

# AI-MEDIATED SCENARIO MODELLING FOR EXPERIMENTAL INTERVENTIONS IN URBAN VOIDS

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## **Abstract**

Urban voids, often emerging as residual gaps within compact urban structures, represent both spatial challenges and opportunities for innovative design interventions. This research explores the potential of artificial intelligence (AI) as a tool for generating experimental design scenarios for the regeneration of such spaces. The study focuses on a vacant lot located within a strictly urbanized environment, characterized by fragmented spatial conditions and limited development potential. The research applies AI-based modelling to generate a series of possible spatial interventions that reinterpret the role of the site within the surrounding urban fabric. Rather than producing a single design solution, the AI system is used to explore multiple speculative scenarios reflecting different spatial, ecological, and programmatic strategies. These generated proposals are subsequently analyzed and categorized according to their spatial logic, degree of intervention, and relationship to the existing urban structure. The resulting scenarios form the basis for a structured set of recommendations that contribute to a working database of potential regeneration strategies for urban voids. The findings suggest that AI-assisted modelling can serve as a supportive exploratory tool in early design stages, expanding the range of possible spatial strategies and supporting decision-making processes in the regeneration of small-scale urban gaps within dense city environments.

**Key words:** AI-mediated design, generative modelling, spatial scenarios, performative urbanism, experimental urbanism

## **Introduction**

Urban voids represent underutilized or residual spaces within compact urban structures that often lack a clear function, yet hold significant potential for transformation (Žolobaničová et al., 2025; Vinczeová et al., 2025). Emerging as a result of historical development, demolition, or incomplete urban planning, these spaces disrupt spatial continuity while simultaneously offering opportunities for innovative interventions. In recent years, artificial intelligence (AI) has begun to influence design processes, particularly in the early stages of ideation. AI-assisted tools enable the rapid generation of multiple spatial scenarios, allowing designers to explore a wider range of possibilities beyond conventional approaches (Čibík and Jankechová, 2023). This study investigates the use of AI-mediated scenario modelling as a method for exploring alternative transformations of urban voids. Rather than seeking a single optimal solution, the research focuses on comparing multiple predefined spatial strategies applied to the same site, with the aim of expanding the understanding of potential design approaches in the regeneration of small-scale urban gaps.

## **Materials and methods**

**Study area:** The research focuses on a selected urban void located on Vajanského nábrežie in Bratislava, Slovakia. The site is situated within the compact urban structure of the city center, directly adjacent to a primary urban artery along the Danube riverfront. The void is defined as a residual gap between two existing buildings, representing a discontinuity in the otherwise continuous street frontage. The selected site originates from a broader database of identified urban voids within the central zone of Bratislava, developed through prior research. These spaces emerge as a result of historical transformations, demolition processes, or incomplete urban development, and often lack a clearly defined function or identity.

**Data Sources and Software Tools:** The primary input data consisted of a high-resolution street-level photograph capturing the frontal view of the selected urban void and its immediate urban context. This image served as the base layer for all subsequent transformations.

The preparation and processing of data involved a combination of the following tools:

- **Adobe Photoshop 2026, AI-based generative image tools (Generative Fill)**, Used for:
  1. precise spatial selection of the void area

2. masking and layer control
  3. iterative refinement of generated outputs
  4. scenario generation based on text prompts
  5. controlled transformation of the selected area (remove tool)
- **ChatGPT (based on GPT-5.3 architecture, OpenAI, 2026)**, Used for:
    1. prompt formulation, and text refinement
    2. methodological structuring

The workflow was designed to ensure that:

Only the internal area of the void was modified, while all surrounding urban elements (buildings, street profile, sidewalk) remained unchanged. This approach enabled a consistent comparative framework across all generated scenarios.

Research Approach: The research adopts a scenario-based exploratory approach combining principles of urban design, case study methodology, and AI-assisted image generation. The selected urban void was used as a fixed spatial framework within which multiple transformation scenarios were systematically tested. The aim was not to produce a single optimal design solution, but rather to explore a range of possible spatial futures under controlled conditions.

### Methodology

Step 1: Selection of the study site and preparation of the visual base

A specific urban void was selected as the case study site. A street-level photograph of the selected site was used as the primary visual input. This photograph served as the fixed base for all subsequent transformations. The surrounding urban context — especially the buildings, street, and sidewalk — was treated as constant, while only the interior of the void was considered variable.

Step 2: Definition of the intervention boundary

The editable area was manually selected in Adobe Photoshop (Fig. 1). The selection followed the actual spatial limits of the void, including the inner edges between the adjacent buildings and the existing frontage line. This step was critical because the intention was to modify only the internal area of the gap and to preserve the surrounding urban frame unchanged.



Fig. 1: AI-assisted workflow: selection of the intervention area, generative fill application, and prompt-based scenario definition within a fixed urban context. Source: author.

Step 3: AI-assisted scenario ideation

At the conceptual stage, six possible intervention scenarios were developed through an iterative process combining author-driven thinking and AI-assisted ideation. ChatGPT was used to help formulate and structure alternative spatial strategies for the same site. These suggestions were not adopted automatically; they were reviewed, adjusted, renamed where necessary, and accepted by the author as the final scenario framework. The final scenario set consisted of:

1. Managed Urban Succession
2. Green Buffer (Public Park)
3. Micro-Public Space (Pocket Park)

4. Infill Lightweight Structure
5. Temporary / Tactical Urbanism
6. No Intervention (Preserved Void)

#### Step 4: Prompt formulation

Each predefined scenario was translated into a separate text prompt describing its spatial character, type of intervention, vegetation structure, expected program, and level of occupation. The prompts were intentionally scenario-specific so that each output represented a distinct design logic rather than a random visual variation.

#### Step 5: AI-based image generation

The prepared prompts were then used in AI image-generation tools to produce visual scenarios. The objective was not to create a completely new urban scene, but to test how different spatial concepts could be inserted into the same real context.

#### Step 6: Iterative refinement and selection

For each scenario, multiple outputs were tested and compared. During this process, it became clear that AI tools frequently tended to alter edges, proportions, or adjacent surfaces beyond the intended boundary. Because of this, the outputs had to be iteratively refined through repeated prompt adjustment, repeated generation, and visual selection of the most plausible result.

#### Step 7: Comparative scenario analysis

The final set of retained scenarios was then compared as a structured experimental series. Since all scenarios were derived from the same base image and the same spatial frame, they could be analyzed comparatively in terms of:

- degree of intervention,
- spatial logic,
- relation to the existing urban structure,
- and programmatic or ecological character.

#### Step 8: Interpretation of results

The resulting scenarios were interpreted not as final architectural proposals, but as speculative spatial models. Their purpose was to explore the range of possible futures for the selected urban void and to test the usefulness of AI-assisted visualization as a support tool in the early stages of design thinking.

### Results

The AI-assisted process produced six distinct spatial scenarios representing different transformation strategies applied to the same urban void under a fixed visual framework (Fig. 2). By modifying only the interior of the site while preserving the surrounding urban context, the results enable direct comparison between alternative intervention approaches.

The scenarios range from minimal intervention (*No Intervention, Managed Urban Succession*), through environmentally and socially oriented strategies (*Green Buffer, Micro-Public Space*), to more intensive transformations (*Temporary Urbanism, Infill Lightweight Structure*). Each scenario reflects a specific spatial logic, including ecological continuity, environmental buffering, social activation, architectural insertion, and temporary adaptation. The results demonstrate that a single urban void can accommodate multiple plausible spatial futures depending on the selected intervention strategy. At the same time, the use of AI revealed limitations in maintaining strict spatial boundaries and required iterative refinement and authorial selection. Consequently, the generated outputs should be understood as speculative representations supporting comparative analysis rather than precise design proposals.

### Conclusion

This study examined AI-assisted scenario modelling as a tool for exploring transformations of urban voids within compact urban structures. Using a controlled image-based approach, it demonstrated that a single site can accommodate multiple distinct spatial strategies within the same urban framework. The results highlight that urban voids represent adaptable spaces with diverse development potential, ranging from minimal ecological intervention to architectural insertion. At the same time, the research confirms that while AI expands exploratory capacity, it requires careful control and authorial validation.

The outputs should therefore be understood as speculative representations rather than precise design solutions. Overall, the study shows that AI-assisted modelling can effectively support early-stage urban design by enabling comparative analysis and broadening the range of possible spatial scenarios.



Fig. 2: Comparative visualization of six AI-assisted scenarios applied to a single urban void under identical spatial conditions. Source: author.

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## Souhrn

Příspěvek se zabývá využitím AI asistovaného scénářového modelování při zkoumání možností transformace městských prázdných v kompaktní urbánní struktuře. Na základě případové studie je ukázáno, že jeden prostor může nést více rovnocenných návrhových scénářů s odlišnou prostorovou logikou. Výsledky potvrzují, že AI je vhodným nástrojem pro rané fáze návrhu, přičemž generované výstupy je nutné chápat jako spekulativní a vyžadující autorskou interpretaci.

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