrofit an entire impaired urban watershed with the explicit goal of improving environmental quality, within the extant state and local legal framework, and without the need for a new governmental authority or regulatory action.

The Shepherd Creek watershed in Cincinnati, OH (U.S.A.) drains approximately 1.8 km<sup>2</sup>. Transportation and driveway surfaces constitute a large proportion of total impervious area in the watershed [32] and therefore generate stormflow that constitutes the majority of annual stream flow. Residential areas built in the 1960's and 1980's, on the east and west hilltops of the watershed, respectively, occupy the headwaters. An assessment of impervious surface revealed that impervious and semi-impervious area comprised 13.1% of the watershed, with 56.3% of the impervious area connected to the MS4 system [32]. The downstream network has generally high slopes with highly incised streambeds and reaches through the mid-section of the watershed cutting through mixed-land use coverage of forests, equestrian-livestock meadows, and low-density residential housing. Approximately 350 parcels within the watershed were identified as potential participants in the stormwater management retrofit program, and two types of practices were offered in the auction: up to four 284 L (75 gallon) rain barrels, a single 16 m<sup>2</sup> rain garden, or a combination of the two. In addition to free materials and installation of the GI options, enrolled properties also received three years of maintenance and access to educational materials for long-term maintenance.

The education campaign consisted of direct mailings to residents and two demonstration rain gardens and one rain barrel at a local public arboretum with signage. The campaign aimed to educate residents on stormwater issues and to promote the opportunity to participate in our project. The first mailing notified landowners of the opportunity to participate via cover letter and brochure (Figure 1). Two weeks later, a second mailing including a cover letter, brochure, and auction bid form was delivered along with a self-addressed, stamped envelope. In addition, all recipients received nominal compensation (\$ 5 USD) for their time and to encourage bidding. In the first round of bidding in 2007, door hangers were distributed as reminders. The bidding process was extended by 2–3 weeks, and an additional letter and bid form were sent during this time.

**Figure 1.** Educational brochure distributed to all eligible property owners.



We conducted voluntary reverse auctions in spring 2007 and 2008. Reverse auctions operate much like competitive bidding processes in the construction industry whereby contractors (*i.e.*, bidders) place a bid for their price to be paid and, in general, lower bids are more successful. A confidential reverse auction was chosen in order to reflect the actual opportunity cost of SWMP implementation [33]. Opportunity cost is defined as the cost of forgoing the next best opportunity. In this case a homeowner places a SWMP on his or her property and forgoes using that land for something else, such as a swing set, vegetable garden, *etc.* In these auctions, homeowners who chose to participate in the program bid the amount that they would require (*i.e.*, their opportunity cost of giving up land area for the collective benefit of stormwater management) to have a rain garden or rain barrels installed on their property.

We developed a landscape-level metric of projected effectiveness, which considered factors such as proximity to tributaries, soil infiltration capacity, area of rooftop connectivity, and total impervious area, to rank bids. In order to achieve highest efficiency with the funds available and to place practices on parcels where they would have the most environmental benefit, bids were ranked from smallest to largest on the basis of a composite index that accounted for both cost and environmental effectiveness (*i.e.*, the least expensive and highly effective implementations were selected first for implementation) [34]. Rain barrels with screened tops were set under roof downspouts that had been cut to length. An overflow pipe from each rain barrel was routed to the downspout drain. Rain gardens were installed according to individual parcel landscape features and owner preferences [35]. A promotional website was created and maintained over the three-year monitoring period for residents to learn more about stormwater management and the role of their practices in promoting good wastewater management, along with contact information and maintenance tips. In depth discussions of the economic, hydrologic, and ecological aspects of this project have been published previously [33–36].

The role of social capital was evaluated using the proximity of homes as a proxy for social networks, the appropriation (*i.e.*, social capital) of which was assessed comparing the locations of residents that successfully bid in 2007 and residents that successfully engaged in the same process in 2008. This assumes that neighbors whom may have been skeptical of the program in its first year engaged with the program in its second year after witnessing neighbors engage successfully. We also assume that any such effects due to neighbor influence should be greatest for adjacent properties and this influence will decrease with increasing distance. Thus, the presence of social capital should be evidenced by an increased correlation between bid outcomes when comparing nearby properties against widely separated properties. These behaviors are typically evaluated using spatial clustering analyses.

Many spatial clustering techniques, such as geostatistics and Moran's I, are frequently based on one or more restrictive assumptions such as normally-distributed response variables on random or gridded locations. Our data violated these common assumptions because they were binomial rather than continuous (bid *versus* no bid), and therefore likely to be non-normally distributed, and because the population of properties offered the opportunity to bid was neither random nor regularly-gridded (see Figure 2). Therefore, we assessed the presence of non-randomness in the spatial distributions of bid responses by applying boot-strapping (with replacement) techniques to the distribution of parcels linked by each of several pairwise distances between properties. We compared the average pairwise distance between properties associated with successful bids to the average pairwise distance between an equal number of properties that were randomly selected from all those offered the opportunity



to bid. We then generated 10,000 sets of randomly selected groups of properties, computed the average pairwise distance for each, and ranked the average pairwise distance for those parcels that had successfully bid, comparing these to generate a probability-of-occurrence ( $P$ ) value. Thus, a very small  $P$ -value indicates that the observed average distance between properties is very unlikely to be due to random chance and therefore is an indication that there is non-random structure present in the locations of the successful bids, *i.e.*, spatial correlation due to the influence of social capital. All calculations were made with the Statistical Analysis System (ver. 9.2; SAS Institute; Cary, NC, USA).

**Figure 2.** Spatial analysis of Phase I (2007) and Phase II (2008) successful bids. Note higher density of clusters among properties along Horizonvue Drive and the Westonridge Drive cul-de-sac (in center of figure). The dashed line marking the boundary between Cincinnati and Green Township roughly follows Latitude 39.182 N.



### 3. Results and Discussion

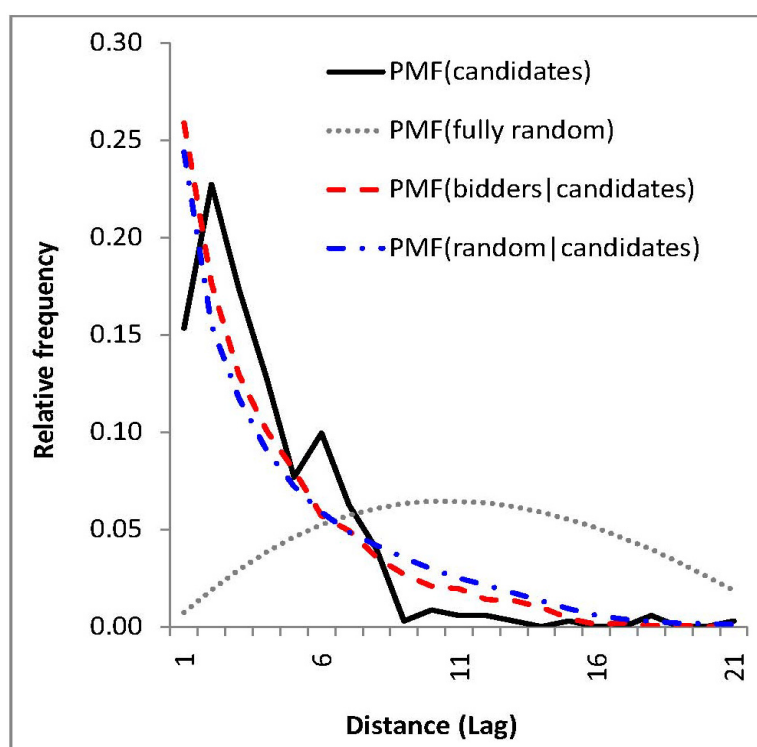
Cumulatively, the auctions led to the installation of 81 rain gardens and 165 rain barrels on more than one-third of the 350 residential properties in the watershed, resulting in an estimated 360 m<sup>3</sup> increase in detention capacity for excess stormwater runoff over pre-implementation conditions. Therefore, the retrofits added substantial capacity to capture and detain stormwater runoff in this watershed.

The Shepherd Creek project did not intend to build or utilize social capital, instead its educational efforts focused on investing in human capital. Nearly half of the received bids were for \$ 0. We assume that participants bidding \$ 0 would have participated in the absence of an economic

incentive and did not bid \$ 0 for competitive strategic objectives (e.g., to underbid other residents to keep them from participating) [34]. To quantify the role of human capital, Thurston *et al.* used \$ 0 bids as a proxy for measuring the effect of the education campaign [34]. Volume detained by residents that bid \$ 0 was compared to volume detained by all participants for both abatement potential and cost effectiveness (cost per liter of detention) [34]. Results of the hypothetical, education-only campaign revealed that a substantial volume of stormwater could be abated through an induction of human capital—196,700 L for gardens alone in a 2-year storm event—and free installation and 3-years of maintenance at a slightly higher level of cost-effectiveness than through economic incentives [36].

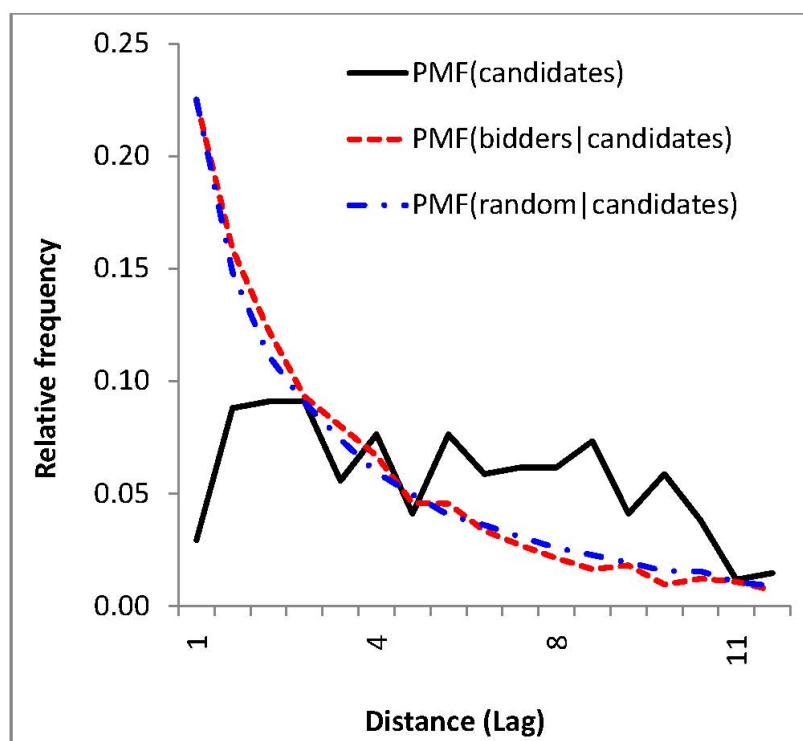
Although stormwater management practices were distributed relatively evenly throughout the watershed, one micro-watershed area of about 50 houses (see Figure 2, clusters in center of map) exhibited unusually high landowner participation. If each of these residences routed all of their runoff to the rain garden and rain barrels, coarse modeling exercises suggest that detention is implemented densely enough in this area to decrease stormwater quantity relative to pre-management conditions at the neighborhood stormwater outfall for at least smaller rainfall depths [37].

**Figure 3.** Normalized relative frequency of pairwise distances between sites, or probability mass functions (PMFs) for the Shepherd Creek reverse-auction. The PMFs were constructed by calculating the distances between all possible pairs of sites, dividing the distances into bins, counting the number of occurrences in each bin, and normalizing the counts to sum to one. The PMF for all candidate properties is depicted by the solid black line and the PMF expected for randomly distributed or gridded properties is depicted by the dotted gray line. The PMF for successful bidders drawn from (conditional on) the population of candidate sites is depicted by the dashed red line and the average of 10,000 unique PMFs for an equal number of sites randomly selected (without replacement) from the candidate properties is depicted by the dash-dot blue line.



The analysis of the spatial distribution of successful bids indicated that there was a significant deviation from conditional randomness ( $p = 0.01$ ), which we interpret to indicate that intentional interactions and influence as social capital modulated the response to the reverse auction held in 2008. The frequency distributions or probability-mass-functions (PMFs) of average distances between sites are depicted on Figure 3. The PMF differed between the randomly selected sites (solid blue line, Figure 3) and those actually observed (dashed red line, Figure 3). There was an increased frequency of successful bids between nearby (more adjacent) properties, and decreased frequency of successful bids between distant properties, relative to what should have occurred randomly. Using the minimum distance between properties as a distance lag (*i.e.*, about 10–15 meters), it appears that successful bids were more likely to occur among parcels that were within a distance metric of the width of approximately five properties.

**Figure 4.** Normalized frequency of pairwise distances between sites, or probability mass functions (PMFs) for the Shepherd Creek reverse-auction. All properties below Latitude 39.182 N are excluded. The PMF for all candidate properties is indicated by the solid black line and is fairly similar in shape to the symmetric mound expected for truly randomly distributed sites (e.g., dotted gray line, Figure 3). The PMF for successful bidders drawn from and conditioned on the population of candidate sites is depicted by the dashed red line, and the average of 10,000 PMFs for an equal number of sites randomly selected (with replacement) from the population of candidate properties is depicted by the dash-dot blue line).



Inspection of Figure 3 suggests that the results of the analysis of spatial distribution might be largely due to the paucity of successful bids in the less-dense sections of the neighborhood (see Figure 2, area south of latitude 39.182 N). However, excluding these locations entirely yielded similar results ( $p = 0.08$ ), although the PMF for the spatial distribution of candidate sites (solid black line,

Figure 4) became, as expected, much more similar to the smooth mound expected for truly randomly distributed locations (e.g., dotted gray line, Figure 3). This may be due to the decreasing density of residential housing, which may also decrease contact among neighbors and thereby the potential for cultivation of social capitals.

Social networks of neighbors transformed their human capital into collective action when they shared their experiences with SWMPs. Together, the human and social capitals gained through civic engagement worked to create losses in the urban hydrologic cycle that may mitigate some of the runoff generated from impervious areas. Thus, our hypothesis that we can add detention capacity via citizen participation is affirmed.

Early evidence of rain barrel practices shows high variability in homeowner use of detained water for domestic use. A small percentage of homeowners maximized the amount of runoff abated by directing rain barrel overflow into their rain garden, while others without rain barrels directed downspout flow through imaginative flow spreaders (e.g., pads with rocks, a small rock garden, doormats) and into rain gardens. Although rain barrels have relatively low detention capacity, installation severs the connection between a residential roof and the sewer system, leaving options open for fully-redirecting stormwater runoff to other sinks. Further, they offer great potential benefit in the form of cultural capital. The rain barrel is a highly-visible tool which may be influential for shifting neighborhood culture [38]. As rain barrels become more ubiquitous in a neighborhood, the trend may spread to other neighborhoods as residents move away and spread the culture of decentralized stormwater management.

#### 4. Conclusions

An incentive approach was used to recruit individual citizen-landowners to be stormwater managers and simultaneously decentralize stormwater management. This multidisciplinary approach to watershed management offers an example of stormwater management that should be readily transferable to other residential watersheds, though effectiveness is reliant upon maximizing participation and will be observed only through good monitoring. Our study indicates that economic incentives may further encourage local environmental management through citizen engagement.

As evidenced in the Shepherd Creek experiment, social capital may be just as, if not more, vital to widespread acceptance of SWMPs as physical, human (education), or financial capital. Thus, external agents should be aware of the benefits and pitfalls of social capital when investing in physical capital. Investing in strategies that grant responsibility and power to individuals may increase the economic benefits of financial investments in small to medium sized physical projects by inducing collective action and strengthening social cohesion and communal health [22,39]. Thus, increased investments in social and human capital must coincide with increased investment in physical and natural capitals in order for the projects to realize maximum benefit.

Application of our findings will be especially vital in the CSO context as sewer and sanitation districts implement GI projects throughout their service areas. The ability to influence human behavior, a benefit of social capital, may not be readily available to sewer and sanitation districts with weak relationships with the community development groups that have expertise in citizen engagement and urban land redevelopment. While social capital may not be readily available to sewer districts,

other forms of capital are not equally available to community groups, namely financial capitals. Thus, large-scale application of GI for CSO-related stormwater management is steeped in social capital issues whereby we must utilize bridging organizations and social networks to form bonds between agencies with the necessary expertise, resources, and interpersonal relationships to solve a collective, municipal problem [40]. Through collaboration, sewer districts under legal mandate to invest heavily in stormwater infrastructure and community organizations with access to stocks of volunteers could leverage alternate forms of capital for actualization of the full suite of GI co-benefits. Such partnerships may prove vital to the long-term success of GI, in terms of both stormwater abatement and community benefits as well as a paradigm shift whereby citizen engagement in decentralized stormwater management becomes the predominant culture.

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### Conflict of Interest

The authors declare no conflict of interest.

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