Goiânia Urban Drainage Master Plan: diagnosis, indicators, and initial results

Plan directeur de drainage urbain de Goiânia: diagnostic, indicateurs et premiers résultats

Jussanã Milograna[(1)]; Priscilla Moura[(2)]; Ana Paula Camargo de Vicente[(3)]
Raviel Basso[(4)]; Kamila Almeida[(5)] Klebber Formiga[(6)];

(1) Institut Fédéral de Goiás - jussana.milograna@ifg.edu.br
(2) Université Fédéral de Minas Gerais - priscilla.moura@ehr.ufmg.br
(3) Université Fédéral de Goiás - camargo.vicente@discente.ufg.br
(4) Université Fédéral de Goiás - ravielbasso@ufg.br
(5) Université Fédéral de Goiás - kamila_santos@ufg.br
(6) Université Fédéral de Goiás - klebberformiga@ufg.br

RÉSUMÉ

Cet article expose le processus d'élaboration du Plan Directeur de Drainage Urbain (PDDU) de Goiânia. Il décrit le diagnostic technico-institutionnel, la structuration d'une base de données géospatiale et la construction d'indicateurs de gestion, de vulnérabilité et de performance, ainsi que les premiers résultats déjà intégrés par la municipalité. Le projet s'inscrit dans un contexte marqué par l'absence d'un registre à jour des réseaux d'eaux pluviales, la récurrence des inondations et des décalages entre les cadres juridiques et les instruments de planification urbaine, avec l'objectif de mettre en place une approche intégrée alliant infrastructures grises, solutions fondées sur la nature (NbS) et gouvernance appuyée par des indicateurs. Parmi les principaux résultats figurent l'adoption d'une nouvelle loi sur le drainage alignée sur le PDDU, la normalisation et l'intégration des paramètres hydrologiques, la mise en œuvre des protocoles du plan par la Protection civile, ainsi que la préparation des données en vue d'un suivi continu des performances. L'étude souligne le rôle central de l'information fiable, de la modélisation hydrodynamique et des indicateurs en tant qu'outils pour éclairer la décision publique, prioriser les investissements et réduire les vulnérabilités socio-environnemental

ABSTRACT

This article presents the process of developing Goiânia's Urban Drainage Master Plan (PDDU), describing the technical institutional diagnosis, the structuring of a geospatial database, and the process of constructing management, vulnerability, and performance indicators, as well as the first results already incorporated by the municipal administration. The starting point was a context marked by the absence of an up-to-date register of stormwater networks, the recurrent occurrence of flooding, and asymmetries between legal frameworks and urban planning instruments, with a view to building an integrated approach that combines grey infrastructure, nature-based solutions (NbS), and indicator-based governance. The results include the approval of a new drainage law aligned with the PDDU, the incorporation of standardized hydrologic parameters, the adoption of the plan's protocols by Civil Defense, and the preparation of data for continuous performance monitoring. The study reinforces the centrality of reliable information, hydrodynamic modeling, and the use of indicators as instruments to guide decision making, prioritize investments, and reduce urban socioenvironmental vulnerabilities.

KEYWORDS

governance, hydrodynamic modeling, indicators, nature-based solutions (NbS), Urban Drainage Master Plan

1 INTRODUCTION

Brazilian cities, especially those experiencing rapid growth, face a set of pressures that alter the urban hydrological cycle. In Goiânia, the expansion of the urban footprint and the increase in impervious surfaces - similar to other large urban centers—have intensified surface runoff, reduced infiltration, and made flooding events more frequent. These events arise from multiple concurrent causes: obstruction of drainage infrastructure by solid waste; obsolescence or absence of network; occupation on valley bottoms and protected areas; and, in a transversal manner, gaps in stormwater management. Added to this are the historical absence of a drainage master plan, the lack of an up-to-date technical registry compatible with municipal information systems, and the lack of effective coordination between drainage legislation and other urban and environmental policy instruments.

In the Brazilian regulatory context, although there are important frameworks related to urban planning (such as the Estatuto das Cidades - BRASIL, 2001), and sanitation policy (as the Marco Legal do Saneamento Básico - BRASIL, 2020), and municipal master plans, incompatibility between guidelines and practices is common, with limited effectiveness both in mitigating the impacts of urbanization on runoff and in incorporating climate change into the designing and operation of systems. This incompatibility prevents management actions from taking effect into observable results.

The preparation of Goiânia's Urban Drainage Master Plan (PDDU) organized a methodological pathway to fill information gaps that are critical to the effectiveness of the proposed actions. The plan is based on the understanding that gray infrastructure must interact with the built environment and natural processes through nature-based solutions and source control devices, in order to reduce peak flows, restore ecosystem services, and increase urban resilience.

2 TECHNICAL DIAGNOSIS AND DATA ORGANIZATION

The municipality of Goiânia, with a total area of 827.10 km², was divided into 13 sub-basins. The diagnosis covered the municipality's urban area, considering both local stormwater systems and main drainage channels, land use and land cover, topography, and environmentally sensitive areas. A multidisciplinary team involving 60 professionals from technical and social communication fields structured a database capable of supporting analyses, modeling, and monitoring dashboards.

In local stormwater systems, the existing inventories were stored in physical archives, often outdated. It was necessary to systematically digitize, vectorize, and georeference the plans, with a topological and semantic review to standardize attributes (diameter, material, invert elevation, device, operational condition) and link them to reaches and nodes within a GIS environment. This process resulted in an urban–hydraulic registry that began feeding a public WebGIS, enabling integrated visualization, querying, and field reporting.

For minor and major hydraulic structures associated with main channels—such as cellular and pipe culverts, small bridges, and bridges - field surveys were carried out, including section measurements, coordinate collection, characterization of construction conditions, and preparation of technical sketches. This stage made it possible to identify hydraulic bottlenecks, the state of conservation, and operational constraints of hydraulic elements, as well as to verify essential data for modeling.

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Main drainage channels mapping included surveys using RPA (Remotely Piloted Aircraft), enabling the production of updated orthomosaics and a Digital Terrain Model (DTM) with resolution suitable for the urban scale. The DTM was employed in 1D/2D hydrodynamic modeling, combining conduit and overland flows to simulate scenarios with different return periods, network maintenance states, and assumptions regarding the implementation of structural measures and nature-based solutions (NbS). This modeling supported the identification of critical areas, the prioritization of interventions, and the definition of reference hydrological and hydraulic parameters for the municipality (Figure 1).

Figure 1 – Equipment used (drone) and devices surveyed in the diagnosis (Source: PDDU, 2024)

3 DATA SOURCES AND INFORMATION GOVERNANCE

Data reliability is determinant of decision quality. After the consolidation of the diagnosis, the network registry came to reflect the actual morphology and operational condition, becoming a central element for performance analyses, preventive maintenance, and response to critical events. External information such as that available in SNIS (National Sanitation Information System) was used as contextual reference, although with the caution that these are self-declared data by service providers and, often, of questionable reliability due to the informants' own limited understanding, as presented by Faria (2023) for the information disclosed for municipalities in the state of Minas Gerais, Brazil. This contrast highlighted the importance of robust, interoperable, and up-to-date municipal information systems.

During the discussion of the indicators, management weaknesses were also observed—from the absence of multi-year planning and prioritization to low integration among sectors (public works, environment, urban cleaning, planning, civil defense). The process of developing the indicators helped to make gaps explicit, organize routines, and assign responsibilities, while promoting institutional alignment with the Municipal Sanitation Council, regulatory agencies, and the drainage management structure.

The construction of the indicators was supported by a literature review, consultation of national databases (SNIS and related instruments), the technical team's experience, and contributions from invited specialists, through successive rounds of technical validation.

4 INDICATORS AND THEIR ROLE FOR THE EFFECTIVENESS OF THE PDDU

Indicators were developed and organized under three criteria as an instrument for continuous monitoring, improvement, and diagnosis of the drainage system within the PDDU. The first set comprises 12 management indicators and assesses institutional and organizational capacity: the existence and updating of the asset registry, the execution of preventive and corrective maintenance, the regularity of cleaning of structures and street gutters, integration with the solid waste policy, budget availability, routines for rainfall and hydrological monitoring, and data transparency. The second set, with 10 vulnerability indicators, identifies impacts on society and the environment: exposed population, recurrence and duration of flooding, incidence in critical areas such as schools and health facilities, material losses, damage to riparian habitats, and impairment of Permanent Preservation Areas (APPs). The third set, with 5 performance indicators, functions as a "thermometer" of the system's effectiveness: flow times, overflow rates per event, efficiency of source-control measures, peak flow reduction in scenarios with structural measures and Nature-based Solutions (NbS), and the system's operational availability under heavy rainfall conditions.

The central point is the causal relationship between management and performance: improvements in planning, operation, and maintenance tend to be reflected in measurable performance gains and in the reduction of vulnerabilities. The indicators were conceived not only as metrics, but as elements of continuous improvement, with progressive, verifiable targets.

The entire process was discussed with municipal managing, regulatory, and sanitation bodies in technical meetings, culminating in public validations that ensured legitimacy and feasibility of implementation. The set of indicators was submitted and approved in two public hearings.

5 INITIAL IMPLEMENTATION RESULTS

The development of the PDDU has already produced normative, operational, and informational outcomes. Notably, a new municipal drainage law - already in its final drafting stage - has been prepared in direct alignment with the plan, incorporating hydrological parameters defined under the PDDU (including hydrological variables and source control design guidelines). The local Civil Defense and the PDDU's complementary documents are aligned on emergency protocols, sharing susceptibility maps derived from the Digital Terrain Model (DTM) and hydrodynamic modeling, thereby improving the ability to anticipate and respond to events. At the sector-management level, the drainage authority has begun implementing routines specified in the management indicators: a data-driven schedule for cleaning and unclogging, georeferenced digital incident records, and ongoing maintenance of the asset registry in a WebGIS environment.

6 CONCLUSIONS

Goiânia's experience confirms that urban drainage is inherently multidisciplinary. It is a cross-cutting public policy that depends on reliable information, intersectoral integration, and regulatory coherence. Without an up-to-date asset registry, decision-making tends to be less effective. With data, modeling, and indicators, management can better prioritize actions, compare alternatives, and negotiate investments on a results basis. Indicators have proven to be a straightforward, shared language among technical areas, planning, and social oversight. This tool is not yet widely used in Master Plans as a means to track system performance. At present, efforts focus on data collection, application of the methodology, and assessing data applicability and outcomes for a pilot basin. Early results suggest the adopted methodology will significantly improve both the evaluation of actions proposed in the PDDU and the ongoing performance monitoring of the city's drainage system.

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LIST OF REFERENCES

Brasil. Lei nº 10.257, de 10 de julho de 2001. Regulamenta os arts. 182 e 183 da Constituição Federal, estabelece diretrizes gerais da política urbana e dá outras providências.

Brasil. Lei nº 14.026, de 15 de julho de 2020. Atualiza o marco legal do saneamento básico. Available at: https://www.planalto.gov.br/ccivil_03/_ato2019-2022/2020/lei/l14026.htm

Faria, Marco Túlio da Silva. Titularidade municipal da drenagem e manejo das águas pluviais em municípios de pequeno porte populacional e impactos na saúde. PhD Thesis. Universidade Federal de Minas Gerais, Escola de Engenharia. 2023

SNIS — Sistema Nacional de Informações sobre Saneamento. Séries históricas e diagnósticos. Available at: https://www.gov.br/mdr/pt-br/assuntos/saneamento/snis