

Simulation and design of green stormwater infrastructures under future climate: First operational tools from the ALLAGUI Project

Simulation et dimensionnement d'ouvrages végétalisées sous climat futur : premiers outils opérationnels du projet ALLAGUI

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ABSTRACT

Urban stormwater management is a major challenge for cities in the context of climate change adaptation. The ALLAGUI project (2025–2028) aims to promote a long-term shift in professional engineering practices by developing and disseminating innovative methods and tools for the design of integrated stormwater management systems. The project first proposes an integrated methodology to simulate the performance of vegetated infrastructures (green roofs, infiltration swales) under future climate conditions (2070–2099), while incorporating environmental and social criteria. These tools will then be tested by external partner municipalities and engineering companies to identify the drivers and barriers to their adoption and to better understand the social and behavioural dynamics of practice change. Finally, a user manual and training modules will be developed to support the use of the methods and tools and the practical implementation of nature-based solutions. The communication will present the first technical and methodological developments of the project, as well as the observation protocol for monitoring tool appropriation by external testers and their first feedback.

RÉSUMÉ

La gestion des eaux pluviales urbaines constitue un enjeu majeur d'adaptation au changement climatique pour les collectivités. Dans ce contexte, le projet ALLAGUI (2025-2028) vise à favoriser un changement durable des pratiques d'ingénierie en développant et en diffusant des méthodes et outils innovants pour le dimensionnement d'ouvrages de gestion intégrée des eaux pluviales. Le projet propose d'abord une méthodologie permettant de simuler le fonctionnement d'ouvrages végétalisés (toitures végétalisées, noues d'infiltration) sous des conditions climatiques futures (2070-2099), en y associant des critères environnementaux et sociaux. Ces outils seront ensuite testés par des collectivités et des bureaux d'études partenaires, afin d'identifier les leviers et freins à leur appropriation, et de comprendre les dynamiques sociales et comportementales de changement de pratiques. Enfin, un manuel d'utilisation et des modules de formation seront élaborés pour accompagner l'usage des outils et la mise en œuvre concrète de solutions fondées sur la nature. La communication présentée rendra compte des premiers développements techniques et méthodologiques issus du projet, ainsi que du protocole d'observation de l'appropriation par les testeurs et des premiers retours de ces derniers.

KEY WORDS

Adaptation au changement climatique, Aide à la décision, Gestion Intégrée des eaux pluviales, Modélisation et simulation, Solutions fondées sur la nature Climate change adaptation, Decision-support, Integrated stormwater management, Modelling and simulation, Nature-based solutions.

1 INTRODUCTION AND CONTEXT

Urban stormwater management is a major challenge in the context of climate change adaptation. In highly impervious urban environments, source control vegetated infrastructures, like green roofs and infiltration swales, offer relevant solutions, yet their design still largely relies on ancient design rules based on past climate that are poorly suited to future climatic conditions, and that do not provide the necessary information on their true behaviour and performance.

In this context, the ALLAGUI project (2025–2028), funded by the Rhône–Méditerranée–Corse Water Agency and the Graduate School H2O Lyon, aims to use climate change as a lever to support the evolution of professional engineering practices. The project brings together the DEEP laboratory at INSA Lyon, the LyRE SUEZ research centre in Bordeaux, the GRAIE in Lyon and the LEHNA laboratory at Université Lyon 1. ALLAGUI is operated as an OTHU (Field Observatory on Urban Hydrology – www.othu.org) research project. It is structured around three inter-related components:

- **Engineering**, dedicated to developing methods and technical tools to simulate and design vegetated stormwater infrastructures with a focus on green roofs and infiltration swales, under future climatic conditions;
- **Social sciences**, to analyse the appropriation of the methods and tools by practitioners and the dynamics of their practice change (perception of incentives and motivations versus blockages and difficulties);
- **Knowledge transfer**, with the development of an operational guide and training modules.

To achieve this, the project includes the design, the testing and the dissemination of digital tools that facilitate the integration of climatic, environmental and socio-economic considerations into the design, the simulation, and the decision-making process for vegetated stormwater infrastructures.

2 LIMITATIONS OF CURRENT METHODS AND OBJECTIVES OF THE TOOLS

The sizing of stormwater infrastructures still frequently relies on ancient methods, based on single design storms and/or traditional over-simplified hydrological approaches like e.g. the “méthodes des pluies” (i.e. rainfall method) in France. Although well-known, widely-used and considered as conveniently operational, these approaches do not allow representing, understanding and analysing the actual behaviour of infrastructures to be simulated, nor do they integrate climate change or account for environmental and social co-benefits. Decision-making also remains fragmented between technical staff, elected officials, operators and users, which limits the exploitation of the multifunctionality potential of vegetated solutions.

To address these limitations, the ALLAGUI project is developing a set of methods and digital tools designed to produce, process and use climate data series to simulate the future performance of infrastructures and support decision-making. The process is based on four stages (Figure 1):

Input data (rainfall and potential evapotranspiration)

- **Historical series** retrieved from publicly available datasets repository (e.g. Météo-France), automatically downloaded and validated, with time steps from 6 min to 1 day.
- **Modelled historical and future series (2070–2099)** derived from the DRIAS portal (in France) or IPCC models climate projections and converted into high-resolution series through a stochastic downscaling process according to the method implemented by Pons *et al.* (2022).

Infrastructure modelling and simulation

- Green roofs and infiltrations swale models developed from the state of the art.
- Models calibration and verification using experimental data from DEEP (experimental green roofs) and from the literature (infiltration swales), aiming also to contribute to improved, more informed and more transparent modelling practices by practitioners (Pons *et al.*, 2023).

Performance criteria and assessment

- Statistical analysis of performance indicators obtained from long term simulations, and failure risks

analysis and statistics.

- Environmental performance assessment (LCA, carbon footprint, biodiversity).
- Assessment of social co-benefits.

Decision-support

- Comparison and evaluation of scenarios using multi-criteria methods (e.g. ELECTRE) to support project selection.

Each stage will result in one or more Python-based tools, made publicly available to facilitate their adoption by municipalities and consulting offices.

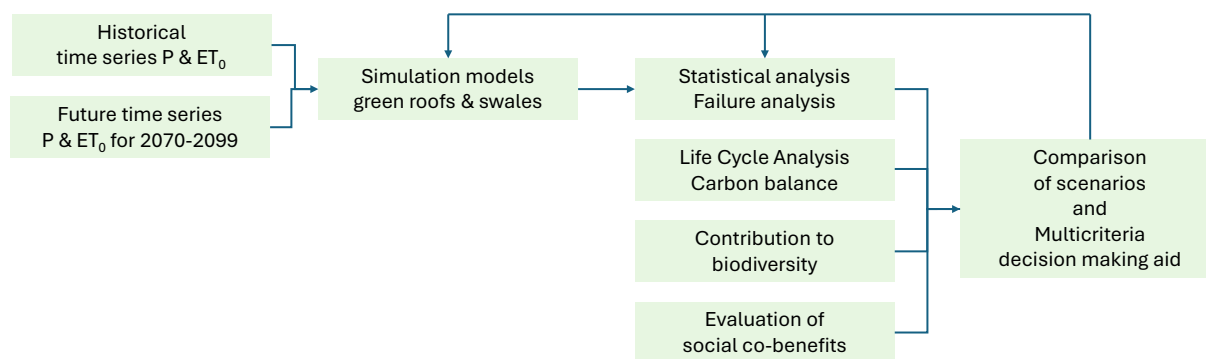


Fig. 1: Scheme of the engineering component of the Allagui project.

3 PRESENTATION OF THE ALLAGUI TOOLS FOR INPUT DATA

Building on the process described in Section 2, the first operational tools developed within ALLAGUI aim to simplify access to historical and future climate data required for dynamic simulations of vegetated infrastructures. Their development is guided by three principles: ease of use, maximum automation, and open public availability.

3.1 Tool 1: Automated collection and validation of historical climate data

The first tool serves as the entry point of the process. It consists of an Excel interface in which the user specifies only the basic information needed to retrieve data: geographic coordinates, study period, desired time step and optional filters.

Based on these inputs, the tool then automatically queries Météo-France servers via an API to extract time series for precipitation (P) and potential evapotranspiration (ET₀), at daily, hourly or 6-minute resolution depending on data availability.

A built-in module then performs systematic data cleaning: detection and correction of duplicates, identification of gaps, flagging of abnormal values and production of data-quality indicators, and delivers a data collection and validation report. This results in historical series that can later on be directly used for i) generation of future time series by Tool 2 and ii) model calibration and verification.

3.2 Tool 2: Generation of future climate series (2070–2099)

The second tool generates fine-resolution future time series required to assess the dynamic behaviour of infrastructures under climate change. It uses a stochastic temporal downscaling method (Pons *et al.*, 2022) based on climate projections from the DRIAS portal or from IPCC models outcomes.

The process includes two steps:

- **Local model calibration:** Historical data obtained via Tool 1 (ideally ≥ 30 years) are used to calibrate the stochastic generator so that it reproduces the local statistical characteristics of precipitation and temperature.
- **Generation of future series:** Projected daily series are downscaled to a short time step (6 minutes by

default). The stochastic nature of the generator makes it possible to produce multiple representative series capturing climate modelling uncertainties. At the moment, future time series are based on the IPCC RCP8.5 scenario.

These series serve as inputs to green roof and swale models to analyse their future performance, and to anticipate extreme events, prolonged dry periods or potential failures (stages 3 and 4).

4 APPLICATIONS AND OUTCOMES

The tools 1 and 2 constitute the first essential building blocks of the future decision-support process developed by ALLAGUI. They notably make it possible:

- to prepare site-specific future climate series for simulating the behaviour of green roofs and swales;
- to anticipate the impact of climate change on their hydrological performance (retention, infiltration, evapotranspiration, overflows) and assess the relevance of the proposed design;
- to compare dynamic simulations under future conditions with results obtained from traditional methods (design storms, classical rainfall method), thereby highlighting their limitations;
- to feed subsequent project modules (life cycle analysis, carbon footprint, biodiversity, social co-benefits and multi-criteria decision-making).

5 STATE OF PROGRESS

Tool 1 is ready and has been submitted to internal testing by Dec. 2025. Tool 2 is under the final debugging phase by Dec. 2025. Both will be operational and tested from early 2026 by a panel of four external testers: two municipalities (Greater Lyon and Greater Bordeaux, France), one consulting engineering company (Egis, France) and one city planning and architecture company (Ateliers Ublo, Montréal, Canada), enabling initial feedback before the Novatech 2026 conference.

Next stage 3 tools (infrastructure modelling and simulation) will be released in Spring 2026 and then submitted to the external testers.

CONCLUSION AND PERSPECTIVES

The two tools presented constitute a major first step in the ALLAGUI project towards modernising urban stormwater management practices. By facilitating access to historical and future climate data at high temporal resolution, they enable dynamic simulation of vegetated infrastructures under future climate conditions—an essential prerequisite for more robust design and for integrating environmental and social considerations.

The next steps of the project will focus on integrating infrastructure simulation models, developing evaluation modules (statistical analyses, life cycle assessment, biodiversity, co-benefits) and implementing a comprehensive multi-criteria decision-support tool. Ultimately, this will form a free and open software platform designed to support long-term evolution of professional practices.

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