

## From vision to action: An integrative approach for circular adaptive reuse

van Laar, B.R.; Hamida, M.B.; Greco, A.

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# From vision to action: An integrative approach for circular adaptive reuse

Circularity in adaptive reuse helps tackle material shortages, environmental damage, and ageing properties, while enhancing asset value. However, bridging the gap between visionary reuse scenarios of existing real estate and design strategies remains challenging. Integrating scenario tools with adaptive reuse frameworks can address this issue. This paper presents an approach to systematically define promising circular real estate scenarios and translate them into actionable strategies.

Brian van Laar, Mohammad B. Hamida and Angela Greco

## 1. INTRODUCTION

Adaptive reuse—or building transformation—has emerged as a key strategy in the transition toward a circular built environment (Tam & Hao, 2019; Remøy, 2010). By reducing the demand for new construction, conserving materials, and extending the lifespan of existing structures, adaptive reuse mitigates environmental impacts while also generating economic and social benefits, such as preserving cultural heritage and enhancing asset value (Foster, 2020).

Despite its multifaceted cultural, societal, and environmental advantages, the implementation of adaptive reuse to enhance circularity continues to face significant technical, legal, and design challenges. These difficulties can be attributed to the intrinsic complexity of decision-making processes, which must balance diverse and often competing criteria (van Laar et al., 2024).

To address this complexity and facilitate more effective adaptive reuse, scholars have primarily focused on two complementary but often disconnected streams of work. The first involves the development of design strategies and frameworks aimed at guiding circular interventions—such as adaptable design, resource efficiency, and the use of low-impact biomaterials—which have demonstrated strong potential to improve environmental performance (Pomponi & Moncaster, 2017; Hamida et al., 2024).

An example is the Circular Building Adaptability for Adaptive Reuse (CBA-AR) framework, which integrates principles of circularity and adaptability to offer context-sensitive strategies (Hamida et al., 2024). However, the practical application of such frameworks is still hampered by knowledge gaps and the difficulty of tailoring strategies to specific economic, functional, and technical conditions (Greco et al., 2024).

The second stream focuses on future-oriented scenario tools, which support stakeholders in exploring long-term consequences and navigating uncertainty in adaptive reuse decisions. These tools are especially valuable in the early stages of planning, where they facilitate collaborative envisioning of different futures. For instance, Cross-Impact Balance (CIB) analysis enables the identification of consistent and plausible scenarios by assessing interrelations among key factors (Weimer-Jehle, 2023; van Laar et al., 2025). While both design frameworks and scenario-building methods contribute critical insights, their development in parallel has limited their combined potential. Current tools tend to focus either on crafting visionary reuse scenarios or on providing practical, context-specific strategies—but rarely both. This separation creates a persistent gap between foresight and implementation, making it difficult for stakeholders to transform aspirational ideas into actionable plans. To bridge this gap, we explore the synergies between the CIB methodology,

which enables the co-creation of resilient long-term pathways, and the CBA-AR framework, which provides concrete guidance for adaptive reuse, to offer a more holistic and future-proof approach to circular real estate reuse.

The aim of this paper is to propose and demonstrate an integrated approach that combines scenario development tools with practical circular design strategies, enabling design and real estate professionals to define and visualize desirable adaptive reuse scenarios alongside applicable strategies that promote a circular built environment.

## 2. BACKGROUND

### 2.1 Circular Building Adaptability (CBA) and its adaptive reuse framework

Circular building adaptability (CBA) is a conceptual framework that combines the principles of adaptable and circular design to create sustainable, resource-efficient building strategies (Hamida et al., 2023). It integrates ten key determinants that contribute to ensuring that buildings can adapt to changing needs over time while reducing waste and building generative capacity. These are: "configuration flexibility", "product dismantlability", "asset multi-usability", "design regularity", "functional convertibility", "material reversibility", "building maintainability", "resource recovery", "volume scalability", and "asset refit-ability". These determinants are operationalized through passive (design-based), active (design- and user-based), and operational (process-based) strategies such as using modular design, providing adjustable products, and applying material passports, respectively. Building on these concepts, the CBA framework has been expanded in a strategic design framework for adaptive reuse (CBA-AR), a tool for mapping each determinant to 33 strategies alongside their enablers (e.g., collaboration and technical innovation) and inhibitors (e.g., lack of expertise or regulatory support) (Hamida et al., 2024). Practitioners can use the CBA as a checklist or guide during adaptive reuse projects

to implement circular design principles, ensuring that buildings remain adaptable, functional, and sustainable across their lifecycles.

### 2.2 Cross-Impact Balance Analysis for scenario development

Cross-Impact Balance (CIB) analysis is a structured method for analysing complex systems and developing plausible scenarios by examining the interdependencies between system components (Weimer Jehle, 2023). CIB is founded on descriptors, variants, and the cross-impact matrix. Descriptors represent the key factors of the system studied, such as regulatory frameworks, market dynamics, or resource availability. The cross-impact matrix is the core analytical tool in CIB. It quantifies how variants influence other variants, revealing interdependencies and feedback loops within the system. Once the matrix is constructed, the analysis identifies consistent combinations of variants, where no contradictions exist in how the variants interact. These consistent combinations are then assembled into scenarios, each representing a logically coherent and plausible future.

CIB systematically explores how changes in one part of the system influences others, making it particularly valuable in fields like urban planning, climate adaptation, and adaptive reuse projects. Its structured approach ensures transparency and allows for stakeholder involvement, making it both robust and participatory.

## 3. RESEARCH METHODOLOGY

### 3.1 Overview and background of the research methodology

This study followed an iterative theory- and practice-oriented research methodology, using literature review and desktop research to develop an integrated methodological approach based on a conceptual framework. Technically, a conceptual framework is a constructed network that brings together interrelated concepts to comprehensively explain a phenomenon or

phenomena of interest (Jabareen, 2009). In mixed methods research, conceptual frameworks can be conceptualized, borrowed, or adopted in a research based on certain theories in relevant fields and act as predicting, determining or informing, or they might be expanded through a data collection process. The creation of frameworks constitutes an important research tool that can aid new discoveries by exposing limitations and enablers of knowledge-driven insights (Sharma et al., 2022).

Accordingly, in this paper, our methodological approach is a processes-oriented framework that brings together certain processes, tools and concepts to aid design and real estate professionals to turn their vision of circular adaptive reuse into a defined set of concrete strategies that can be implemented. The development of this approach is based on knowledge gained from adaptive reuse and circular economy related literature combined with desktop research and interviews.

### 3.2 Methods

#### 3.2.1 Literature review

A brief literature review of circular adaptive reuse was carried out, covering academic literature (Foster, 2020; Hamida et al., 2022; Vafaie et al., 2023; van Laar et al., 2024, Fusco Girard & Vecco, 2021; Gravagnuolo et al., 2024; Hamida et al., 2023; Ikiz Kaya et al., 2021), and grey literature sources. The focus was on methods for circular adaptive reuse and requirements for a methodological approach. The sources were selected in a purposive way. The included themes were applied as a coding scheme to process the requirements, methods, and approaches for circular adaptive reuse. Literature on approaches and frameworks for circular economy in the built environment and circular adaptive reuse were reviewed to initially define steps in the approach while grey literature and methods-based literature were reviewed to define useable tools to be incorporated into the methodological approach.

#### 3.2.2 Desktop research

Based on the reviewed literature, a set of functional requirements are put forward that serve as prerequisites for the integrative methodological approach (section 4). Desktop research was conducted to bring together the scenario development- and strategies-oriented tools and concepts in a stepwise structure. The CIB- and CBA-AR-related literature identified existing tools, while process related literature contributed to synthesizing the steps of the methodological approach. The definition and visualization of the approach were interactively carried out, including rephrasing and merging different steps to avoid redundancy in the process. The approach was then tested in a hypothetical case to validate its potential use. A specific vacant monumental project in the Netherlands was considered as a hypothetical case. Accordingly, the methodological approach was developed during the research while guidelines were put forward for users.

## 4. REQUIREMENTS FOR AN INTEGRATIVE METHODOLOGICAL APPROACH

The literature review indicates that current decision-support tools for adaptive reuse face significant challenges and lack mechanisms to connect high-level foresight with adaptable, project-specific strategies. Many existing tools prioritize either broad functional outcomes or specific design details, which can limit their ability to provide comprehensive, future-proof solutions for adaptive reuse projects (van Laar et al., 2024). Furthermore, there is often a gap between the visionary nature of scenario planning and the practical steps needed to implement circularity principles effectively.

To address these challenges, we apply a methodological approach combining scenario development and circular strategy based on literature:

1. **Clear definition of steps:** Providing practitioners with stepwise approaches is useful for facilitating emerging innovations and practices

in the built environment (Arfa et al., 2022; Foster, 2020; Geldermans, 2016; Stijn & Gruis, 2019).

2. **Consistency and Plausibility:** Scenarios must be internally consistent and plausible, ensuring that future-oriented projections are logically cohesive and applicable (Weimer-Jehle, 2023). The CIB methodology provides a structured approach to scenario development by assessing interdependencies among scenario elements, supporting realistic and stable projections (Weimer-Jehle, 2006).
3. **Normative Scenarios Aligned with Project Goals:** The scenarios are driven by the specific goals and objectives of the adaptive reuse project. This ensures that envisioned future pathways correspond with the broader project sustainability, community, and financial aims, enabling design and real estate professionals to envision and collaboratively pursue desirable outcomes. By anchoring strategy selection to these high-level project goals, the approach maintains coherence between long-term vision and practical actions.
4. **Adaptability to Evolving Project Conditions:** Given the uncertainty inherent in adaptive reuse, the methodology must allow for flexibility in strategy selection and application to accommodate changing environmental, social, or regulatory conditions. This adaptability enables project-specific tailoring of CBA strategies, ensuring that chosen actions remain relevant and effective under various potential future scenarios.

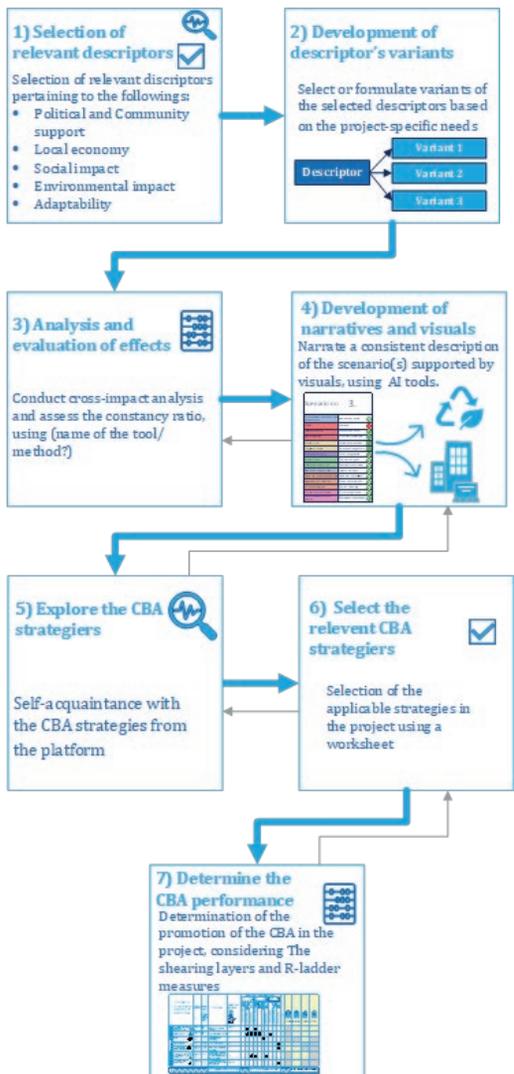
Together, these requirements provide a foundation for an integrated and robust methodological approach that can be further developed and implemented in practice, offering decision-makers a balanced, forward-looking, and methodological approach to circular adaptive reuse.

## 5. RESULTS

### 5.1 Overview of the content of the methodological approach

Based on the literature review and desktop research, we developed a stepwise methodological approach of 7 steps (Figure 1). This methodological approach brings together

**FIGURE 1** ▶ AN INTEGRATIVE METHODOLOGICAL APPROACH FOR DEFINING SUITABLE ADAPTIVE REUSE SCENARIOS AND THEIR PRACTICAL STRATEGIES



three elements, namely informative activities (steps), concepts (circularity and adaptive reuse), and tools (CIB, AI, and CBA-AR worksheet). First, the steps of the approach are detailed, followed by a demonstration of its application to a hypothetical case, illustrating how it fulfils the functional requirements.

The initial definition of the seven steps has been inspired by the model by (Arfa et al., 2022), in which the six subphases of the preparation phase begin with an analysis and evaluation of values and feasibilities of feeding design decisions and outcomes. This has been adapted to accommodate the scenario development process steps from Weimer-Jehle, (2023), enriched with narrative and visualisation techniques by van Laar et al. (2025), and the practical CBA-AR framework (Hamida et al., 2024).

The first four steps are adapted from the scenario development methodology by (Weimer-Jehle, 2023), specifically focusing on Cross-Impact Balance (CIB) analysis to create internally consistent, future-oriented scenarios. The final three steps are derived from the CBA-AR framework (Hamida et al., 2024). The first four steps are visionary, while the last three steps are more practical.

### *5.1. Description of the steps composing the methodological approach*

#### **Step 1: Identification of Relevant Descriptors**

This step focuses on identifying descriptors that capture the key uncertainties and influences within the adaptive reuse context. Descriptors (see 2.2) are the central themes that influence the scenario space (Weimer-Jehle, 2023). This step is essential for establishing a scenario framework that is both context-specific and broad enough to encompass various possible futures, aligning with the emphasis on the scenario factors such as economic, environmental, social, and functional.

#### **Step 2: Development of Descriptor Variants**

Following the CIB methodology, descriptor

variants are crafted to represent a range of plausible outcomes for each descriptor. Variants are defined as: “potential future alternatives” (Weimer-Jehle, 2023). This step is informed by the principle of future openness, where descriptors must cover all potential states without overlap, allowing for a complete exploration of future possibilities. Creating distinct variants ensures that scenarios reflect the diverse conditions that might impact adaptive reuse projects.

#### **Step 3: Cross-Impact Analysis and Consistency Check**

This step applies the CIB analysis to evaluate the interdependencies among descriptor variants. By assessing these, this step generates scenarios that are internally consistent, discarding those that are contradictory or logically incoherent. This analytical process is critical for ensuring the reliability and robustness of each scenario, as inconsistencies could undermine stakeholder confidence and strategic decision-making crucial in adaptive reuse projects.

#### **Step 4: Scenario Narratives and Visualizations**

This step transforms consistent scenarios into accessible narratives and visuals to facilitate stakeholder understanding and dialogue on adaptive reuse priorities. Generative AI tools can be used to produce vivid visualizations and detailed descriptions, incorporating data from CIB analysis and insights from workshops. Unlike traditional methods like artist impressions, AI provides speed, consistency, and adaptability, enabling efficient content creation tailored to diverse audiences (Epstein et al., 2023). This enhances the storytelling process, making complex scenarios more relatable and applicable for stakeholders.

#### **Step 5: Exploration of CBA Strategies**

The CBA-AR framework highlights the importance of familiarizing users with various CBA strategies, categorized as passive, active, and operational. This step provides design and real estate professionals with the opportunity to explore available strategies. By grounding

scenario planning in practical strategies, this step aligns visionary scenarios with applicable actions, bridging the gap between theoretical analysis and practical application.

### Step 6: Selection of Relevant CBA Strategies

This step employs the CBA-AR as a worksheet framework, allowing users to map selected CBA strategies to specific scenario outcomes, by ensuring that strategy selection is informed by the scenario objectives and project-specific descriptors identified in the initial steps.

### Step 7: Assessment of CBA Performance

In the final step the effectiveness and impact of the chosen CBA strategies is evaluated using performance metrics relevant to circular economy goals. This assessment provides insight into the outcomes aligned with circular principles.

## 5.2. Application to Hypothetical Case

The following section discusses how the methodological approach is applied to a hypothetical transformation project and examines how it fulfils the functional requirements.

### Step 1: Identification of Relevant Descriptors

11 descriptors were selected for the scenario development process, namely: Political &

Community support, Cost, market Potential, Social Impact, Building Technology, Indoor Environmental Quality, Rules and Regulations, Flexibility and Adaptability, Durability and Quality, Historic and Cultural value, aligning with the recommended range of 9-15 (Weimer-Jehle, 2023). These descriptors were derived from the criteria and objectives outlined by van Laar et al., (2024), related to the project's objectives, creating normative scenarios aligned with project goals.

### Step 2: Development of Descriptor Variants

Each descriptor has three ordinal variants: a strong variant where the objective is fully achieved, a medium variant where the objective is partially achieved, and a weak variant where the objective is not achieved.

### Step 3: Cross-Impact Analysis and Consistency Check

A cross-impact matrix was used to evaluate the interdependencies among descriptor variants, ensuring logical coherence and consistency in scenarios that were in line with the first functional requirement. Each variant's direct effects on others are rated from -3 to +3, representing negative, neutral, or positive impacts. Scenarios with high inconsistency (e.g., a negative impact

FIGURE 2 ► PRODUCED CONSISTENT SCENARIOS FOR OUR HYPOTHETICAL EXAMPLE

Scenario No. 1	Scenario No. 2	Scenario No. 3	Scenario No. 4	Scenario No. 5	Scenario No. 6	Scenario No. 7	Scenario No. 8	Scenario No. 9	Scenario No. 10	Scenario No. 11	Scenario No. 12	
A) Political and Community Support A1) Everybody on board					A) Political and Community Support A3) Lack of support	A) Political and Community Support A1) Everybody on board	A) Political and Community Support A3) Lack of support					
B) Cost B2) Very costly												
C) Market Potential C1) Great Market Potential				C) Market Potential C3) Limited Market potential		C) Market Potential C1) Great Market Potential		C) Market Potential C3) Limited Market potential				
D) Social Impact D1) Social Heaven				D) Social Impact D2) Socially acceptable		D) Social Impact D1) Social Heaven		D) Social Impact D2) Socially acceptable				
E) Building technology E1) A technical tour de force				E) Building technology E2) Technologically sufficient		E) Building technology E1) A technical tour de force		E) Building technology E1) A technical tour de force	E) Building technology E2) Technologically sufficient	E) Building technology E1) A technical tour de force	E) Building technology E2) Technologically sufficient	
F) Environmental impact F1) Sustainability Heaven				F) Environmental impact F2) Environmentally friendly		F) Environmental impact F1) Sustainability Heaven		F) Environmental impact F2) Environmentally friendly				
G) Indoor Environmental quality G1) Decent indoor climate												
H) Rules and Regulations H1) Following the rules				H) Rules and Regulations H3) Regulatory challenges		H) Rules and Regulations H1) Following the rules		H) Rules and Regulations H3) Regulatory challenges	H) Rules and Regulations H2) overseable non-compliance	H) Rules and Regulations H3) Regulatory challenges	H) Rules and Regulations H2) overseable non-compliance	H) Rules and Regulations H3) Regulatory challenges
I) Flexibility and Adaptability I1) Flexible and adaptable		I) Flexibility and Adaptability I2) Moderately flexibel		I) Flexibility and Adaptability I2) Moderately flexibel		I) Flexibility and Adaptability I2) Moderately flexibel		I) Flexibility and Adaptability I1) Flexible and adaptable		I) Flexibility and Adaptability I2) Moderately flexibel		
J) Durability and Quality J1) Strong and durable				J) Durability and Quality J2) Sufficiently durable		J) Durability and Quality J3) Poor building quality		J) Durability and Quality J3) Poor building quality				
K) Historic and Cultural value K1) Preserving history						K) Historic and Cultural value K2) Attention to history						

Figure developed with scenario wizard, adapted from van Laar et al., 2025



## 6. CONCLUSION AND DISCUSSION

This paper aims to provide design and real estate professionals with an approach to coherently define promising scenarios and strategies for circular adaptive reuse. The approach links future-oriented scenarios with applicable strategies that are co-designed by designers and developers.

This paper has established a seven-step methodological approach. The first four steps are vision- and future-oriented activities, while the last three steps are practical and solution-oriented. This approach allows the alignment of project-specific scenarios with practical strategies, ensuring that decisions are grounded in future-oriented sustainability goals. The research underscores the importance of linking scenarios with strategies to align reuse goals with circular principles. Further research on consistent scenario-strategy connections would make these processes repeatable across project types, facilitating earlier decision-making. Future studies could explore how to systematically map scenario descriptors to relevant design strategies. Developing semi-quantitative tools or decision-support mechanisms may also help practitioners balance subjective judgments with more standardized criteria. Additionally, iterative testing in real-world projects would support refinement of the methodology, improving its usability and ensuring that circularity goals are not only envisioned but effectively implemented.

In the scenario development process, the descriptors and variants are crucial for deciding which circular building adaptability (CBA) strategies can be applied. Decisions in this phase

directly impact which strategies are feasible. For instance, if project stakeholders prioritize a “strong” variant for the “Historic and Cultural Value” descriptor over others, preserving historical integrity becomes a central theme. This choice supports strategies like retaining monumental parts but may limit strategies such as integrating renewable energy technologies, as installing solar panels on a heritage-protected roof could compromise historical authenticity. By combining value-driven scenario development with strategic planning, practitioners can ensure that chosen strategies align with project goals, minimizing the need for costly adjustments later. A key challenge noted is that practitioners must consider legal, cultural, environmental, and technical factors to select relevant descriptors. Future research could address this subjectivity by developing semi-quantitative tools to standardize descriptor selection and balancing subjective insights.

The presented approach in this paper has two limitations associated with its use and outputs. First, it is an informing, visualizing, and guiding tool that aids design and property professionals in aligning circular vision with applicable strategies, but it does not generate a design. Second, the AI outcomes are based on the user input, and could be misaligned with the actual project situation – ‘garbage in – garbage out’.

In sum, this study provides a scenario-based approach for embedding circularity into adaptive reuse projects. Future research could refine the approach for an even more effective process that enhances both the sustainability and adaptability of our built environment.

## ABOUT THE AUTHORS

**Brian van Laar** is a PhD researcher at Delft University of Technology (TU Delft), focusing on decision-making processes in adaptive reuse projects within the built environment.

**Mohammad B. Hamida** is a PhD researcher at TU Delft, developing frameworks that integrate circular economy principles into sustainable building adaptation.

**Angela Greco** serves as an Assistant Professor in Innovation Management at TU Delft and is also a Senior Scientist at TNO Vector, Centre for Societal Innovation and Strategy.

## FOOTNOTES

1 [https://www.cross-impact.org/english/CIB\\_e\\_ScW.htm](https://www.cross-impact.org/english/CIB_e_ScW.htm)

2 <https://cba-ar.com/>

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