

PUBLIC PERCEPTION AND WILLINGNESS TO PAY FOR GREEN INFRASTRUCTURE IMPROVEMENTS IN NORTHERN NEW JERSEY

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ABSTRACT: *Significant water pollution caused by flooding due to heavy precipitation and extreme weather events such as Hurricane Sandy and similar storms of the past have become a considerable problem. Urbanized areas of northern New Jersey experience heavy downpour-related contamination and water pollution when stormwater and untreated sewage are diverted through old drainage systems to adjacent water bodies. These contaminated discharge events are from combined sewer overflows (CSOs). Though the effects of contamination from CSOs have been studied, the socio-economic aspect of these issues has not received similar scientific attention. This study seeks to understand the socio-economic facets of the continued use of CSOs in Elizabeth, New Jersey. An econometric stated preference method was used to analyze the willingness of residents to pay for improvements to CSO infrastructure through the assimilation of green infrastructure (GI) such as bioretention gardens, rain barrels, and green roofs. The analysis also sought to understand how different factors such as age, economic status, and ethnicity, in addition to perceptions of environmental problems and governmental action, affect their willingness to pay for GI improvements. We found that respondents were mostly willing to pay for GI annually and as a one-time payment, and had overall positive outlooks on GI while citing some concerns about existing infrastructure. These findings are important in assessing the overall attitude towards these fixtures, and may be critical in crafting local policy and development, especially in terms of environmental equity.*

Keywords: *Stormwater Management, Combined Sewer Overflow, Green infrastructure*

INTRODUCTION

New Jersey has suffered from considerable water contamination as a result of rapid industrialization and urbanization, which has created significant adverse effects for both human and environmental health (Crawford et al., 1995; Iannuzzi et al., 1997). Previous research on combined sewer overflow (CSO) infrastructure has largely focused on the technology aspect of stormwater management problems, and have rarely considered public preferences and opinions in policy and decision-making processes on management strategies (Jaffe, 2009; Jayasooriya and Ng, 2014).

The socio-economic aspects of stormwater management are not well understood in current literature, and are rarely integrated alongside scientific and technological advancements in better understanding stormwater problems and improving design and public policy solutions (Jayasooriya and Ng, 2014; Keeley et al., 2013). In the wake of Hurricane Sandy, which damaged 70 drinking water systems and 80 wastewater treatment plants statewide, perceptions of the problems associated with continued use of CSO infrastructure have been heightened, and efforts by the New Jersey Department of Environmental Protection (NJDEP) and the United States Environmental Protection Agency (USEPA) to mitigate CSO discharges have improved (NJDEP 2015). These improvements come in addition to existing technological solutions for CSO mitigation, such as improved grey infrastructure and different varieties of green infrastructure (GI) installation. There remains, however, limited understanding of the public perception and understanding of the economic and environmental tradeoffs of these solutions, particularly regarding GI (Jaffe, 2009; Jayasooriya and Ng, 2014; Mell, 2009; Tsihrintzis and Hamid, 1997). As such, this study has attempted to fill this gap by studying the socio-economic aspects of stormwater management and assessing public perceptions in order to improve management decision making for public officials.

Combined sewer systems are characterized by a sewer infrastructure that uses a common pipe to transport sewer water, street runoff, and other waste water to a water treatment plant. During periods of significant runoff, the combined system can be overwhelmed, causing a discharge into nearby waterways. Urban areas are particularly vulnerable to this problem, as even small rainfall events can cause CSO discharges; some urban areas of New Jersey can face discharge events with as little as one inch of rainfall (Battelle, 2005; Donovan et al., 2007). Changing water

dynamics and uncertainties caused by global climate change have given these issues more urgency, as increased discharge from CSOs brought on by rising water levels or increased storm frequency or intensity could make contamination more common (Jagai et al., 2015; Keupers and Williams, 2013).

CSOs create significant problems for both human and environmental health, both of which are well documented (Donovan et al., 2007; Jagai et al., 2015; Veronesi et al., 2014). The USEPA estimates that over 23 billion gallons of untreated sewage may be discharged annually into North Jersey waters due to CSO failures (EPA, 2012). Even mild events can trigger enough stormwater discharge to cause significant waterway contamination or toxicity, especially near the discharge site (Casadio et al., 2010; Sandoval et al., 2013), suggesting that the situation can worsen with large storm events. CSOs discharges also contribute to the pollution of waterways by releasing petrochemicals and agrochemicals, nutrients, like inorganic nitrogen and phosphorous, as well as pharmaceutical chemicals and hormones. These potentially lead to environmental damages such as eutrophication, endocrine imbalances in aquatic life, and reduced site aesthetics (foul odors, loss of scenic vistas) (Veronesi et al., 2014).

To mitigate CSO discharges and other stormwater management challenges, cities across the United States are increasingly using Green Infrastructure (GI) (de Sousa et al., 2014; Cohen et al., 2012). GI refers to source control measures that reduce stormwater flow by promoting infiltration, evapotranspiration, and the capture and reuse of rainwater (de Sousa et al., 2012). GI comes in the form of green roofs, rain barrels, rain gardens, biofiltration basins, and permeable pavements, among many others, all of which function by providing an infiltration pathway for flood waters in urban settings (USEPA, 2013). GI has grown in popularity due to its utility and versatility, and is advantageous in areas where traditional grey infrastructure may be of limited use, such as rooftops (USEPA, 2013). In addition to helping mitigate water accumulation problems, studies show that different GI types can remove pollutants from water, enhance carbon sequestration, and improve quality of life, aesthetics, and real estate value (Cohen et al., 2012; de Sousa et al., 2014). While these infrastructure technologies have proven to be useful, the benefits of these systems for the populace on an individual level are less understood. Thus, GI can create concerns for environmental justice and equity, as the benefits may not necessarily reach those who are in most need.

For this study, we evaluated GI alternatives for stormwater management in the Newark Bay region using contingent valuation, assessing the socio-economic acceptance of their environmental and economic benefits using non-market valuation approaches, and examining public policy options for furthering their adoption. We used a survey-based approach to assess public willingness to pay for different GI in order to understand the value that the public attributes to different management alternatives. This approach will be valuable in identifying prevailing attitudes and level of education about different GI fixtures, and in later studies may be used in regression analysis to provide quantitative economic data that can be used in management decisions. This method can help identify the best approach to get the public involved in investing, managing, and actively participating in stormwater management strategies, and may not only help allocate resources more effectively, but also add resources in the form of social capital. The results of this study can be of interest to government agencies, city planners, and environmental managers, and may help fill gaps in current research and create a more complete picture of the socio-economic structure behind stormwater management decisions.

METHODOLOGY

This study aims to better understand the perceptions of flooding and infrastructure, attitudes towards environmental issues, and willingness to pay for green infrastructure as a potential solution. We sought to achieve this goal by using a contingent valuation survey targeting respondents in Elizabeth, New Jersey.

Study Area

Elizabeth is the fourth largest city in New Jersey with a Census Vintage 2019 Estimates estimated population of 129,216 (US Census, 2021). Elizabeth shares many of its economic strengths with Newark, including its harbor, refineries, and parts of Newark's international airport. Elizabeth bears 28 CSO discharge sites, which places it third among cities in New Jersey. The waterways prone to CSO discharges include the Elizabeth River, the Arthur Kill, and the Hudson River, where it opens up into Newark Bay. Estimates claim that 19.5% of its residents are African American and another 65% are Hispanic. Around 17.6% of the population lives under the poverty line and just 13.5% have a college education (US Census, 2021). Because of the minority status of many of these residents, Elizabeth is of particular interest, as studies have found that flooding events disproportionately affect minorities (Chakraborty et al. 2019, Fielding 2017). This city was chosen for this study due to this confluence of CSO sites and vulnerable populations, as well as for its similarity to other cities in northern New Jersey that have similar problems. A map of the study area including the sampling site and the city's CSOs is presented in Figure 1 below.

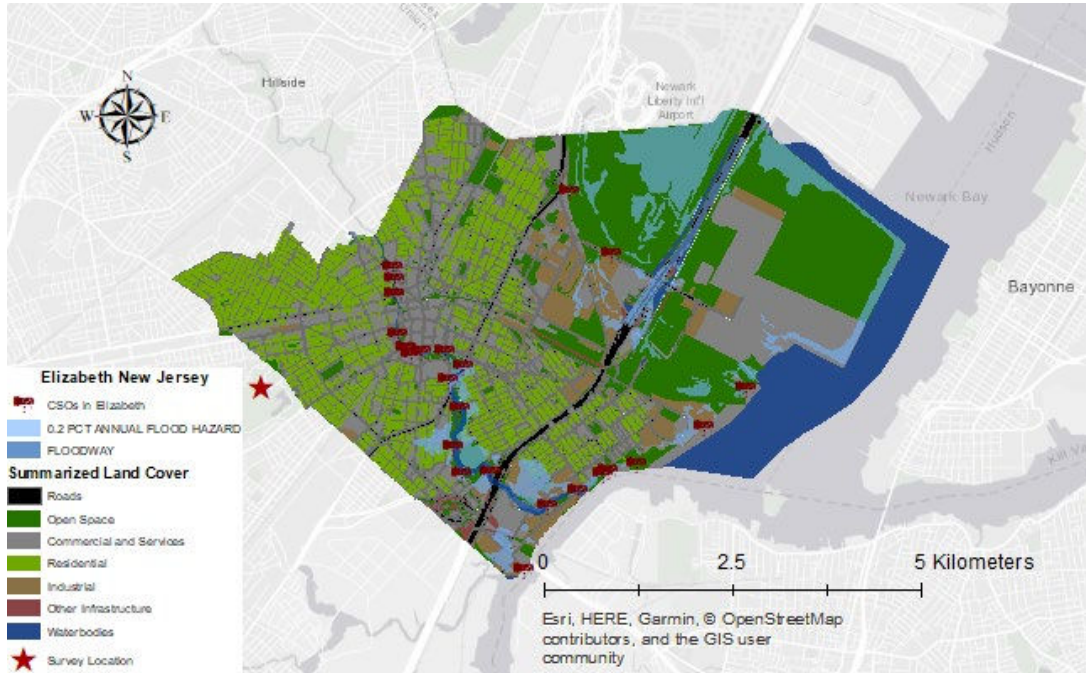


Figure 1. CSO locations, 500 year floodway, and land uses for Elizabeth, New Jersey.

Contingent Valuation

Contingent valuation is a popular method in environmental economics that uses a survey-based method to elicit respondent willingness to pay (WTP) for an environmental benefit or willingness to accept (WTA) for losing a benefit. This value can be used to form an estimate on how the good or service is valued, and even factors that influence higher or lower values. Contingent valuation does not need existing datasets to function, and therefore can create valuations of difficult to measure or understudied benefits. It can also elicit values for future environmental fixtures, which some valuation methods, such as hedonic valuation, cannot do as they rely on observable trends. Contingent valuation suffers from numerous weaknesses due to its reliance on the hypothetical market. Since respondents do not have to actually accept or pay any money, economists have called the accuracy of these values into question (Ashford and Caldart 2008). Further, respondents are not hampered by budget issues in a hypothetical market, nor do they necessarily have to be versed in the topic at hand to answer, which may further confuse accuracy (Ashford and Caldart, 2008; Jilkova et al., 2010). Despite these weaknesses, however, contingent valuation is still relatively common in environmental economics. For example, Jilkova et al. (2010) used the contingent valuation method on the Czech-German border to understand the willingness to pay for residents and tourists for green tourism investments. Thus, contingent valuation is a useful method for measuring the socio-economic values of non-market products.

Survey Design

To gauge the general public's knowledge and understanding of CSOs and GI, we developed a survey that was administered to a sample of the population from Elizabeth, New Jersey. The survey attempted to understand resident's perceptions of CSOs on human health and environmental issues, and determine their willingness to pay for mitigation strategies, namely GI. The survey included 16 multiple choice questions assessing awareness and willingness to pay, 13 Likert scale questions to gauge attitudes and personal experiences with flooding in Elizabeth, and an additional 11 questions of background information, including age, gender, and income. The survey introduced the topic of GI with a brief explanation of potential benefits and pitfalls, and pictures of some common GI installations. Respondents were asked their perceptions of stormwater dynamics, the behavior and dangers of stormwater in their area, and how they had personally been affected by flooding or other stormwater behavior in the past. The survey asked their willingness to pay for GI and their preferred method of payment as a one-time payment, and/or as an annual payment. This question was informed by the pre-survey that asked respondents to give a realistic amount that they would be willing to pay for GI improvements by soliciting an open-ended response, and these responses were to

establish four equidistant bid amounts for each question (one time and annual WTP) on the final survey. Respondents in both the pre-test and final survey were also asked to give reasons for agreeing or disagreeing to pay the bid amount in their survey from a number of options, such as a belief that current taxes should be sufficient or a desire to contribute to the common good. The background section of the survey enquired about respondents' socio-demographics. To ensure best practices and ethical sampling, the project sought and received IRB approval (approval number IRB-FY15-16-166) to ensure the survey would have no ill effects. The survey was printed in both English and Spanish to cater to study area demographics, and the student researchers were also fluent in both languages to address any questions or concerns. Student researchers from were paid for their work on the project, and received on-site training in addition to CITI training to facilitate ethical sampling.

The survey was first pre-tested at four public parks in Elizabeth. Of these four, Warinanco Park received considerably more responses in the pre-test, and was therefore chosen due to the larger available sampling population. Participants were randomly chosen at the entrances of the park and the park meeting grounds (every other person was approached) between June and August 2016. All visitors to the park over the age of 18 were considered eligible participants; questions on the survey itself clarified the respondents' relationship to the city (resident, local employee, etc.). Surveys were administered on weekdays during these months (Monday to Friday) between the hours of 9 AM and 3 PM. While the location and timing of the survey administration can be problematic in terms of bias, we felt that this method was the best approach for an in-person survey. Many public areas (for example, a library or public transit center) can be restrictive in terms of access (for example, one cannot enter some transit stations without a ticket, and many cannot spare the time it takes to complete the survey before their transit arrives). The park, in contrast, is located in an area accessible by car, bike, or walking, and there is no entrance fee. Though it can be argued that visitors to a park could have a greater affinity towards natural issues, similar contingent valuation studies have also sampled using face-to-face interviews in parks and recreational areas, with no significant bias (Jilkova et al. 2010, Wilker and Rusche 2013). Further, the summer months attract larger amounts of park-goers, allowing for a larger sample size. While the times could potentially disqualify respondents working typical 9-5 jobs, observations from pre-testing suggested that the park enjoyed the most visitors during these hours. Overall, 123 complete individual responses were recorded for analysis.

RESULTS AND DISCUSSION

Since respondents were chosen randomly, ideally the survey should be representative of the population that we were analyzing. In many cases, we believe we were able to capture the demographics of the area. The area has a considerable Hispanic/Latino population that is represented well in our survey, with 59.48% of respondents identifying with this ethnic group compared to 59.5% in Elizabeth overall, according to census data. In terms of home value, 47.73% of residents noted that their home appeared in the same bracket (\$22,001 to \$49,999) in which the median home value rests according to the Census data. Our sample of population in poverty was slightly overrepresented, as 28.3% of respondents replied that their household income was under \$22,000 annually, compared to 17.6% in Elizabeth overall. Respondents were distributed as male (40.7%) and female (59.2%). The descriptive statistics for the key binary questions of the survey can be found in Table 1.

Table 1. Descriptive statistics for Yes/No survey questions.

| Question | No | Yes |
|---|-----------|------------|
| Were you familiar with green infrastructures and their benefits prior to this survey? (N/Y) | 60.8% | 39.2% |
| If the City Municipal Utilities Authority were to charge annual payment in order to install and maintain green infrastructure in your area, including public AND private areas (including your home) would you be willing to pay for the green infrastructure? (N/Y) | 34.2% | 65.8% |
| If the City Municipal Utilities Authority were to charge one-time payment in order to install and maintain green infrastructure in your area, including public AND private areas (including your home) would you be willing to pay for the green infrastructure? (N/Y) | 31.2% | 68.8% |
| Have you been affected in any way by flooding in last 2 years? (N/Y) | 70.7% | 29.3% |
| Would you describe your residence to be in a flood prone area? (N/Y) | 54.9% | 45.1% |
| Are you aware of past, ongoing, or future green infrastructure projects in your city? (N/Y) | 74.2% | 25.8% |

In both annual and one-time willingness to pay, respondents had a positive WTP, with 65.8% responding yes to an annual payment and 68.8% willing to pay a one-time payment. When asked about their reasoning, 44% responded that they wanted to contribute to the common good, 26.8% wanted the direct benefits and 27.6% expressed concerns about flooding. Respondents who were unwilling to pay also expressed reasons for their choice, with 18.7% stating that their taxes should already be paying for such infrastructure and 12.2% believing their contribution would not significantly help a regional issue like flooding. This is considerably higher than Wilker et al. (2014), who found that only 38.2% would be willing to pay for future green infrastructure projects. However, unwillingness to pay due to a feeling that existing tax payments should be sufficiently are commonly a major reason that respondents are not willing to pay (Wilker et al. 2014, Jilkova et al. 2010).

The results of the survey show that while there is some disagreement about flooding and other environmental health issues, 65.8% and 68.8% of respondents were willing to pay for GI annually and one time, respectively. While such a large number is somewhat surprising, since 60% of respondents reported being unfamiliar with GI before their experience with the survey. The lack of familiarity with GI and its potential to mitigate some of the harmful effects of flooding (which respondents reported being concerned about in later areas of the survey) suggests a lack of knowledge of GI benefits and uses, which may constitute a failure in municipal/community outreach. Compounding this lack familiarity with GI, the majority of residents reported that they were unaware of ongoing projects, as nearly 75% of respondents reported that they were unaware of any past, current, or planned GI projects in their city; this suggests a lack of outreach from the city in its efforts, a lack of media coverage on GI flooding issues, a lack of interest, communication failures (including language) between government and residents, or some combination of these and unknown factors. Because many respondents stated that taxes should already cover such infrastructure, it can be reasoned that some number of recipients were unwilling to pay not because of economic cost, but on principle, as they did not believe their current tax money was being allocated well enough to stop this flooding danger. However, this response may also simply suggest that many of the respondents could not afford an additional cost for the municipality on top of what they were already paying. This is supported by Wilker et al. (2014)'s findings, wherein unwillingness to pay due to taxes or an inability to afford it combined for 92.6% of the total sample of residents unwilling to pay.

Though flooding is a prevalent problem in the area, results of the survey suggested that the residents surveyed were not affected significantly by it, as 70% of respondents replied that they had not been affected by flooding in any way in the last 2 years. Additionally, 55% of respondents felt that their homes were not in a flood prone area. Interestingly, while 70% of residents said they had not been affected by flooding, only 55% reported that they did not feel that their home was in a flood prone area, suggesting that there are some residents who felt that they were in some danger from flooding but had not experienced it. The respondents who did experience flooding events, however, had some variation in how often they were affected; 35% replied that they experienced 1 flooding event per month under normal circumstances, 46% reported 2-3 events, 11% reported 4-5 events, and 8% reported over 5 events. However, those that had been affected by flooding reported a considerable number of flood events, as all responses to that question denoted a number of flooding events under normal weather patterns (i.e. no major storms, such as Nor'easters) in a month. We can infer from this that the survey did indeed capture some number of residents that are affected by these floods and are at risk for further damages, and would therefore be the ones that would most benefit from GI.

We also captured general attitudes regarding stormwater management in the area. On the question of infrastructure and general preparedness, 48% felt that current infrastructure was not enough (38% disagree and 10% strongly disagree), and only 16% of respondents agreed or strongly agreed that it was sufficient. 31% of respondents felt that flooding was a threat to their property, with an equal number of respondents responding neutrally to the statement. In terms of health risks, 39% of respondents agreed that they were concerned with health risks involved with the current infrastructure, with an additional 11% strongly agreeing with the statement. This may suggest that residents are wary of flooding, either from smaller local floods or relatively recent memory of the damage caused by Superstorm Sandy.

A relatively small percentage of respondents felt that current infrastructure was sufficient to shield them from flooding issues, which, compared to the majority of respondents willing to pay, suggests a respondent base that feels relatively unprotected by current systems in place and is willing to contribute some funds in order to improve them. This is supported by the fact that, of the options, respondents felt that flooding was a risk to them more often than not. Half of the survey's respondents also felt that they were at risk of health issues from problems unhindered by current infrastructure, providing more evidence that respondents are willing to pay for something they feel is necessary to protect their health and property.

Table 2. Descriptive statistics of Likert scale survey questions.

| Statement | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|--|-------------------|----------|---------|-------|----------------|
| There is enough infrastructure and preparedness to deal with excessive overland flows (flooding) | 10.0% | 38.0% | 36.0% | 12.0% | 4.0% |
| Flooding event in my area is not frequent and it is not likely to cause significant property damage. | 9.9% | 30.7% | 30.7% | 22.8% | 5.9% |
| I am concerned with health risks involved with current infrastructure. | 3.1% | 9.2% | 37.6% | 38.8% | 11.2% |
| Green infrastructures are a fad and will not last. | 17.0% | 40.4% | 29.8% | 9.6% | 3.2% |
| Green infrastructures are too costly and require a lot of maintenance. | 4.2% | 26.0% | 34.4% | 25.0% | 10.4% |
| Green infrastructures can potentially improve scenery in my area. | 3.1% | 4.1% | 28.6% | 40.8% | 23.5% |
| Green infrastructures can potentially lower the risk of flooding. | 2.1% | 6.2% | 24.7% | 43.3% | 23.7% |
| Green infrastructures can potentially improve quantity and quality of water resources of the area. | 5.1% | 3.0% | 24.2% | 38.4% | 29.3% |
| My city is at considerable risk of flooding. | 8.2% | 20.4% | 35.7% | 24.5% | 11.2% |
| Flooding in my area is a cause of environmental problems. | 4.3% | 17.0% | 41.5% | 25.5% | 11.7% |
| I have encountered personal health problems/illnesses in my household as a result of flooding in the past. | 22.7% | 25.8% | 28.9% | 13.4% | 9.3% |
| Global climate change will worsen flooding in this area in the future. | 5.1% | 9.2% | 25.5% | 32.7% | 27.6% |

We also captured general attitudes regarding stormwater management in the area, which is illustrated in Table 2 above. Respondents tended to have positive views on GI itself. Respondents largely disagreed that GI was a “fad” and would not last, with 40.43% disagreeing, 17.02% strongly disagreeing, and only 12.8% agreeing or strongly agreeing with the statement. Respondents were largely neutral (34.4% neutral, 26% disagreeing, 25% agreeing) on whether or not infrastructure was costly and required a lot of maintenance, but there was considerable agreement that GI could potentially improve scenery (40.8 agree, 23.5 strongly agree) and lower the risk of flooding (43.3% agree, 23.7% strongly agree). Respondents also largely agreed that GI could be used to improve local water resources (38.4% agree, 29.3% strongly agree). These perceptions about GI overall differs from other surveys in the literature such as Shandas (2015), who found negative perceptions of GI shortly after its installation in Seattle, Washington, though these became more favorable over time. A survey in suburban Philadelphia by Kuper (2009), found low levels of familiarity with green roofs and neutral attitudes towards having one installed in their neighborhood, but found that

they believed it improved scenery and provided environmental benefits. Tsantopoulos et al. (2018) found relatively positive attitudes towards installation in Athens, though had low familiarity with green infrastructure generally. Our results agree with the positive trend of attitudes towards green infrastructure, especially in terms of its potential to provide benefits to the community.

For health and flooding, respondents were neutral on whether or not the city was at risk of flooding (35.7%) and whether or not flooding in the area is the cause of environmental problems (41.5%). However, there was general disagreement that respondents had been affected by health problems as the result of flooding in the past (25.8 disagree, 22.7 strongly disagree). There was a strong sense of agreement that global climate change would worsen flooding in the future (32.7% agreed, 27.6% strongly agreed). General confusion about the risk of the city’s flooding, how it relates to environmental problems, and how it could cause health problems may suggest a lack of outreach and education by the municipality. For example, prior to the administration of the survey, there was no available information about flooding, climate change, or CSOs on Elizabeth’s municipal website. A better consensus on flooding issues and GI’s ability to mitigate them may be critical to improving willingness to pay and positive perceptions, as previous studies have stressed the importance of water quality improvement and flood risk mitigation in adopting GI (Kim et al. 2020, Ureta et al. 2021).

The neutral response regarding flooding risk reinforces earlier findings that many residents did not feel that their residences were at risk of flooding. If the residents did not perceive that they were at risk of flooding in their own homes, it would make logical sense for them to carry that belief to the city at large. Interestingly, despite the presence of many CSOs in Elizabeth, nearly half of the respondents felt that they had never had their health affected by a flooding event. This could suggest that our survey did not capture a population that is sufficiently close to CSOs, or perhaps that CSO overflow events, if common, are not especially harmful to residents due to lack of direct contact with contaminated water. The strong agreement that global climate change is going to make current issues worse as time goes on supports earlier data that suggests that residents are skeptical of existing infrastructure being able to protect them from flooding events. This also further suggests that residents are aware of a danger and do indeed want improved infrastructure to shield them from its consequences.

Table 3: Cross-tabulation of willingness to pay annually (percent of total).

| | Sufficient Infrastructure | | | | | GCC will worsen flooding | | | | | GI effective reducing flooding | | | | |
|---|----------------------------------|----------|---------|-------|----------------|---------------------------------|----------|---------|-------|----------------|---------------------------------------|----------|---------|-------|----------------|
| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
| N | 4.1 | 11.2 | 11.2 | 6.1 | 0.0 | 2.1 | 6.3 | 11.5 | 7.3 | 6.3 | 2.1 | 3.1 | 11.5 | 13.5 | 3.1 |
| Y | 5.1 | 27.6 | 25.5 | 5.1 | 4.1 | 3.1 | 3.1 | 13.5 | 25.0 | 21.9 | 1.0 | 2.1 | 13.5 | 29.2 | 20.8 |

| | Education | | | | | Income | | | | Association with Neighborhood | | | | | |
|---|------------------|-------------|--------------|------------|----------|---------------|-------------|-------------|--------|--------------------------------------|--------|------------|----------|---------|-------|
| | Elementary | High School | Some College | Bachelor's | Graduate | <\$22k | \$22k-\$40k | \$50k-\$80k | >\$90k | Resident | Worker | Fam/Friend | Customer | Visitor | Other |
| N | 9.0 | 14.4 | 4.5 | 2.7 | 2.7 | 11.2 | 14.6 | 7.9 | 2.3 | 18.2 | 4.6 | 3.6 | 1.8 | 4.6 | 1.8 |
| Y | 16.2 | 23.4 | 13.5 | 8.1 | 5.4 | 18.0 | 31.5 | 12.4 | 2.3 | 38.2 | 12.7 | 2.7 | 0.0 | 11.8 | 0.0 |

To further support our general findings, we used cross-tabulations to investigate any interesting trends in the data, which is presented in Tables 3 above and 4 below. Respondents in both scenarios that felt that infrastructure was not sufficient to prevent flooding were more likely to pay than any other response. Similarly, those who either agreed or agreed strongly that green infrastructure was effective in reducing flooding most commonly were willing to pay for

improvements. Further, respondents that agreed that global climate change will worsen flooding made up the largest percentages of willingness to pay responses. Together, this analysis supports the findings of our descriptive statistics, wherein respondents seemed to be generally supportive of green infrastructure and more concerned with both present and future flooding risks. While the results change slightly between annual and one-time payments, the same trends generally run through both, suggesting that respondents with this mindset are more likely to be willing to pay than other respondents.

Table 4: Cross-tabulation of willingness to pay one-time (percent of total).

| | Sufficient Infrastructure | | | | | GCC will worsen flooding | | | | | GI effective reducing flooding | | | | |
|---|---------------------------|----------|---------|-------|----------------|--------------------------|----------|---------|-------|----------------|--------------------------------|----------|---------|-------|----------------|
| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
| N | 3.3 | 8.8 | 11.0 | 4.4 | 1.1 | 1.1 | 5.6 | 9.0 | 4.5 | 9.0 | 1.1 | 2.2 | 7.8 | 12.2 | 5.6 |
| Y | 5.5 | 31.9 | 24.2 | 6.6 | 3.3 | 3.4 | 3.4 | 15.7 | 29.2 | 19.1 | 1.1 | 3.3 | 15.6 | 32.2 | 18.9 |

| | Education | | | | Income | | | | Association with Neighborhood | | | | | | |
|---|------------|-------------|--------------|------------|----------|--------|-------------|-------------|-------------------------------|----------|--------|------------|----------|---------|-------|
| | Elementary | High School | Some College | Bachelor's | Graduate | <\$22k | \$22k-\$40k | \$50k-\$80k | >\$90k | Resident | Worker | Fam/Friend | Customer | Visitor | Other |
| N | 11.5 | 14.4 | 3.9 | 1.0 | 1.0 | 11.8 | 11.8 | 5.9 | 1.2 | 17.5 | 7.8 | 1.9 | 0.0 | 2.9 | 1.0 |
| Y | 12.5 | 24.0 | 14.4 | 9.6 | 7.7 | 18.8 | 34.1 | 14.1 | 2.4 | 39.9 | 9.7 | 4.9 | 0.0 | 13.6 | 1.0 |

In terms of education, those with a high school education were the most common respondents willing to pay in both scenarios. It should be noted, however, that respondents with college or graduate level education were significantly more likely to agree to pay than other groups (especially in the annual scenario), with respondents with some college education also having significantly more willing to pay than unwilling. As higher levels of education could suggest a better familiarity with various environmental issues tied to flooding in green infrastructure, this generally falls in line with our earlier findings. Respondents in the \$22001-\$49999 income bracket were the most common in the survey. Interestingly, higher incomes do not appear to necessarily contribute to a higher willingness to pay, even though the bid price remained in a constant range regardless of income. For our final background cross tabulation, we found that respondents who lived in the study area were the most commonly willing to pay across both scenarios. These demographic analyses suggest interesting trends that could be better understood with regressions in future study.

CONCLUSIONS AND FUTURE STUDY

The results of the data analysis have given us some insight into the perceptions and attitudes of citizens in Elizabeth. Our survey managed to capture a few important observations about the populations in this area; analysis of descriptive statistics suggests a strong willingness to pay for GI, and simultaneously suggests that respondents perceive GI to be a useful tool for flood mitigation, improving water resources, and other purposes. There is some disagreement among respondents on how severely flooding affects them and therefore how dangerous flooding is in the city, but there is general agreement that global climate change may cause more severe storms in the future and that current infrastructure is not up to the task of keeping their property safe currently or in the future. When viewing these factors together, it would appear that many residents are willing to pay for GI, as they find it useful in a number of ways and feel their current infrastructure is not up to the task of protecting them from worsening storms. As many unwilling respondents stated that they were unwilling to pay because they felt their current taxes should be sufficient to cover

such projects, it may be that these residents would like to see GI projects paid for by local and federal government initiatives, or, since our survey captured a sizable sample of persons in poverty, they are unable to pay more. It is, however, worth mentioning that there appears to be a significant shortcoming in education and outreach, as a majority of the respondents were unfamiliar with GI before the survey, and over 75% were unaware of ongoing projects in their city. These results suggest that further outreach by the town, including community meetings, media campaigns, or targeted outreach would be invaluable in keeping the public informed about new developments. Since the survey captured a large sample of minority groups, these results can also be considered in terms of environmental equity, as many of these respondents are concerned with current infrastructure, but their income affords them the most meager opportunity to adapt on their own. Ultimately, however, these results suggest a positive reception for GI solutions to flood management, even at a public cost, and may therefore signal public desire for GI plans.

Future study will focus on expanding the results of this survey, and developing it for use in other areas. For example, further study will attempt to expand the cross tabulation analysis and run regressions on the results to understand some of the motivating factors behind willingness to pay in terms of responses and background information. Further, regressions may be able to test hypotheses posed in this paper, such as a link between poverty and unwillingness to pay due to an inability to do so or one between willingness to pay and having been affected by floods. This survey can also be adjusted to include more questions in terms of understanding flooding and solutions for residents, in addition to asking more questions about communication from municipalities on these issues. These surveys can be distributed to a number of cities in New Jersey or in the tri-state area of the Northeast, giving a wider view of perception for these areas. Ideally, this work will also be converted to be used as a mail, internet, or phone survey to eliminate potential biases we may have encountered with our methodology to ensure more accurate results. By gaining a more inclusive response from residents in Elizabeth, NJ and similarly afflicted areas we could potentially generate data that could be influential in GI development and improved environmental policies.

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