

Participation communautaire dans des scénarios d'infrastructures vertes et bleues pour la réduction des inondations sous changement climatique – étude de cas à Belo Horizonte, Brésil

Community participation in green and blue infrastructure scenarios for urban flood mitigation under climate change – a case study in Belo Horizonte, Brazil

Deyvid W. B. ROSA¹, Andressa P. RAMOS², Maria Paula S. M. DELEFRATE³, Nilo O. NASCIMENTO⁴, Rogério P. Z. ARAÚJO⁵, Jupira G. MENDONÇA⁶

^{1, 2, 3, 4} Department of Hydraulics and Water Resources Department, Federal University of Minas Gerais - dwbroso@ufmg.br ; andy15@ufmg.br ; mpdelefrate.ufmg@gmail.com ; niloon@ehr.ufmg.br

^{5, 6} School of Architecture, Federal University of Minas Gerais - rogeriopalharesaraujo@gmail.com ; jupira@gmail.com

RÉSUMÉ

Cet article présente une initiative de recherche et d'extension visant à soutenir la planification participative et la prise de décision pour la mise en œuvre de Solutions fondées sur la Nature (SfN) dans un sous-bassin urbain de Belo Horizonte, au Brésil. Des scénarios d'occupation du sol ont été élaborés à partir de données municipales, de modélisation hydrologique et d'un processus participatif structuré avec les habitants. L'étude a identifié des zones fortement susceptibles aux inondations, dont plusieurs se superposent à des établissements informels socialement vulnérables. Des ateliers de formation ont permis aux résidents de participer à une cartographie collaborative et à la co-construction de scénarios de SfN en cohérence avec leurs priorités locales. Des modèles hydrologiques et hydrodynamiques sont utilisés pour évaluer le risque d'inondation dans les conditions actuelles et futures d'occupation du sol, en tenant compte des effets du changement climatique sur les pluies extrêmes. Les résultats apportent des éléments pour intégrer les infrastructures vertes et bleues dans la planification urbaine et soulignent l'importance de la participation sociale pour une mise en œuvre efficace et durable des interventions fondées sur la nature.

ABSTRACT

This paper presents a research and outreach initiative designed to support participatory planning and decision-making for implementing Nature-based Solutions (NbS) in an urban subcatchment of Belo Horizonte, Brazil. Alternative land-use scenarios were developed using municipal datasets, hydrological modelling, and a structured participatory process with local residents. The study identified areas highly susceptible to flooding, many of which overlap with socially vulnerable informal settlements. Capacity-building workshops enabled residents to engage in collaborative mapping and the co-design of NbS scenarios aligned with local priorities. Hydrological and hydrodynamic models are being used to assess flood risk under current and future land-use conditions, considering climate-change impacts on extreme rainfall. The results provide evidence to support the integration of Green and Blue Infrastructure (GBI) into urban planning and reinforce the importance of social participation for effective implementation and long-term sustainability of NbS interventions.

KEYWORDS

climate change scenarios, hydrological modelling, nature-based solution, participatory process, urban drainage

1 INTRODUCTION

Green and Blue Infrastructure (GBI), Nature-Based Solutions (NBS), Water Sensitive Urban Design (WSUD), Low Impact Development (LID), and Sustainable Urban Drainage Systems (SUDS) are terms often used to describe sustainable approaches to urban stormwater management (Fletcher et al., 2014). These approaches emphasise the integration of decentralised drainage techniques – such as green roofs, permeable pavements, bioretention cells, and infiltration trenches – with urban parks and green open spaces to mimic the natural hydrological cycle within urban environments. This integration enhances interception, infiltration, evaporation, and evapotranspiration, reduces surface runoff, and improves water quality. Numerous studies have highlighted the importance of GBI in promoting social and ecological adaptation to the effects of climate change in urban areas (Seddon, 2022).

However, the effective implementation of GBI depends on the integration of these principles into land use planning and management at both regional and local scales. In Belo Horizonte, the capital of Minas Gerais, the current Master Plan (Municipal Law No. 11,181 of 2019) mandates the installation of stormwater control, storage, and infiltration systems in all new projects approved in the city and prohibits the culverting of streams. Additionally, it requires that urban drainage and stormwater management projects prioritise GBI and NBS and that riparian areas be restored through an Urban-Environmental Structuring Plan (PEA), aimed at improving environmental conditions and preventing further urban development.

In this context, the Strategic Development Programme for the Jatobá Region includes the development of the municipality's first PEA guided by NBS principles. The programme is funded by the World Bank and commissioned by the Municipal Government of Belo Horizonte through a public tender won by the Práxis-Metrics Consortium, which also includes a team of researchers from the Federal University of Minas Gerais.

The main objective of this research is to assess the potential hydrological benefits of GBI in alternative implementation scenarios developed collaboratively with the community, using the Jatobá Creek catchment as a case study to support public discussion and decision-making regarding NBS and multifunctional structural measures for flood control under projected climate change conditions in Belo Horizonte.

1.1 Jatobá Creek catchment

The Jatobá Creek is the most upstream tributary of the Arrudas River, the main watercourse flowing through Belo Horizonte's central region. The Jatobá Creek and its tributary, the Olaria Creek, originate in the Serra do Curral State Park to the south (Figure 1) and flow northward, primarily in a natural streambed, until converging with Túnel Creek. From this point, it flows through a closed concrete channel beneath Canal Avenue.

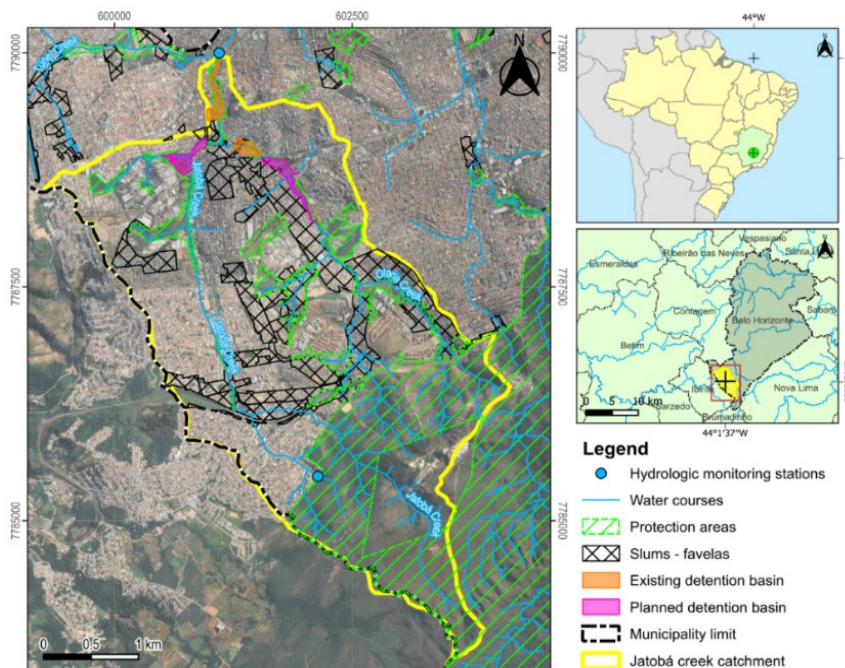


Figure 1. Jatobá creek catchment location map.

The watershed covers 13.6 km² and is home to approximately 91,000 residents, of whom 36,000 live in informal settlements or irregular occupations on public lands (IBGE, 2022). Two detention basins located downstream, upstream of the confluence with Túnel Creek, have been constructed, with two additional basins planned to attenuate peak flows and reduce flooding along Canal Avenue.

2 METHODS

The methodology outlined in the flowchart (Figure 2) consists of three main steps. The first is a technical and participatory diagnosis that supported the development of the current land use scenario and the assessment of existing drainage infrastructure. The second step is the participatory construction of alternative future scenarios, including the integration of NBS to mitigate the impacts of additional urban development permitted by planning regulations. The third evaluates the impacts of combining alternative land use and climate change scenarios on flood dynamics, using hydrological modelling (Storm Water Management Model - SWMM 5.2) and hydrodynamic modelling (Hydrologic Engineering Center - River Analysis System - HEC-RAS 6.5).

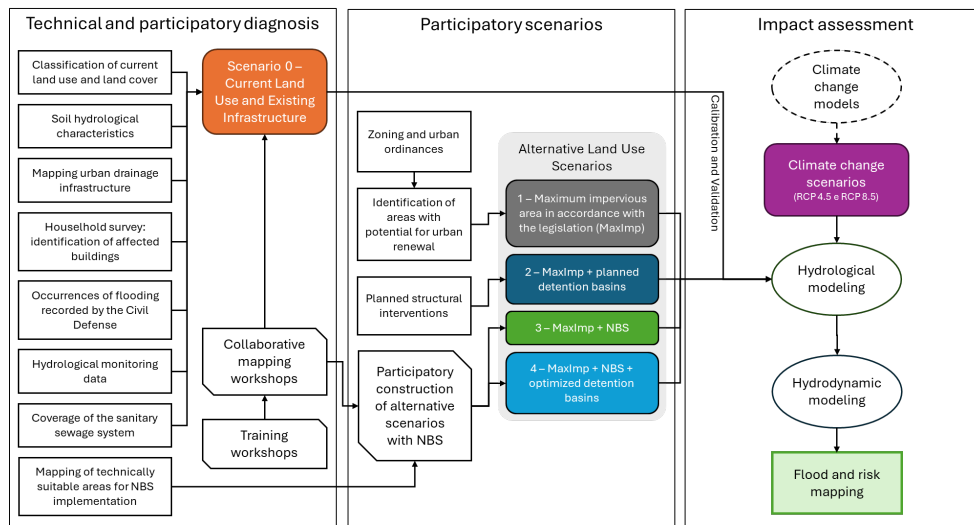


Figure 2. Methods flowchart.

The methodology of this research and extension project includes the participatory construction of NBS implementation scenarios in the catchment, in collaboration with the local community. This approach is based on the premise that the community, as those who know the territory best and experience its needs firsthand, can significantly contribute to identifying the region’s potential. To achieve this, training workshops on NBS and geodesign were conducted, followed by collaborative mapping workshops (Figure 3), where the scenarios to be simulated were developed. This methodology combines technical knowledge with local expertise, fostering a collaborative process to design solutions that address the region’s demands.



Figure 3. Training and collaborative mapping workshops

3 RESULTS

The results summarise the technical and participatory diagnosis and the initial assessment of land-use and drainage scenarios. Four scenarios have been defined so far: 0, representing current watershed conditions; 1, reflecting maximum urban development allowed by planning regulations with conventional drainage solutions; and 2, incorporating the detention basins already planned by the municipality. Scenarios 3 and 4, currently under development, will simulate the effects of the GBI proposals generated in the geodesign workshops, evaluating their potential to reduce flooding and improve socio-environmental conditions.

Hydrodynamic modelling (HEC-RAS) was used to simulate flood extents for Scenarios 0, 1, and 2 under different return periods. The results highlight the urgency of mitigating flood risks, particularly because many affected buildings are exposed even to frequent events ($TR \leq 10$ years) and are located in areas that should not have been occupied. The detention basins represented in Scenario 2 reduce downstream impacts substantially, but additional measures are required upstream, within the Jatobá Creek catchment, where flooding remains significant.

Figure 4 presents the integrated map of areas suitable for implementing GBI (public and private), zones with potential for urban agriculture, and the proposed linear park along riparian areas, including floodplains for TR up to 10 years, riparian vegetation, and ecologically important forest remnants.

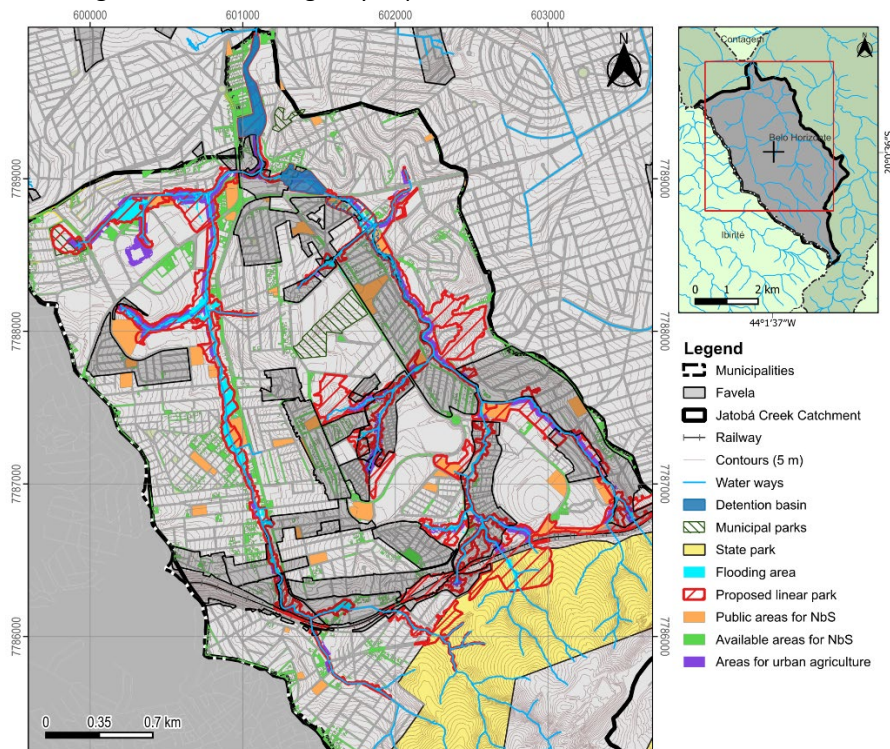


Figure 4. Summary map of the NbS scenario.

4 FINAL REMARKS

These preliminary results highlight persistent challenges in managing flood risk in the Jatobá Creek catchment, especially in informal settlements exposed to insufficient drainage infrastructure. Ongoing work includes the hydrological–hydraulic modelling of nature-based solution scenarios and the integration of climate-change projections to evaluate the intensification of extreme rainfall events. The definition of the park boundary is also under discussion with public authorities and the local community, and the complete article will provide expanded methodological detail and a comprehensive assessment of these developments.

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LIST OF REFERENCES

- Belo Horizonte (2019) Law No. 11,181: Municipal Master Plan, Official Gazette of the Municipality, Belo Horizonte.
- Fletcher TD, Shuster W, Hunt WF, Ashley R, Butler D, Arthur S, Trowsdale S, Barraud S (2014). SUDS, LID, BMPs, WSUD and more – The evolution and application of terminology surrounding urban drainage. *Urban Water Journal*, 12, n. 7.
- IBGE – Brazilian Institute of Geography and Statistics (2022). Information base by census sectors - 2022 Census.
- Seddon N (2022). Harnessing the potential of nature-based solutions for mitigating and adapting to climate change. *Science*, 376, n. 6600, p. 1410-1416.