Identifying and Addressing Challenges of Adaptive Water Supply in Puerto Rico and Beyond

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Summary

Figure 1. Locations of non-PRASA systems across Puerto Rico

Small community water systems (CWS) in Puerto Rico, known as non-PRASA systems, face substantial challenges in delivering safe and reliable drinking water amid climate change and natural disasters. This study aimed to identify key barriers to the resilience of these decentralized water systems and explore alternative solutions for adaptive water supply in Puerto Rico's non-PRASA communities, with a particular emphasis on hurricane impacts. Data, especially perishable information following Hurricane Fiona, was gathered through various methods to pinpoint primary technical, economic, and social factors compromising water supply resilience. Stormwater-to-drinking water (STDW), a concept extending beyond traditional rainwater harvesting, has emerged as a promising, well-accepted alternative for water supply in these small communities. The resilience of STDW stems from its water source diversification, decentralization, and modular design. Insights from Puerto Rico's experience offer valuable guidance for current and future efforts to develop resilient water supply solutions in increasingly vulnerable coastal, island, and other regions.

Objectives

Objective I: To investigate non-PRASA water supply systems and identify the major barriers to their adaptation to water supply in daily situations.

Objective II: To assess and compare behaviors of non-PRASA water supply systems in the aftermath of Hurricane Maria and Fiona.

Objective III: To assess the role of STDW as an alternative pathway in enhancing water supply in non-PRASA communities**.**

Methods

- Survey: A survey including questions about the water supply systems under both daily and emergency situations was carefully developed, then distributed both online and in person.
- Site visits: Interviews with community members and observations through site visits were thematically analyzed.
- Literature review: The potential of stormwater capture for household water supply in Puerto Rico was assessed.

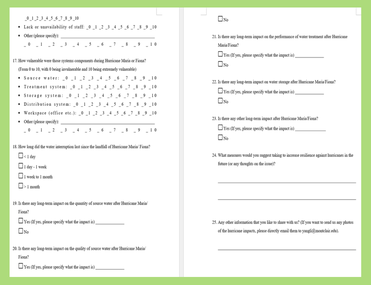

Figure 2. Sample of the survey (bilingual surveys were conducted)

Results

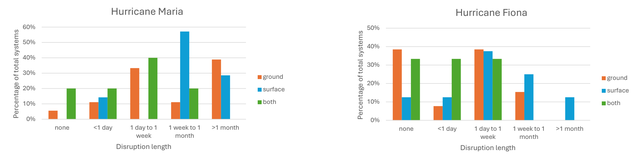

Figure 3. Lengths of service disruptions in the non-PRASA communities during hurricanes

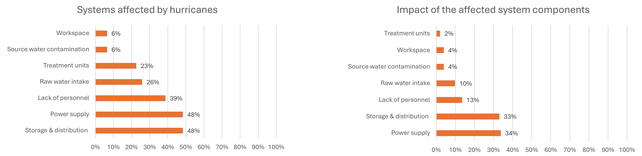

Figure 4. Identifying vulnerable components and key external factors contributing to water outage

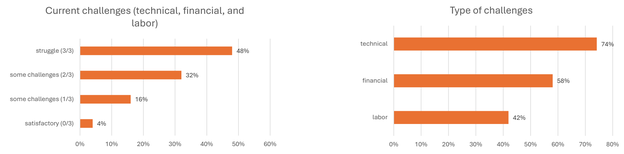

Figure 5. Current challenges for the community water systems

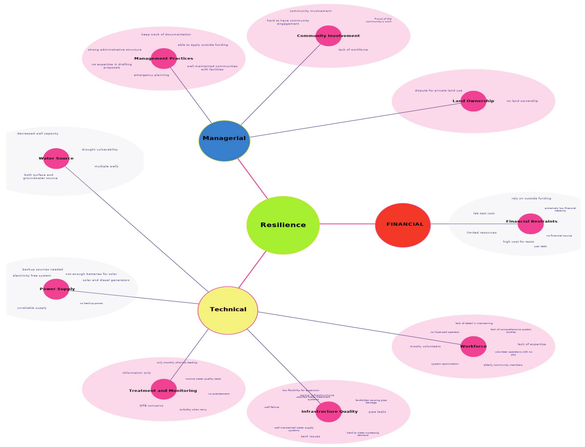

Figure 6. Thematic map for resilient community water supply

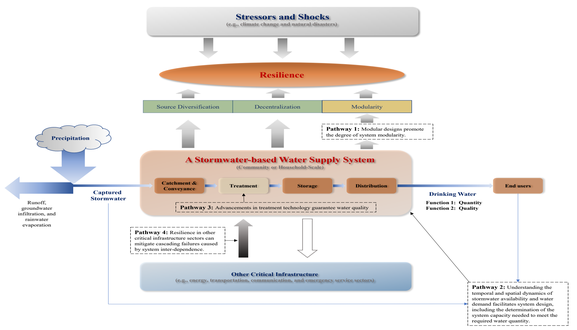

Figure 7. A conceptual framework outlining potential pathways for building adaptive water supplies using stormwater in vulnerable continental coasts and small oceanic islands.

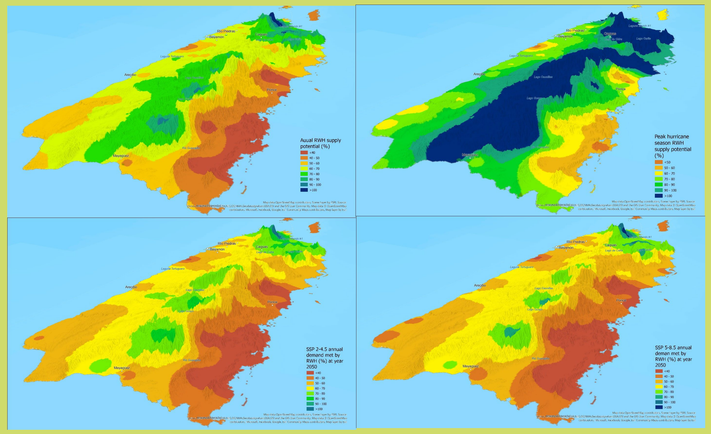

Figure 8. Domestic water demands partially or fully met by STDW under different scenarios

Figure 9. Reliability of STDW

Major findings

- In most communities, chlorination is the only treatment option applied, which leaves the systems unable to effectively address the presence of emerging, persistent contaminants or manage sudden turbidity fluctuations.
- Alternative water sources, upgrading backup power supply options, and securing vulnerable infrastructure—such as pipelines and water intakes—can enhance the resilience of community water systems during emergencies.
- Although most communities are struggling financially, technical challenge is identified as the most common challenge
- The technical challenges faced by these communities are primarily rooted in aging infrastructure, outdated treatment techniques, and lack of technical expertise in the workforce.
- Strong community involvement and effective management capacities are essential for the sustainability of community water systems.
- Stormwater-enabled water supply systems, at community and household scales, represent a promising solution for adaptive water supply in Puerto Rico under both daily and disaster emergency situations. Enhanced resilience is driven by three system attributes: water source diversification, decentralization, and modularity.
- In regions with higher precipitation, such as the central mountainous areas and eastern coasts, STDW can reliably meet household water demand year-round, especially during peak hurricane months when it can cover 100% of household needs. On the other hand, drier regions like the southern coast and San Juan demonstrate lower STDW potential, where it can only meet a small fraction of household water demand during dry periods. When used as a supplemental water source, STDW provides an effective and steady means of conserving water, particularly in areas with consistent rainfall like San Juan. Moreover, during peak hurricane season, STDW can play a vital role as an emergency water source,
- In the face of different climate impacts, such as shifting precipitation patterns in the future, STDW will remain an important tool for improving water security and resilience, especially in remote communities and during periods of extreme weather.

Acknowledgements

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