Green and blue infrastructure in urban revitalization with impacts on drainage: The case of Rio Comprido watershed, Brazil

Infrastructures vertes et bleues dans la revitalisation urbaine avec un impact sur le drainage: Le cas du bassin versant de Rio Comprido, Brésil

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RÉSUMÉ

L'expansion des zones urbaines et la pression sur l'utilisation des terres ont modifié les fonctions écologiques et écosystémiques de l'environnement. Des stratégies adaptatives telles que des infrastructures bleu et vert peuvent réduire les effets négatifs des actions anthropiques, ainsi que fournir des avantages en matière de santé et de meilleure qualité de vie à la population. Ces stratégies peuvent constituer des solutions plus durables, économiques, multifonctionnelles et flexibles par rapport les solutions traditionnelles. Parmi les différentes fonctions que l'infrastructure bleu et vert peut assumer, ces travaux mettent en évidence la capacité de réduction des risques hydrauliques liée à la revitalisation de l'environnement urbain, par la création de parcs urbains, la restauration de la végétation et de l'interconnexion d'espaces verts à des nouvelles zones à loisir. Pour le développement de cette analyse, des interventions ont été proposées dans le bassin versant du Rio Comprido, à Rio de Janeiro, en considérant le fleuve comme un élément structurant du paysage. Les résultats montrent que malgré le nombre limité d'espaces ouverts, la multifonctionnalité des infrastructures bleu et vert introduit plusieurs améliorations pour la société.

ABSTRACT

The expansion of urban areas and the pressure on land use have changed ecological and ecosystem functions of the environment. Adaptive strategies such as green and blue infrastructure can reduce the negative effects of anthropogenic actions, as well as provide health benefits and better quality of life for the population. These strategies can be more sustainable, economical, multifunctional and flexible alternatives than traditional solutions. Among the various functions that green blue infrastructure can assume, this work highlights the capacity for reducing hydraulic risk allied to revitalization of the urban environment through the establishment of urban parks, restoration of vegetation and interconnection of green areas to new leisure areas. For the development of this analysis, interventions were proposed in the Rio Comprido watershed in Rio de Janeiro, considering the river as a structuring element of the landscape. The results show that despite the limited open spaces, the multifunctionality of the green and blue infrastructure introduces several improvements for society.

KEYWORDS

Green and blue infrastructure, multifunctionality, urban drainage, urban revitalization

1 INTRODUCTION

Human activities change the pattern of land use and the quality of the natural and built environment (Miguez *et al.*, 2018). Urbanization is one of the anthropogenic actions that causes the greatest environmental impacts, due to the removal of the original plant cover, increased soil sealing, introduction of canalization works and occupation of riverbanks. These changes result in increased peak flows and extravasation of river channels, reduction of base flows, reduction of the watershed time of concentration and degradation of river ecosystems.

When looking at open spaces as a multifunctional system, there is strong potential to reduce the risk of urban floods, especially those due to failures in the capacity of rainwater conduction by the traditional drainage approach. A storage volume, for instance, can be designed, with a multifunctional system through stormwater management that includes leisure and recreation spaces for the population.

This paper proposes the use of green and blue infrastructure for the revitalization of Rio Comprido watershed, located in Rio de Janeiro. The concept of green and blue infrastructure is based on principles that value the use of multifunctional landscapes and the connectivity of systems (Herzog, 2016). A multi-sectorial logic should be employed for the balance of the region, in which the sustainability of the urban conglomerate depends on the density of green and blue space connections. When integrated green and blue infrastructure can connect fragmented natural open spaces, reduce runoff, increase biodiversity and offer cultural, health and leisure benefits through public access to valuable natural resources (Bacchin *et al.*, 2014; Nascimento *et al.*, 2016).

2 METHODS

The Rio Comprido watershed is located in Planning Area 1 of the city of Rio de Janeiro and belongs to the Canal do Mangue catchment, which covers an area of about 45 km². Traditional districts that suffer from frequent floods are located in this area, such as São Cristóvão, Estácio, Rio Comprido, Maracanã, Vila Isabel, Andaraí, Tijuca and Grajaú.

The Rio Comprido district has about 334.20 ha and is characterized by its intense occupation, with more than 60% urban area. This district comprises part of the Tijuca Massif and, besides the Comprido, it is drained by the Bananal River (Martins, 2015).

The urban areas of Rio Comprido watershed are generally flat, with high potential for flooding. When leaving the drainage network, the water can take any path, dictated by urbanization patterns. This brings complexity to the definition of flows, which can run through both the drainage networks and on streets and sidewalks.

The model chosen to represent this situation is particularly useful in urban environments. The hydrodynamic model called MODCEL (Mascarenhas and Miguez, 2002; Miguez *et al.*, 2017) simulates the physical situation through a set of flow-cells, which are compartments able to represent average characteristics of the urban surface, store water and communicate with each other through hydraulic links, composing a flow network.

Thus, the current situation of the drainage system and various design options for flood mitigation were simulated for the case study. The proposed design to mitigate floods included interventions chosen along Avenida Paulo de Frontin in order to structure the avenue from the free space system and its connectivity with the Rio Comprido. All points were chosen based on underutilized plots that had public potential. The intervention sites are described below and identified in Figure 1.

- Community Garden + Pets Plaza: new sites with permeable soil, with the function of assisting in the infiltration of water in rainy season and offering services to society in the dry season;
- Triangle Plaza + Culture Square + Childhood Square: new proposed sites that perform urban functions (leisure, recreational and cultural spaces) during the dry season and water retention functions during flood periods;
- Condessa Plaza: due to its importance for the vitality of the district, it is proposed to maintain existing functions and incorporate a sports court with the capacity to function as a temporary reservoir;
- Other interventions: modifications in the cross section of the Rio Comprido to improve hydraulic capacity; two upstream reservoirs (COPPETEC, 2000); another reservoir in an urban square (Rezende, 2018); and corrections in an undersized drainage culvert.

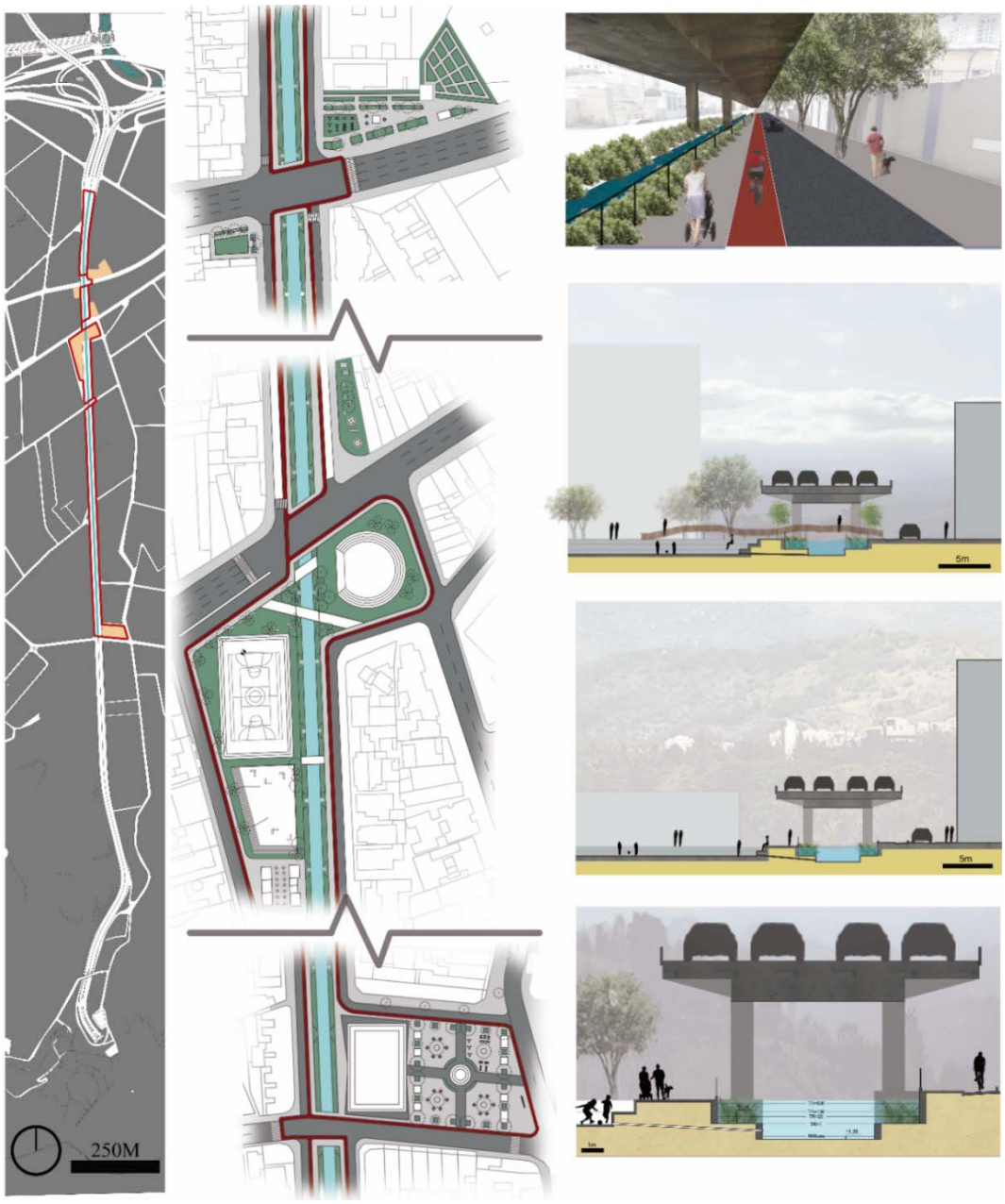

Fig. 1 Intervention sites and proposed multifunctional design.

3 RESULTS AND DISCUSSION

Green and blue infrastructure can play the role of leisure space and provide a more pleasant aesthetic for passersby to contemplate the landscape. Green corridors also assist in flood control and improve water quality and microclimate. It can even be said that they allow the improvemed flow of people through bike and walking paths, which establish a pleasant space for walking and cycling. In addition to these benefits, they provide areas for the practice of physical activities and can encourage economic activities in the region.

In relation to the hydrodynamic simulation of the interventions, Figure 2 shows the variation of maximum water levels along the Rio Comprido, between Condessa Plaza and its mouth in Canal do Mangue, for current and projected scenarios. The figure also highlights the most critical section of the river in relation to the overflow of the river gutter and the section in which the flow occurs in an underground culvert. The proposed multifunctional project is able to mitigate floods of the Rio Comprido for a 25-year recurrence time, maintaining practically all flood volumes of the macro drainage system within the river's channel.

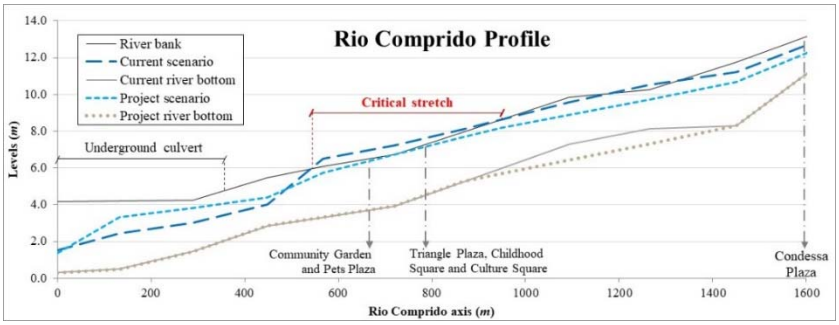

Fig. 2 Rio Comprido water levels for the 25-year recurrence time.

4 CONCLUSIONS

Green and blue infrastructure has a strong potential to integrate hydraulic and landscape functions in the urban environment, making it more resilient. The case study of the Rio Comprido watershed represents an opportunity to incorporate scientific knowledge in the revitalization of urban regions that suffer from frequent flooding. In relation to the benefits in the macro drainage system, the proposed interventions could reduce the flood levels in several areas of the basin, in addition to maintaining the 25-year recurrence time flow in the river channel. These interventions also would provide improvements in the quality of life and leisure for the population and help increase urban resilience.

Although the proposals are focused on the case study of the Rio Comprido watershed, these strategies can be adapted to other urban areas, promoting the reduction of the hydraulic risk combined with the improvement of river ecosystems. The drainage system can be a catalyst for changes when flood mitigation is needed. The need for mitigation, in turn, leads to a search for storage spaces and possibilities of infiltration, in order to recover hydrological functions lost during the urban expansion. This adds further evidence of the need to incorporate the logic of green blue infrastructure in urban space planning.

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