

## Local Engagement in WSUD Projects in Informal Settlements: Experiences from Duque de Caxias, RJ, Brazil

### Engagement communautaire dans les projets de WSUD en quartiers informels : retours d'expérience à Duque de Caxias RJ, Brésil

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#### RÉSUMÉ

L'article examine les stratégies d'adaptation climatique communautaires dans les quartiers informels de São Bento, à Duque de Caxias, au Brésil, en mettant l'accent sur la gestion de l'eau par la collecte des eaux de pluie et les systèmes urbains de drainage durable (SUDS). Les quartiers informels de cette zone sont confrontés à un risque élevé d'inondation et à un accès limité à l'eau potable, soulignant ainsi la nécessité de solutions locales adaptées. L'étude documente un partenariat entre l'Université fédérale de Rio de Janeiro et des associations communautaires visant à mettre en place des citernes verticales à faible coût et à promouvoir la participation sociale. Cinquante citernes ont été installées à Vila Alzira et Novo São Bento. La formation des résidents, et en particulier des femmes, a permis à la fois le développement de compétences techniques et l'autonomisation communautaire. Des ateliers ont été organisés pour identifier les zones sujettes aux inondations, en s'appuyant sur les connaissances locales et des images prises par drones. Le projet intègre les perceptions locales dans la planification des SUDS afin d'optimiser la rétention d'eau et de réduire le risque d'inondation. Les résultats soulignent l'importance de l'engagement communautaire dans le renforcement de la résilience urbaine. Cette étude contribue à la compréhension des applications pratiques du Water Sensitive Urban Design dans les quartiers informels et met en évidence le potentiel des approches participatives pour soutenir une adaptation climatique durable et inclusive

#### ABSTRACT

This paper addresses community-based climate adaptation strategies in informal settlements of São Bento, Duque de Caxias, Brazil, focusing on water management through rainwater harvesting and Sustainable Urban Drainage Systems (SUDS). Informal settlements in the area face high flood risk and limited access to piped water, highlighting the need for local solutions. The study documents a partnership between the Federal University of Rio de Janeiro, a local NGO, and community associations to implement low-cost vertical cisterns and promote social participation. Fifty cisterns were installed across Vila Alzira and Novo São Bento, prioritizing socially vulnerable households. Training residents, particularly women, enabled both skill development and empowerment. Workshops identified flood-prone areas using local knowledge and drone imagery. The project integrates local perceptions into the planning of SUDS to improve water retention and mitigate flooding. Findings emphasize the importance of community engagement in enhancing urban resilience. The study contributes to understanding practical applications of Water Sensitive Urban Design in informal settlements. It highlights the potential of participatory approaches to support sustainable, inclusive climate adaptation

#### KEYWORDS

(climate change adaptation, informal settlement, public participation, water sensitive urban design, Duque de Caxias -RJ-Brazil)

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## 1 INTRODUCTION

Literature on climate change highlights the importance of the local level in building adaptation strategies. For Wannewitz and Garschagen (2023) adaptation is at least partly a communal task given that communities are in many ways bound together through infrastructure, geography, or resource management. They shared a common perception of hazard risk. Adapting to climate change is a growing challenge for local communities, especially in marginalized informal settlements. Many informal settlements face a high risk of floods and landslides because of poor-quality housing and insufficient infrastructure to prevent flooding, withstand intense storms, and cope with heat waves (Wannewitz and Garschagen, 2023; Satterthwaite et al., 2020). Communities, and especially those who are marginalized, excluded, or particularly vulnerable, must have some control over how their community will adapt (Adger et al. 2011).

The literature on community-based climate change adaptation highlights the need to strengthen the understanding of the human dimensions of climate-related changes, to value local knowledge as a means of enhancing adaptive capacity, and to prioritize the scales at which impacts are experienced, linking these actions to pro-poor development outcomes and including the use of participatory (McNamara and Buggy, 2017). The question is if a vulnerable population has the political power – or political capability – to influence adaptation decisions. In this sense Holland (2017) stresses the importance of alliances built by vulnerable or marginalized communities to enhance their capacity to be politically capable of shaping adaptation decisions, such as alliances with media, academics, non-profit organizations, political advocacy groups.

In countries of the Global South, different experiences demonstrate the potential of rainwater harvesting in socially vulnerable areas, complementing the supply of treated water, and supporting adaptation strategies concerning access to water. The potential to integrate rainwater harvesting into existing urban water supply systems was analyzed for seven cities in Ethiopia, Jordan, and Nigeria by Demeke and Amali (2023). Rainwater has the potential to support domestic supply in all the cities studied. A study by Hasana and Irfanullahb (2022) analyses a community-based model to mitigate challenges related to rainwater harvesting in urban informal settlements in Bangladesh, showing that it could ensure efficient and equitable rainwater management for the urban poor. Sheth and Iyer (2023) report a successful experience in the city of Bhuj, India, involving strong social participation in the implementation of the systems.

In Brazil, rainwater harvesting for household use in informal urban settlements is still scarcely documented in academic studies. Recently the national government passed a new law (Law 14,546/2023) that amends the Law 11,445/2007 that regulate water and sanitation services to promote rainwater harvesting. The new law encourages the use of rainwater and the non-potable reuse of greywater in new buildings and in landscaping, agricultural, forestry, and industrial activities, in accordance with regulations. (Brazil, 2023)

Also addressing the issues linked to rainwater, the development of Sustainable Drainage Systems (SuDS), introduce new strategies which mimic natural process processes like infiltration, attenuation (slowing), and evapotranspiration as alternatives to manage floods. This concept asserts that drainage systems can be developed to enhance urban design, addressing environmental risks and improving the built environment. However, it is generally conceived for applications in formal urban settings.. A central challenge lies in how to implement these solutions in informal settlements and how to ensure their maintenance after implementation. It is understood that engaging residents in the construction of these solutions may be a way to address this challenge.

This paper addresses this topic through a case study in São Bento neighborhood, in Duque de Caxias, a municipality in the Metropolitan Region of Rio de Janeiro that is severely vulnerable to flooding. Data on flood susceptibility indicate that 45% of households of Duque de Caxias are in high-risk situations (Casa Fluminense, 2024). At the same time, Duque de Caxias inhabitants face a lack of access to piped water. About 30% of residents considering data from 2022 Census (IBGE, 2022), don't have access to the public system of piped water. Even those connected to the system suffer from frequent interruptions; there is a high degree of intermittency in the public water supply system (Prefeitura de Duque de Caxias, 2017).

Focusing on the issue of social participation in climate adaptation strategies connected to urban and based on water and water sensitive urban design (WSUD) principles, the paper describes an ongoing experience of local engagement developed in informal communities in São Bento. The primary concern is using rainwater as a resource to build a more resilient and livable neighborhood. The experience is based in based in two pillars of WSUD: rainwater harvesting and sustainable drainage strategies (SUDS).

## 2 SÃO BENTO NEIGHBORHOOD: WATER ISSUES IN TWO INFORMAL SETTLEMENTS

The neighborhood of São Bento is in the 2nd district of Duque de Caxias (Campos Elíseos), in an area bounded by the São Bento Environmental Protection Area (APA), on the banks of the Iguaçú River and near the Duque de Caxias Refinery (REDUC). Since the 1980s, new informal settlements have emerged in the neighborhood: Novo São Bento, Cristo Rei, Parque Esperança, Guedes, Morro do Céu, Comunidade da Paz, Vila Alzira, Parque São Bento, Parque da Liberdade, and Medina. This study was developed in Novo São Bento e Vila Alzira. Both settlements are in the Iguaçú River floodplain. The two settlements are adjacent.

In Vila Alzira part of the houses are in polder areas (plains protected against flooding), near unfinished dike constructions (structures built to control and regulate water levels in rivers, lakes, or canals) that connect local channels to the Iguaçú River. The occupation led to the removal of riparian vegetation and the channeling of streams, which increased the speed of stormwater runoff toward the river. Furthermore, the high population density in the area contributes to soil impermeabilization. The area is repeatedly affected by floods. As other informal settlements of São Bento, the water supply systems in Novo São Bento and Vila Alzira were built by the residents. They installed water pipes and a pump and the water public company CEDAE aggregated to install a connection between the informal network and the main water supply pipeline. As the settlement grew, new residents began connecting individually to the informal network without registration with CEDAE. The number of informal connections increased, and the water provided by CEDAE system became insufficient. Neither the former public operator CEDAE nor the new private operator Águas do Rio (since 2021) have performed maintenance on the pipelines or attempted to bill households.

Vila Alzira and Novo São Bento faces regular water cuts. Every Thursday, the water supply is interrupted and only returns on Saturday. In the event of a pump failure or pipe rupture, some households experience even longer periods without water supply. The use of individual water storage tanks is common among households. The types of tanks range from professionally manufactured polyethylene tanks to informal reservoirs, such as converted gallons or open containers used to storage also rainwater.

## 3 WSUD IN INFORMAL SETTLEMENTS IN SÃO BENTO: ALTERNATIVES BASED IN COMMUNITY ENGAGEMENT

In response to the challenges of water access in informal settlements, the implementation of rainwater harvesting, and storage systems has emerged as a viable alternative. Duque de Caxias, characterized by a tropical climate, receives an average monthly precipitation of 122 mm, with a rainy season extending from November to March, creating favorable conditions for water collection. The harvested water can be utilized for non-potable purposes, such as household cleaning, laundry, and toilet flushing. After analyzing different systems, vertical cisterns were selected for their low cost and ease installation.

The project was developed through a partnership between the Federal University of Rio de Janeiro (UFRJ) and FASE, an NGO with longstanding operations in Duque de Caxias. It involved collaboration with the Association of Women with Initiative and Social Commitment (AMAC) in Vila Alzira. The installation process encompassed field surveys, interviews with residents, and satellite and drone imagery to assess feasibility and household conditions. Through this partnership, twelve residents (eleven women and one man) were selected by AMAC and trained by UFRJ team to install the cisterns. One aspect to highlight is the potential for this technical skill to serve as a source of future income for low-income women and female heads of households.

The externally installed vertical cisterns, connected to gutters via PVC piping, have a storage capacity of up to 70 liters per unit (figure 1). Their low cost, ease of installation, and adaptability to different types of dwellings make them particularly suitable for informal settlements.



Figure 1: Cistern model

Seventy families applied to receive a cistern, with priority given to households exhibiting the highest social vulnerability and suitable conditions for system installation. 50 cisterns were installed, 13 in Vila Alzira and 37 in Novo São Bento. The project is currently undergoing an assessment of the cistern utilization and socio-environmental impact of the cisterns on the beneficiaries' lives.

Through the relationships established with the women of Vila Alzira via AMAC, it was also possible to discuss the issue of flooding and potential SUDs strategies to mitigate the problem. A workshop was conducted with 22 women from Vila Alzira, which began with a debate about the events of heavy rainfall, the challenges experienced, and the measures they take to protect themselves and their houses as raising furniture and other items and separating important documents and personal belongings in case evacuation becomes necessary. It was reported that those living near the rivers leave their homes as early as possible and seek shelter with friends, relatives, or at AMAC itself, which aids flood victims.

A subsequent part of the workshop was carried out using a three-dimensional model based on drone imagery, in which frequent points of floods and waterlogging occurring during heavy rains were identified by the women (Figure2). The points raised during the workshop, together with ongoing hydrological modeling study, will serve as the basis for planning SUDs solutions aimed at enhancing water absorption and mitigating flooding; it is the subject of a beginning master thesis.

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