Digital planning of blue-green infrastructure for a climate-resilient city

Planification numérique d'infrastructures bleues et vertes pour une ville résiliente au changement climatique

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RÉSUMÉ

Le projet SmartWater développe un outil numérique d'urbanisme, le Blue-Green Infrastructure Planner (BGI Planner), afin d'intégrer dès le début des processus de planification des mesures décentralisées de gestion des eaux pluviales. L'objectif est de renforcer la résilience climatique des zones urbaines, d'atténuer les risques d'inondation, de réduire la chaleur urbaine et de diminuer la pollution des rivières de Berlin. Le BGI Planner repose sur une structure modulaire et relie des géodonnées, des questions et des simulations d'effets. Dans deux zones pilotes à Berlin, les effets des infrastructures bleues et vertes sont analysés à l'aide de modèles – en termes d'inondations, de pollution de l'eau, de climat urbain et de balance hydrique. Des outils de modélisation établis tels que InfoWorks ICM, GERRIS/HYDRAX/QSim, ENVI-met et ABIMO sont utilisés. Les premiers résultats de simulation confirment l'efficacité des mesures sélectionnées et constituent la base de modèles d'évaluation simplifiés dans l'outil. À l'avenir, le BGI Planner sera utilisé comme outil numérique dans l'administration berlinoise pour soutenir un développement urbain durable et adapté au climat.

ABSTRACT

The SmartWater project is developing a digital urban planning tool – the Blue-Green Infrastructure Planner (BGI Planner) – to integrate decentralised stormwater management measures into planning processes at an early stage. The aim is to strengthen the climate resilience of urban areas, mitigate flood risks, reduce urban heat and lessen the pollution of Berlin's waterways. The BGI Planner is based on a modular structure and links geodata, checklists and effect simulations. In two pilot areas in Berlin, the effects of blue-green infrastructure are being analysed using models – in terms of flooding, water pollution, urban climate and water balance. Established modelling tools such as InfoWorks ICM, GERRIS/HYDRAX/QSim, ENVI-met and ABIMO are being used. Initial simulation results confirm the effectiveness of selected measures and form the basis for simplified evaluation models in the tool. In future, the BGI Planner will be used as a digital tool in Berlin's administration to support sustainable and climate-adapted urban development.

KEYWORDS

Blue-green infrastructure, climate adaptation, flooding, heat, impact modelling

1 INTRODUCTION

The challenges posed by climate change, such as heavy rainfall, flooding, heat and drought, are constantly increasing. At the same time, the increasing sealing of urban areas and pollution of water bodies, particularly through combined sewer overflows, are heightening the need to adapt stormwater management, especially in cities. In order to strengthen the resilience of urban areas and ensure quality of life, many municipalities are focusing on climate adaptation strategies that promote decentralised stormwater management through green and blue infrastructure instead of conventional drainage into the sewer system.
The SmartWater project is developing a digital tool to support the early integration of blue-green infrastructure into urban planning processes. The aim is to reduce urban heat islands, minimise flood risks and reduce water pollution through sustainable stormwater management. In addition, the impact of planned measures on the water balance is being analysed in order to support resource-efficient and climate-adapted urban development.

2 METHODOLOGY

As part of the SmartWater project, a total of three digital tools are being developed to promote climate resilience in Berlin. These are an online portal for information and visualisation of heavy rain and flood risks, a game for citizens to provide information and raise awareness of blue-green infrastructure and to communicate the effects of blue-green infrastructure, and a tool for the early integration of climate adaptation measures into urban planning processes (BGI Planner). The following sections present the BGI planner with a particular focus on the effect assessment implemented in it.

2.1 BGI Planner

The Blue-Green Infrastructure Planner (BGI Planner) is being developed as a map-based web application to support the Berlin administration in integrating blue-green infrastructure measures into planning processes. The aim is to strengthen Berlin's climate resilience by promoting decentralised stormwater management, particularly with regard to heavy rainfall, heat, water balance and the protection of Berlin's water bodies. This tool is designed to facilitate strategic decision-making in the early planning stages and support the implementation of specific measures in the later stages. To this end, a modular structure has been developed (see Figure 1) that allows access at various points, depending on the planning procedure, planning phase and prior knowledge of the project area. Relevant data is provided at an early stage by linking to current open-source environmental and geodata (SenStadt, 2025a; SenStadt, 2025b). Based on geospatial data and check questions, needs for action are derived and feasibility aspects are analysed. For example, information on pluvial flood risks, degrees of surface sealing, urban heat islands, or decoupling and green-roof potential is visualised in an accessible manner. Figure 1 shows the modular structure of the BGI Planner and illustrates its underlying architecture. The planning process begins with creating a project in which key information, such as project name, project description, spatial selection and use case, is defined. Three coordinated modules then support users in identifying, evaluating, and documenting suitable measures.

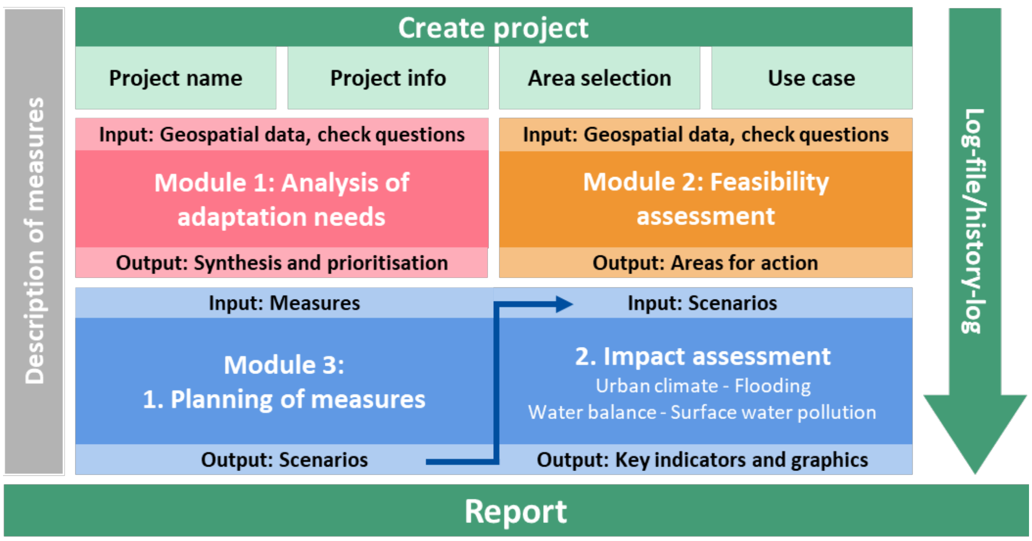

Figure 1: Modular structure of the BGI Planner.

In module 1 “Analysis of adaptation needs”, relevant problem areas such as heat or flooding risks are identified based on geospatial data/maps and a set of questions. Module 2 “Feasibility assessment” uses the same data sources to analyse where measures can be implemented within the project area and highlights corresponding areas. In module 3 “Planning of measures & impact assessment”, appropriate measures can be selected from an existing catalogue and combined into concrete scenarios. The potential impact of the planned measures on various environmental factors, including urban climate, flooding, the water balance and surface water pollution, is analysed and presented using indicators and graphics. This evaluation is carried out using various models and model chains, which are described in the following sections.
All processing steps are continuously documented in a log file. Finally, the results can be compiled into a project-specific report and used for subsequent planning processes or communication with stakeholders.

2.2 Modelling the impacts of blue-green infrastructure

The impact assessment in the BGI Planner is used to quantitatively estimate the effects of planned measures on key environmental objectives such as flood protection, surface water quality, urban climate and water balance. Model-based simulation approaches are employed for this purpose. These models make it possible to analyse and comparatively evaluate different implementation scenarios. The effectiveness of the measures is examined using two exemplary pilot districts in Berlin, one newly developed area and one dense existing urban area, in order to represent different urban planning contexts.

2.2.1 Pilot areas

The modelling approaches for assessing the effects of blue-green infrastructure are applied in two pilot districts in Berlin: the newly developed area “Alte Schäferei” in Pankow and the existing urban district “Ostkreuzkiez” in Friedrichshain-Kreuzberg. These districts differ significantly in their building structure, land use and planning context, thereby enabling a practice-oriented validation of the modelling approaches under realistic conditions. The “Alte Schäferei” in Französisch Buchholz is intended to be developed as a sustainable urban quarter. In addition to residential buildings, public green spaces and educational facilities are planned. A low-car traffic concept and sustainable stormwater management aim to minimise surface sealing, retain stormwater on site, and contribute to heat reduction through evapotranspiration and greening. The “Ostkreuzkiez” district in Friedrichshain is densely built and characterised by limited green spaces and high heat stress in the summer months. Despite local greening initiatives, a climate-friendly transformation requires comprehensive, cross-departmental planning.

2.2.2 Flooding

For the flood modelling of the pilot area “Ostkreuzkiez”, a 2D surface runoff model was developed using the software InfoWorks ICM and coupled with a 1D sewer network model. In this setup, street inlets and manhole covers act as inflow points from the 2D surface into the sewer network or as outflow points from the sewer network onto the 2D surface. In a first step, flood hotspots were identified for selected heavy rainfall events in the existing urban area. The results of this modelling will also be used in the future for the development of Berlin’s heavy rainfall hazard maps. Building on this, the effects of various blue-green infrastructure measures on flood risk are compared and evaluated.
For the pilot area “Alte Schäferei”, no sewer network has yet been established. For this reason, a simplified 2D surface runoff model without a sewer network, based on current planning documents, is intended for modelling the new development area.

2.2.3 Surface water pollution

To assess the positive effects of blue-green infrastructure on the reduction of combined sewer overflows and the improvement of water quality in Berlin’s rivers, a modelling chain with various decoupling scenarios is already available (Knoche et al., 2024). The assessment tool is based on a modelling chain consisting of the combined sewer network model of Berlin’s combined sewer system in InfoWorks ICM and the water quality model in GERRIS/HYDRAX/QSim. Together, these models cover the entire combined sewer system and all receiving water bodies, including 18 combined sewer catchments, 17 main pumping stations, and 176 combined sewer outlets. Based on existing decoupling scenarios, we aim to develop a simplified, data-driven model that may enable real-time simulation within the tool application.

2.2.4 Urban heat

Urban climate modelling is carried out using the ENVI-met software (2D/3D). Typical Berlin urban structure types from the Berlin Geoportal (SenStadt, 2025a) are simulated for three different climate scenarios (summer day, hot day, tropical night). This is done for both the current state and various expansion scenarios of blue-green infrastructure measures. A local monitoring campaign is used to calibrate and validate the simulation results. The results are then integrated into the BGI Planner and combined in such a way that new scenarios can be generated by interpolating existing simulations. For model development, public data from the Berlin Geoportal were used. Surface, building, tree, water body, and green space data are used to represent the current state of the planning area.

The input data for the various simulations are collected using a *Barani MeteoHelix* weather station located in the planning area. The model results are calibrated and validated using 30 LoRaWAN temperature sensors deployed at different locations in the "Ostkreuzkiez" pilot area.

2.2.5 Water balance

To estimate the impacts of blue-green infrastructure on the urban water balance, an enhanced version of the ABIMO software is used (Rachimow & Rachimow, 2009; Del Punta et al., 2024). ABIMO models the components of surface runoff, evapotranspiration, and infiltration of the long-term water balance across all of Berlin, based on climate data, land-use data, and relevant natural parameters. The overall deviation of the urban water balance from natural conditions is quantified using the parameter ΔW (in percent), by comparing evapotranspiration, infiltration, and surface runoff with their respective natural reference values.

3 OUTLOOK

The BGI Planner is being developed in an agile process in close collaboration with urban planners to ensure its integration as a central tool within the Berlin administration. Prototype programming started in autumn 2025. The prototype will undergo regular testing and optimisation at all development stages.

The development of the impact assessment models has been partially completed. Preliminary simulations demonstrate the non-linear relationship between the extent of blue-green infrastructure and the subsequent reduction of flood depth. Furthermore, simulations of various decoupling scenarios have demonstrated that surface decoupling rates of 20 – 40 % are necessary in all combined sewer catchments to achieve a substantial enhancement in surface water quality. The ongoing investigation of the relationship between climate-related risks and the urban water balance may enable the creation of simplified models for integration into the BGI Planner.

With these results, the BGI Planner will ultimately serve as a digital administrative tool that supports more efficient, sustainable, and responsive design of urban areas, thereby promoting climate-resilient urban development.

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