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RESILIENCE FINDINGS

Perceptions of Flooding Risk and Water Resilience in the Southernmost City in California

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Findings

Imperial Beach (IB), situated at the southernmost point along the California coast, frequently experiences compound flooding, leading to the risk of stormwater pollution. This paper presents results from a brief survey (n=103) to examine IB residents' views on persistent flooding challenges in IB, explore potential solutions to stormwater pollution, and identify barriers to adopting sustainable measures like rainwater harvesting practices (rain water harvesting). The findings indicate that participants are open to experimenting with rain water harvesting practices; however, a significant number lack familiarity with the proper utilization of these interventions, highlighting the need for easily accessible information and resources.

1. QUESTIONS

Imperial Beach (IB), California, identified as a disadvantaged community (FEMA.gov, n.d.), faces elevated risks of compound flooding, a phenomenon resulting from the interaction of sea-level rise (due to climate change) with an already-saturated groundwater table (Sangsefidi et al. 2023; Bosserelle, Morgan, and Hughes 2022). Compound flooding poses additional threats, as stormwater, laden with pollutants, becomes unabsorbable (Werbowski et al. 2021). In San Diego, stormwater runoff generated from rain and impermeable surfaces such as parking lots, rooftops, and paved streets prevents pollutants like chemicals from being absorbed into the ground (EPA, 2023; Frazer 2005). The resulting polluted water can be detrimental to bodies of water, including rivers and coastal waters (EPA, 2023). For example, recent infrastructure failures following heavy rainfall in 2023 have worsened pollution runoff in the Tijuana River Valley (SanDiegoCounty.gov 2023), leading to beach closures and economic impacts such as reduced tourism and property devaluation (Schwartz 2023). IB, already facing socio-economic challenges with a poverty rate of 15.3% in 2022, with 3,997 of its 26,077 residents living below the poverty line (U.S. Census Bureau, n.d.), lacks a comprehensive understanding of community perspectives on these issues. Prior research has found that individuals are more likely to engage in rainwater harvesting practices when incentives are offered, and education and outreach initiatives are implemented (e.g., Fiala 2013; Meder and Kouma 2010). However, renters are anticipated to face distinct barriers compared to homeowners in adopting these practices due to rental agreement constraints.

To address these gaps, the present study aims to uncover viewpoints within this diverse community, focusing on awareness, familiarity, and barriers to the adoption of rainwater harvesting practices.

This study addresses several key questions:

- To what extent are IB residents aware of local flooding issues, and how does this awareness shape their willingness to engage in mitigation efforts?
- How familiar are IB residents with rainwater harvesting technology, and what knowledge gaps exist regarding its benefits and applications?
- What specific motivations, including financial incentives or education programs, are most effective in encouraging the adoption of rainwater harvesting practices among IB residents?
- What structural or policy barriers, particularly in rental agreements, limit the uptake of rainwater harvesting practices, and how can these barriers be addressed?

2. METHODS

2.1. Electronic survey and target population

It is estimated that an average Southern CA rooftop can conserve one thousand gallons of water for every inch of rain (The Ecology Center 2016). The current study focused specifically on the rain water harvesting practices of rain barrels and rain gardens which are low-cost adoption-rated stormwater management applications (Gao et al. 2016). Previous research emphasizes the diverse advantages of rain barrels, noting affordability, reduction of water bills, and effectiveness in addressing stormwater pollution, erosion control, and flood prevention (Fiala 2013). Meder and Kouma (2010) found that "do-it-yourself" rain barrel programs significantly increased community awareness, participation, and education.

To gain a deeper understanding of local perspectives on the ongoing flooding in IB and potential solutions to stormwater pollution, as well as identifying barriers to adopting sustainability measures (e.g., rain water harvesting), we conducted a survey. Rain water harvesting is recognized as an effective solution for capturing stormwater and preventing flooding (Carollo, Butera, and Revelli 2022). A case study showed a rain garden removed 96% of anthropogenic debris (human made waste) and 100% of black rubbery fragments on average, highlighting its potential to mitigate microplastic pollution (Werbowski et al. 2021). With a growing population and decreasing

fresh water supply, rain water harvesting also offers a promising alternative for potable and non-potable uses, while mainly used for irrigation, 25% of harvesters use rainwater for potable purposes (Thomas et al. 2014).

An electronic survey was conducted using the Qualtrics platform. The survey was then distributed electronically by IB city staff via official social media accounts, via QR code on a flyer about the study, and through in-person at the IB public library and community events like a weekly Farmers Market. In-person survey recruitment involved tabling at these local community events, where researchers engaged directly with attendees to explain the study and invite participation. Participants could complete the survey on-site or access it later via an online link, ensuring outreach to individuals actively involved in community activities.

As expected, more homeowners (n=74) participated in the survey than renters (n=29), potentially due to barriers like rental agreements restricting rain water harvesting practices. Between March and December 2022, 103 participants responded to the survey. All participant responses were kept confidential, and there was no compensation provided for their involvement; however, the survey provided respondents an opportunity to share their perspectives. It is important to note that several residents explicitly declined to participate during in-person data collection, citing decades-long frustration with unresolved pollution from untreated sewage that flows from Tijuana, Mexico into IB via the Tijuana River Estuary (Dawson 2024).

2.2. Question methodology

The survey tool consisted of 20 questions, featuring both multiple-choice and short-answer formats, designed using display logic to adapt based on participant responses (see **Figure 1** for an example).

3. FINDINGS

A large majority of participants showed awareness of IB's flooding issues, with 89.2% of homeowners and 62% of renters acknowledging them (Dedina 1995; Sanders et al. 2020; Sangsefidi et al. 2023). Residents demonstrated a stronger grasp of the term "rain water harvesting " compared to the broader concept of green infrastructure (refer to **Figure 2A**), suggesting a more pronounced recognition of associated rain water harvesting practices. Out of the 87 participants who indicated at least moderate familiarity, there was a significant focus on the understanding and utilization of rain barrels, with only 15% of all participants mentioning not being familiar at all (see **Figure 2B**).

Additionally, 11.8% of homeowners (n=11) and renters (n=1) are already using a rain barrel, while 1% (one homeowner) is using a rain garden (Figure 2B). Most participants showed more enthusiasm for incentives for rain barrels, with 77.4% of homeowners and 70% of renters expressing interest,

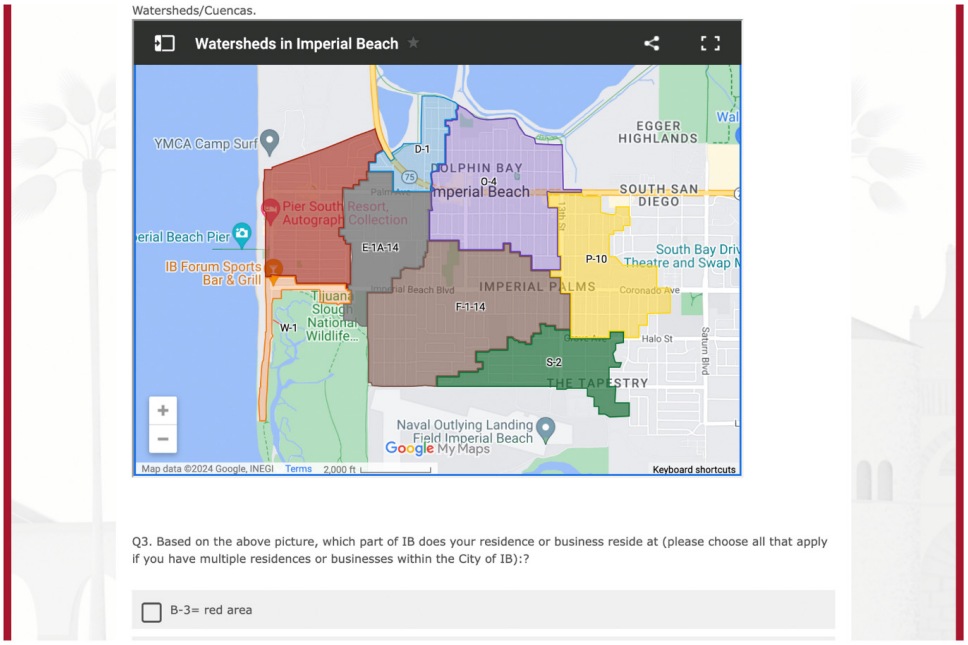

Figure 1. Example image showcasing the Qualtrics survey tool utilized during field collection - survey respondents were prompted to identify the watersheds in IB where they reside and/or worked.

while over 50% of both groups were interested in incentives for rain gardens. This pattern was further highlighted by the significant support shown for receiving a complimentary RB, with 83.6% of homeowners (56 out of 67) and 77.8% of renters (21 out of 27) interested (**Figure 3**).

Although a majority of our renters embraced rain water harvesting practices in the quantitative responses, as indicated in **Figure 3**, hesitation emerged in qualitative responses (see **Table 1**). This reluctance stemmed from doubts regarding their ability to actively partake in these practices within the constraints of their rental agreements.

In assessing respondents' willingness to participate in rain water harvesting practices, the average incentive request was lower for rain barrels (M = $116.5; **Figure 3A**) than for rain gardens (M = $161.4; **Figure 3B**).There was no significant correlation between participants' average monthly water bill (M = $88.7; **Figure 3C**) and their incentive requests for rain barrels ($r = 0.118$, $p = 0.357$) or rain gardens ($r = 0.226$, $p = 0.051$), indicating that incentive requests were unaffected by water bills. Qualitative data (Table 2) show homeowners are motivated by financial rewards and environmental considerations.

This study offers insights into enhancing water resilience in IB, California, emphasizing community engagement and future research opportunities. Respondents displayed significant awareness of IB's flooding issues, highlighting the need for prompt action. Varying familiarity with rainwater harvesting technology highlights the importance of education and outreach

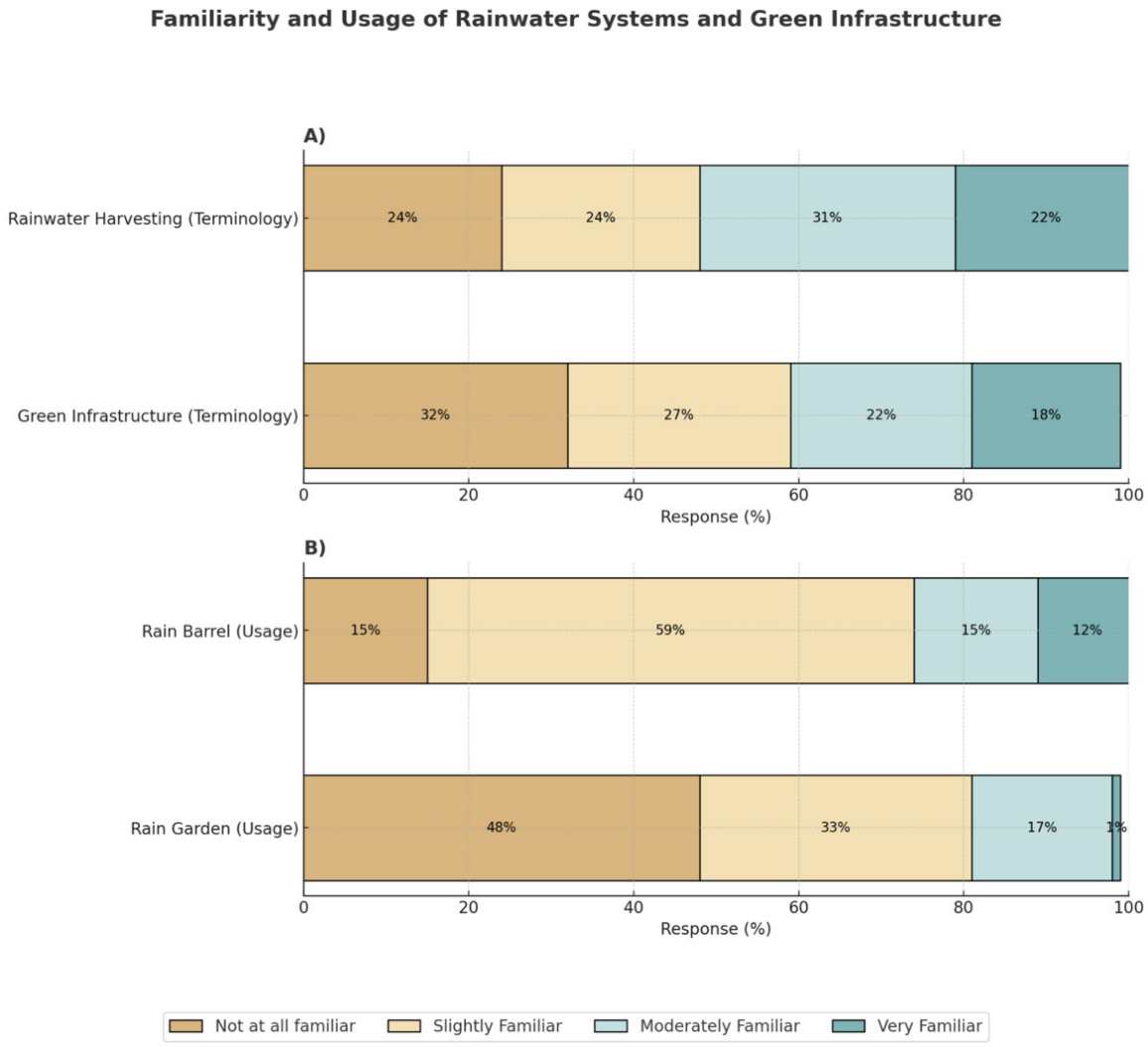

Figure 2. **A)** Assessing community in with terminology employed in green water harvesting interventions through Likert scale assessments. **B)** Present usage and acquaintance with rain water harvesting practices.

initiatives, as seen in previous studies (e.g., Fiala 2013; Meder and Kouma 2010). The results also reveal a notable difference in respondents' preferences between rain barrels and rain gardens, with significantly greater interest in incentives for rain barrels. Respondents were even willing to accept lower compensation for installing rain barrels compared to rain gardens, suggesting that rain barrels are perceived as a more practical or accessible solution due to their lower cost, simpler installation, and immediate applicability for individual households (Fiala 2013), supported by positive outcomes from education programs (Meder and Kouma 2010). Incentive programs show promise in promoting rainwater harvesting adoption, particularly among homeowners, while addressing barriers for renters, such as rental agreements, requires collaborative solutions with landlords and policymakers. Policymakers can leverage the community's interest in rain barrels to drive immediate engagement while designing longer-term strategies to address the more substantial structural or behavioral barriers associated with rain garden

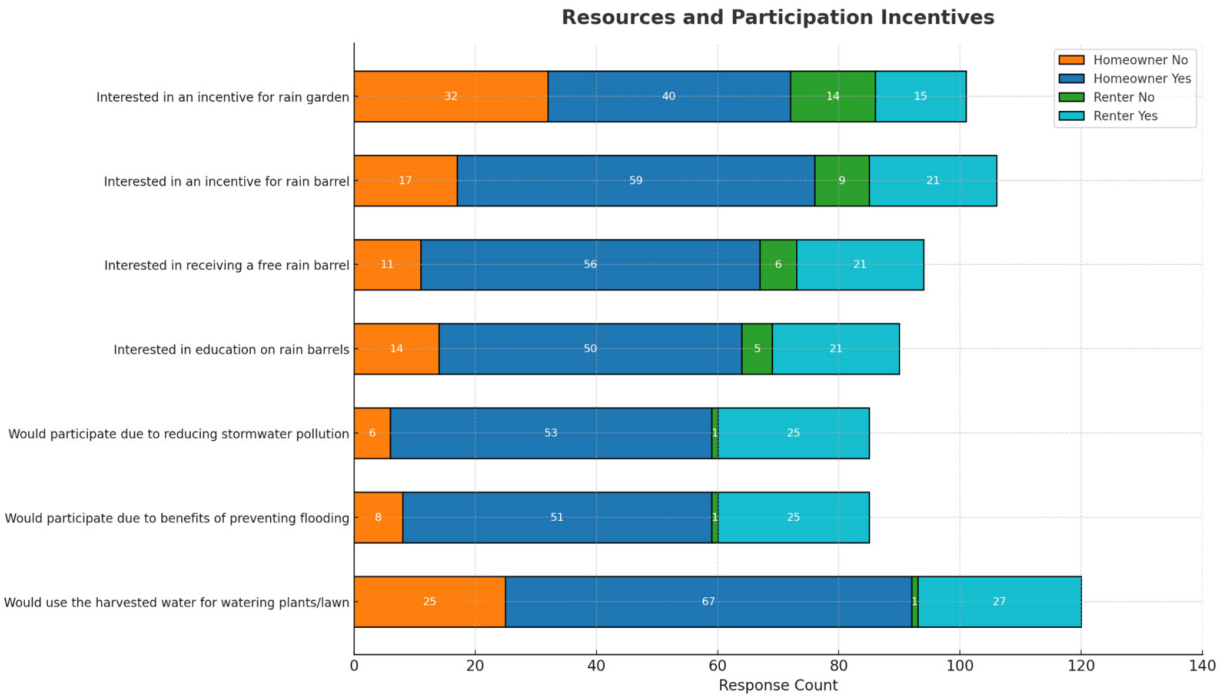

Figure 3. Resources Necessary for Participation By Housing Status

Table 1. Renter Quotes of Concerns

Authorization Barrier:
"Don't think we would be allowed to as renters." *"Sadly, my landlord needs a financial incentive before he decides to do what he knows is the right thing."* *"Isn't it illegal?"* *"Big fan of the practice but it's up to my landlord. He is always incentivized by money."* *"Renter so not sure about landlord."*
Infrastructural Constraints:
"I don't have a yard, if I had a house I would." *"Part time resident."* *"Yes due to not having a yard just a patio."* *"Can't do it, space constraints"*

implementation. Future initiatives could explore tiered incentive structures or combined approaches to gradually integrate both solutions into community practices.

While this study provides valuable insights, several limitations should be acknowledged. The small sample size, particularly among renters, limits the generalizability of findings. Additionally, the limited number of renter responses restricts the ability to test for statistically significant differences in views between homeowners and renters. These limitations should be considered when interpreting the results and designing future research to ensure more robust and representative data.

Further research, including larger sample sizes and longitudinal studies, is crucial for understanding targeted interventions and their outcomes. This study advocates for collaborative efforts to promote sustainability amidst climate challenges, using IB as a model for coastal cities globally. It highlights

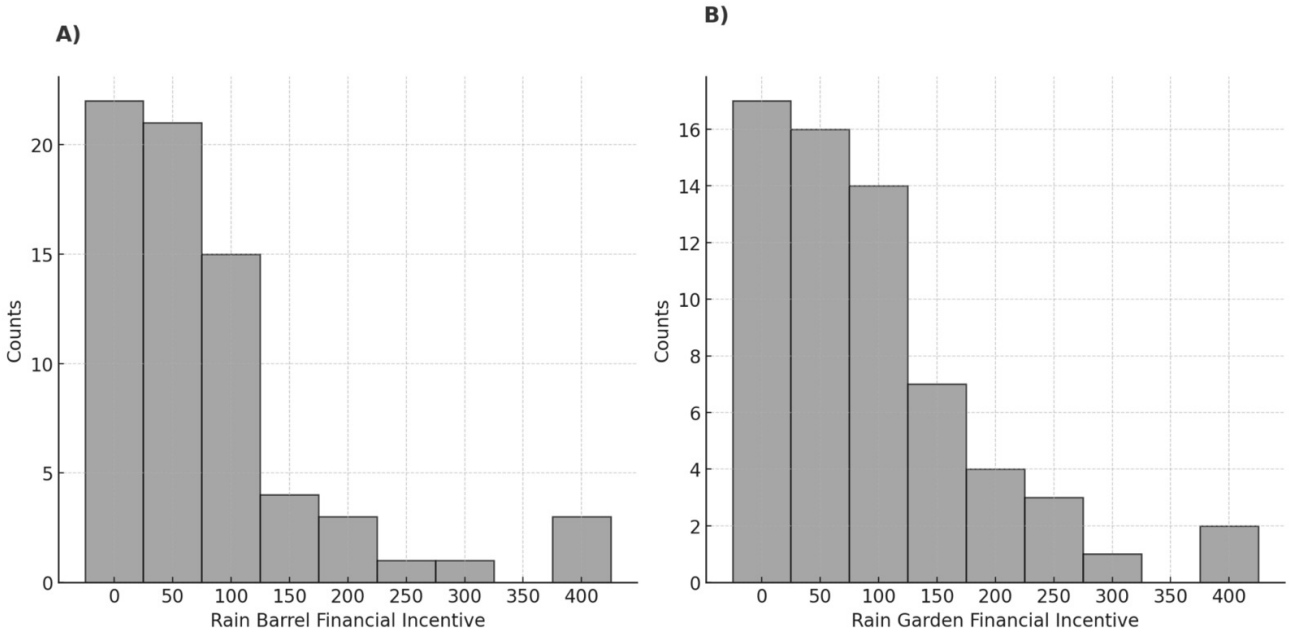

Figure 4. Histogram plots for **A)** participant requested rain garden financial incentives and **B)** participants requested a rain barrel financial incentive.

Table 2. Homeowner Quotes for Motivators

Environmental Motivators:
"We grow a lot of our own food and use drip irrigation. Rain barrel use might help cut some water use." "Incentive to increase my rain storage and use capacity" "I want to retain as much rainwater for beneficial use as is reasonably possible" "I'm interested in good environmental practices and saving money is a bonus." "I care about conserving our natural resources." "No need to get money for doing the right thing for the environment"
Financial Motivators:
"I'm interested in setting up a rain barrel system, but the cost is a concern. Having an incentive or rebate would be very helpful and motivational." "Rain gardens require a larger investment to construct than the use of barrels so an incentive would help." "I would like to know more about how to do it and whether there are free programs that offer assistance." "I purchased two 1500 Gal water tanks to collect rooftop rainwater in the past 2 years, and they have been very effective. I'm retired on a fixed income with several other housemates also on fixed income. So this would be a help to us." "Anything to save a bit of money…" "It would take time and money to create a rain garden, and an incentive would be helpful."

the importance of community engagement and sustainable infrastructure in mitigating climate impacts, particularly in implementing effective rainwater harvesting strategies to address stormwater pollution caused by compound flooding.

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