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RE-USE MAP: A Computational Evaluation and Decision Support Model for Adaptive Reuse of Existing Buildings

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Abstract

This study proposes a model that supports designers' decision-making in the adaptive reuse process of existing buildings. The model, called "RE-USE MAP," aims to extract data from the existing building through its generated Revit model (such as spatial area data and structural span information, etc.) and to classify transformation scenarios of the building according to an adaptive reuse score. The adaptive reuse score is calculated as the average of the values from four scoring tables: the Reversible Transformation Index, the Intervention Intensity Score, the Circularity Impact Score, and the Function Fit Score. The building's transformation scenarios are compared based on these indicators, thereby aiming to generate concrete data that helps determine whether adaptive reuse is a rational option compared to other scenarios. The findings indicate that different transformation scenarios can be systematically compared through the collected data, and that adaptive reuse decisions can be strengthened with concrete evidence.

Keywords: Adaptive reuse; decision support system; reversible transformation; circular economy; transformation scenarios.

1. Introduction

1.1 Background and Context

The environmental impact of the construction sector has increased the importance of sustainable approaches in the built environment. Construction and demolition activities consume large amounts of raw materials and energy while producing significant waste. In this context, the conversion and reuse of existing buildings for specific purposes have become important topics in contemporary architectural research and practice.

Many existing structures, despite having lost their original functions over time, retain their structural and spatial potential. However, these structures are abandoned or demolished because they can no longer respond to changing social, economic, or functional requirements. Adaptive reuse approaches aim to extend building lifecycles by transforming existing structures with new functions, rather than demolishing and rebuilding them.

Adaptive reuse contributes to energy conservation and urban continuity while reducing demolition waste and material consumption. Consequently, transformation-oriented approaches are increasingly gaining importance in decision-making processes regarding the fate of existing structures.

At the same time, adaptive reuse projects involve numerous parameters that require comprehensive evaluation. Intervention intensity, structural preservation, material reuse, spatial compatibility, and reversibility simultaneously affect the transformation process. However, these parameters are typically evaluated through subjective interpretations and intuitive ideas based on static objects such as photographs, rather than on measurable or comparable systems.

In this context, Building Information Modelling (BIM) technologies offer significant potential for developing data-driven evaluation systems. BIM-based models enable the direct extraction of spatial, structural, and material-related data from existing buildings. These data can support more systematic and measurable approaches for evaluating adaptive reuse processes.

1.2 Problem Statement and Research Gap

Although adaptive reuse has become an important research topic, most existing studies focus primarily on determining whether a building is suitable for reuse rather than comparing multiple transformation scenarios for the same structure, and they rely on intuitive assessment methods. Many of these approaches typically evaluate adaptability, sustainability, or reuse potential separately rather than considering them holistically within an integrated system.

Studies such as the Adaptive Reuse Potential (ARP) developed by Langston (2012), adaptSTAR proposed by Conejos et al. (2013), and Durmisevic's (2018) reversible building design approaches make significant contributions to adaptive reuse and building adaptability. However, computational systems capable of systematically comparing different adaptive reuse scenarios through measurable Building Information Modelling-based data are limited in the existing literature. Additionally, BIM-based decision support systems are generally used for renovation performance, life cycle analysis, or energy-focused evaluations rather than adaptive reuse-oriented scenario comparisons. This situation creates a methodological gap in the development of measurable, data-driven evaluation systems for adaptive reuse processes.

1.3 Objectives and Hypotheses
This study proposes "RE-USE MAP", a computational evaluation and decision support model for adaptive reuse processes. The primary aim of the study is to develop a measurable, scenario-based evaluation model to compare different transformation approaches for existing buildings.
The proposed system evaluates adaptive reuse scenarios based on four indicators using data extracted from a Building Information Modelling-based model: Reversible Transformation Index (RTI), Intervention Intensity Score (IIS), Circularity Impact Score (CIS), and Functional Fit Score (FFS).
The study is based on the hypothesis that adaptable reuse processes can be transformed into more transparent and comparable decision-making systems through Building Information Modelling-based data generation and computational evaluation methods.

1.4 Significance and Structure of the Article
The significance of this study lies in its attempt to provide concrete data and evaluate them within a systematic framework, rather than relying on a single suitability assessment for adaptive reuse. The proposed model aims to compare multiple transformation scenarios for the same structure through measurable data and a multi-criteria evaluation system.
The study also contributes to the integration of Building Information Modelling technologies into adaptive-reuse-focused decision-support systems. By converting building data into measurable evaluation parameters, the proposed model supports more systematic and transparent architectural decision-making processes.

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2. Materials and Methods
2.1 Study Design and Setting
This study adopts an approach of extracting data from a building information model to evaluate adaptive reuse processes using concrete data and to investigate the obtained data in a scenario-based system. The proposed methodology integrates Building Information Modelling, data production workflows, and multi-criteria evaluation systems. Within this

framework, the adaptive reuse process is addressed not only as a design problem but also as a measurable decision-making process.
The study focuses on the comparative evaluation of different transformation scenarios developed for an existing building. Instead of analysing whether a structure is suitable for adaptive reuse through a single assessment, the proposed approach evaluates the effects of different intervention strategies on reversibility, circularity, intervention intensity, and functional compatibility.
Previous studies have emphasised the importance of decision support systems in renovation and transformation processes (Kamari et al., 2018). Similarly, adaptability-focused frameworks such as Adaptive Reuse Potential (ARP) and adaptSTAR emphasise the need for systematic evaluation approaches in adaptive reuse studies (Langston, 2012; Conejos et al., 2013). Based on these discussions, this study aims to verify whether the building is truly suitable for this purpose through measurable building data. It aims to develop a scenario-based calculation that can compare multiple adaptive reuse alternatives.
The methodological workflow of the study consists of four key stages:
1. Obtaining the Building Information Model if available; otherwise, Building Information Modelling for the existing building,
2. Data generation,
3. Data processing and scoring,
4. Scenario comparison and evaluation

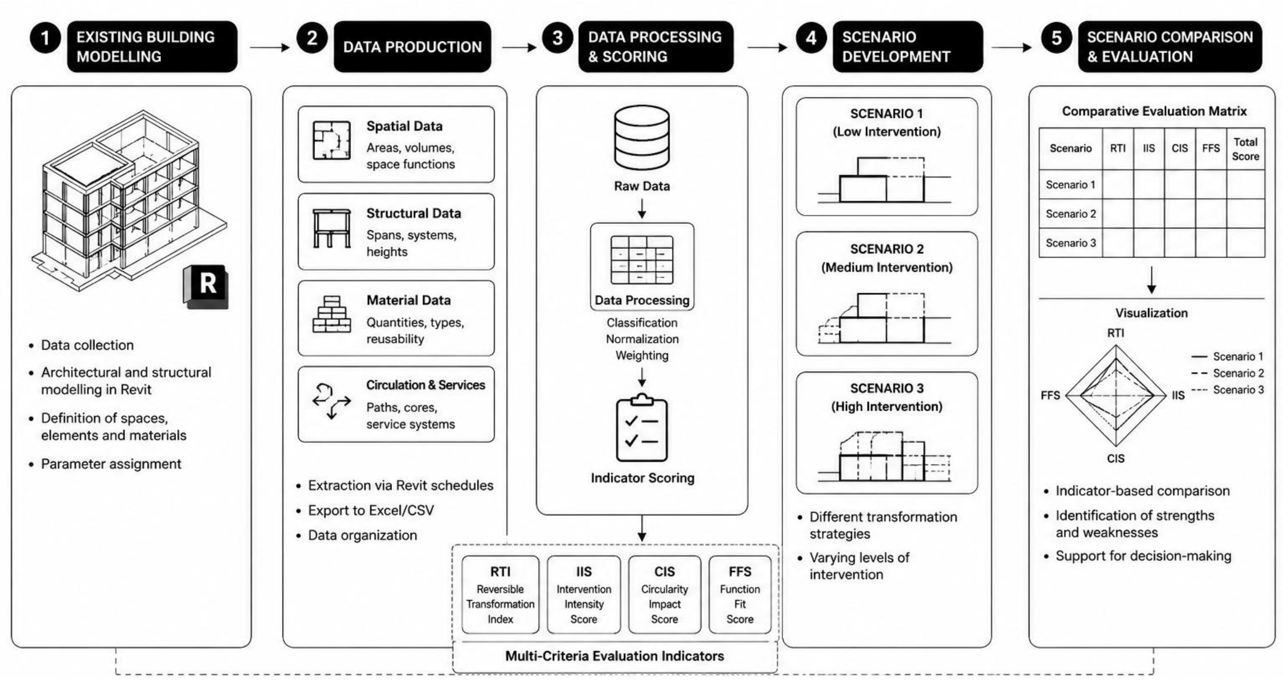

Figure 1. Methodological Workflow of the RE-USE MAP Framework.

2.2 Participants or Topics
The study was tested not by modelling based on an existing tangible structure, but by extracting data from a project that already had a building information model and processing this data as required.
In addition, the study aims to develop a transferable evaluation framework adaptable to diverse current building conditions, rather than focusing on a specific building typology. Therefore, the building information model used primarily serves as a testing environment for the proposed calculation methodology.
Information on spatial dimensions, structural openings, floor heights, and materials was integrated into the digital model to support the adaptive reuse analysis.

2.3 Materials and Equipment
BIM technologies provide significant advantages in renovation and transformation-oriented workflows due to the ability to analyse building elements through parameter-based systems (Eastman et al., 2011). The primary digital data used in the study were the Structure Information Model data. The Building Information Model data was extracted digitally from the existing Revit project.
In addition to Revit, Microsoft Excel was used for data processing, parameter classification, and scoring calculations. The evaluation system was developed using Excel-based tables to organise building data into comparable indicators.
Materials produced within the digital workflow include the following:
Existing building plans and model data,
Spatial area charts,
Structural opening information,
Material quantities,
Circulation and plumbing system data,
Scenario comparison tables,

Multi-criteria evaluation matrices.
These materials formed the computational infrastructure of the RE-USE MAP system.

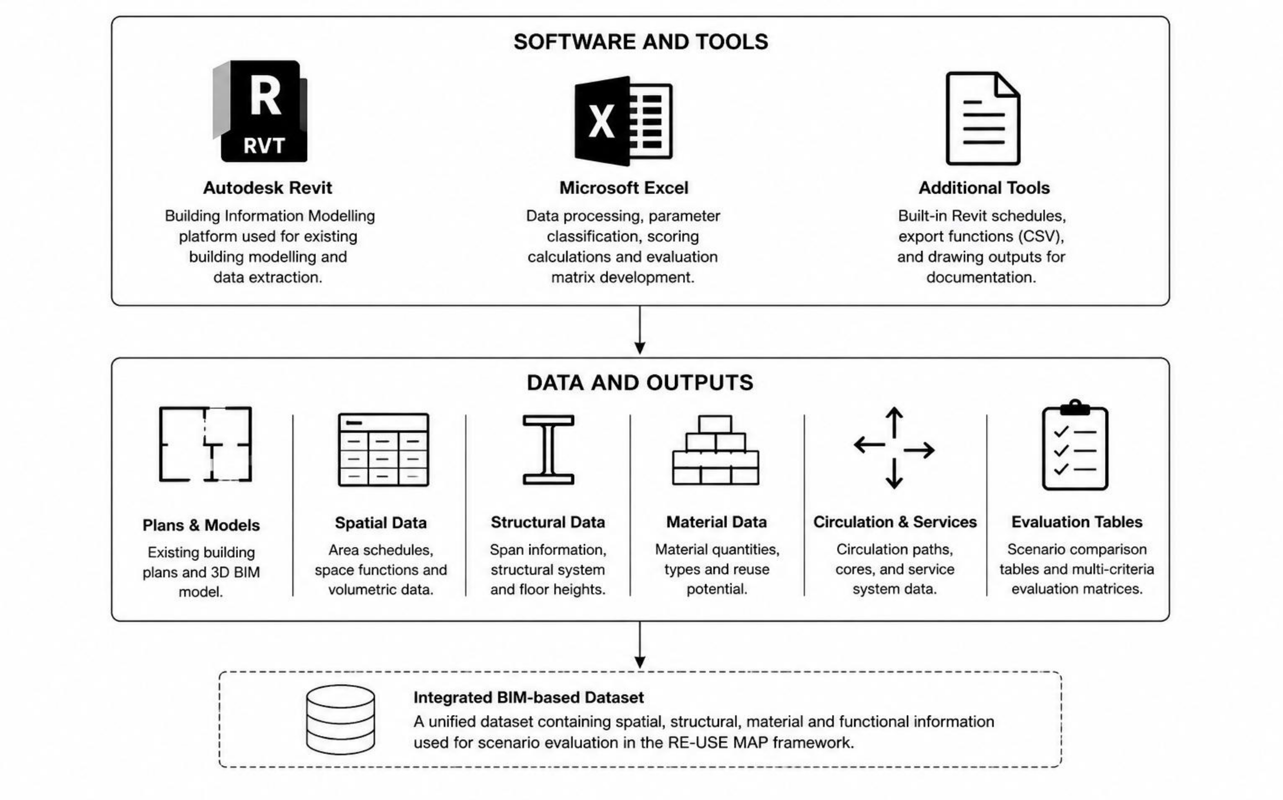

Figure 2. Materials and Equipment used in the Study.

2.4 Procedures and Protocols

The first stage of the methodology involved creating a Building Information Model if there is no existing project or structure, and using a digital model of the existing structure if one exists. At this stage, spatial organisation, floor plans, structural systems and material-related components were used to create a measurable building information system.
Following this process, data extraction was performed through Revit charts and parameter systems. Spatial area data, structural span measurements, floor heights, and material-related information were systematically collected and organised.

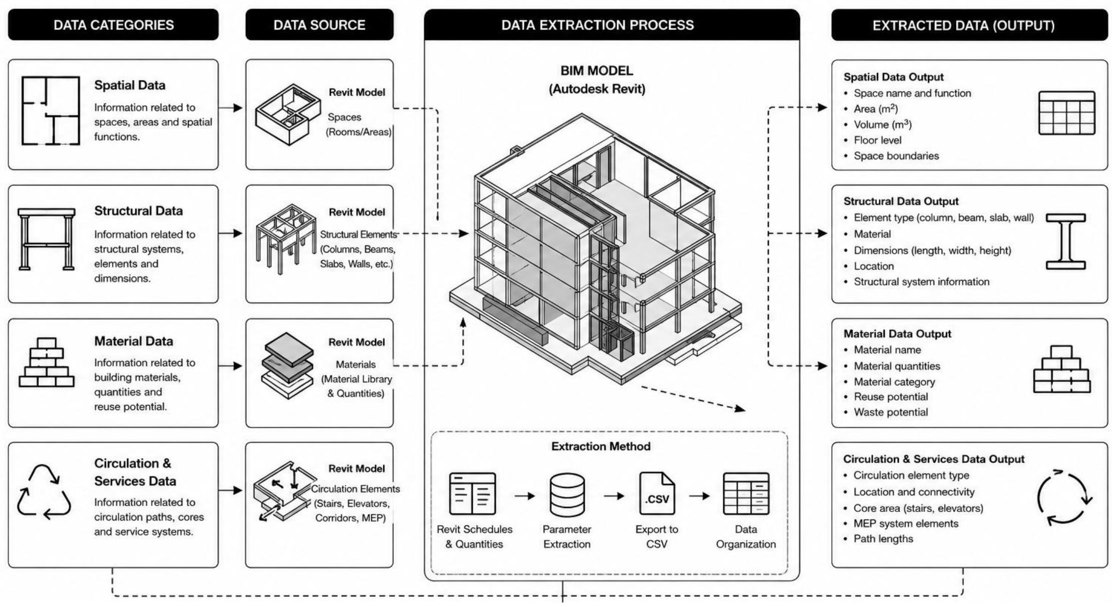

Figure 3. Data Sources and Extraction Process from the BIM Model.

The data extraction process was carried out using the Revit-based BIM model of the existing building. Spatial data, such as space areas, space functions, floor heights, and circulation relations, were obtained from plans and spatial parameters in the BIM model environment. Structural data, including span measurements, column positions, beam dimensions, floor configurations and structural element characteristics, were extracted directly from the structural model and element lists.

Information about the material, such as material types, quantities, reuse potential and post-demolition replacement conditions, was obtained through material measurement charts and parameter-based quantity extraction systems. In addition, circulation and service-related data, including vertical circulation cores, corridor systems and service infrastructure elements, were collected through circulation analysis and BIM component classification.

Following the extraction process, all generated datasets were imported into CSV- and Excel-based analysis environments. The extracted data were then classified, normalised, and converted into measurable evaluation parameters within the RE-USE MAP framework.

Spatial compatibility data were primarily used to calculate the Functional Compatibility Score (FFS), while structural protection and removable system information contributed to the Reversible Transformation Index (RTI). Material reuse and protection data were evaluated using the Cyclicity Impact Score (CIS), while the extent of destruction, structural changes, and intervention-related changes were assessed using the Intervention Intensity Score (IIS).

The collected data were subsequently transferred to an Excel-based evaluation environment. At this stage, the structural data were classified and converted into parameters suitable for adaptive reuse evaluation. The evaluation framework was developed based on four key indicators:

Reversible Conversion Index (RTI),
Intervention Intensity Score (IIS),
Circularity Impact Score (CIS),
Functional Fit Score (FFS).

The RTI indicator assesses the reversibility of interventions and the protective capacity of existing building components. IIS focuses on the intensity of physical interventions applied to the structure. CIS analyses circularity-oriented performance by considering criteria for material preservation and reuse. FFS evaluates the compatibility between the existing spatial organisation and the proposed new function.

After the evaluation framework was established, multiple reuse scenarios with different intervention levels were developed. These scenarios were comparatively analysed through the proposed scoring system to determine the relationships between reversibility, intervention intensity, circularity, and functional compatibility.

Previous studies have shown that parameter-based evaluation systems can support more systematic architectural decision-making processes (Kamari et al., 2018). Similarly, reversible design frameworks emphasise the importance of reducing irreversible interventions in transformation-oriented architectural approaches (Durmisevic, 2018). The procedures developed in this study build on these discussions by integrating scenario comparison into a BIM-based adaptive reuse workflow.

2.5 Data Analysis

The data analysis process focuses on comparing adaptive reuse scenarios through the mentioned indicators. Instead of relying solely on qualitative interpretation, the proposed model transforms building-related data into a multi-criteria computational evaluation framework.

Each adaptive reuse scenario was analysed based on four evaluation indicators:

RTI,
IIS,
CIS,
FFS.

The indicators were evaluated comparatively to determine the relationships among intervention intensity, reversibility, circularity, and functional compatibility. The analysis process aimed to reveal how different transformation approaches affect adaptive reuse performance within the same existing structure.

The scenario comparison results were interpreted through comparative tables, workflow diagrams, and evaluation matrices. Visual comparison tools were used to enhance the readability of the generated data and strengthen the transparency of the decision-making process.

This analytical framework enables evaluation of adaptive reuse processes based on measurable, comparable outputs rather than mere intuitive interpretations.

Table 1: Evaluation Indicators and Associated Building Data Used in the RE-USE MAP Framework.

Indicator	Purpose	Data Source	Evaluated Parameters
RTI – Reversible Transformation Index	Evaluates reversibility and preservation capacity	Revit structural and material data	Dry systems, removable elements, preservation of existing structure
IIS – Intervention Intensity Score	Measures the physical intervention level	Structural and spatial modification data	Demolition amount, new structural additions, spatial reconfiguration
CIS – Circularity Impact Score	Evaluates circularity-oriented transformation performance	Material quantity and reuse data	Material preservation, reuse potential, waste generation
FFS – Function Fit Score	Evaluates compatibility between the existing building and the proposed function	Spatial organisation and circulation data	Space compatibility, circulation efficiency, functional adaptation

3. Results

3.1 Presentation of Key Findings

The findings from the RE-USE MAP model show that adaptive reuse scenarios can be systematically compared using measurable building data and multi-criteria evaluation indicators. The proposed model comprehensively analyses the intervention intensity, reversibility, cyclicity, and functional compatibility, enabling the evaluation of different transformation approaches for the same existing structure.

The results show that different intervention levels directly affect the adaptive reuse performance of transformation scenarios. Scenarios involving lower intervention levels have generally produced stronger reversibility and cyclicality-oriented results due to the preservation of existing structural and spatial components. In contrast, scenarios requiring more intensive intervention improved functional compliance, while at the same time increasing the intensity of intervention and reducing the potential for reversibility.

The findings also show that adaptive reuse processes involve measurable relationships between multiple evaluation criteria rather than evaluating with a single eligibility condition. Dec. Thanks to the proposed model, these relationships have become more visible and comparable within the decision-making process.

In addition, the integration of Structural Information Model-based data production into the evaluation workflow has enabled the transformation of spatial, structural and material-related building information into measurable evaluation parameters. In this way, it has been possible to develop a more transparent and data-driven adaptive reuse evaluation process.

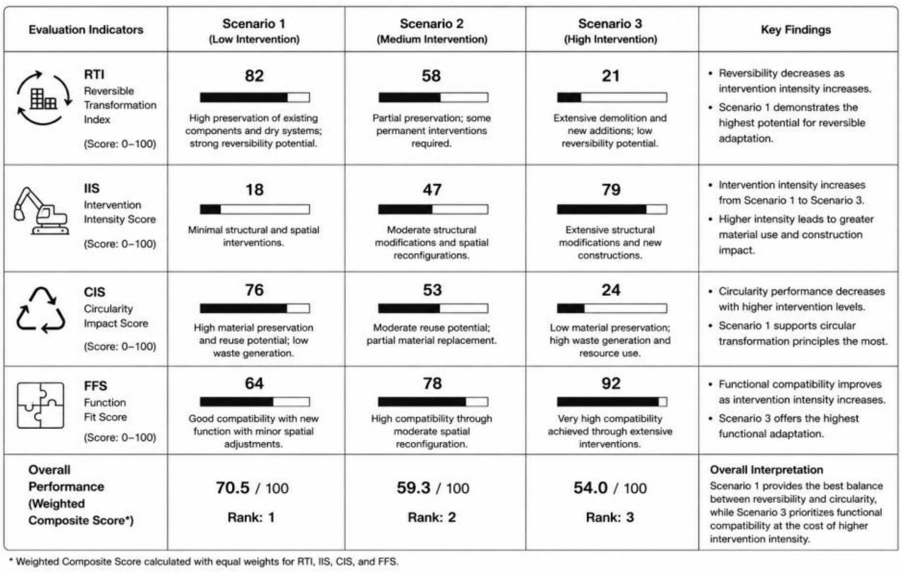

Figure 4. Summary of Key Findings Across Adaptive Reuse Scenarios.

3.2 Use of Tables and Figures

The evaluation outputs produced within the scope of the study were presented through comparative tables, workflow diagrams, scoring matrices and scenario-based visual comparison systems. These visual representations have been used to increase the readability of the generated data and to support the interpretation of adaptive reuse relationships between different transformation scenarios. Dec.

The methodological workflow diagram shows the general structure of the RE-USE MAP system, including the current building modelling, data generation, parameter processing, scoring procedures and scenario comparison stages.

Comparative evaluation tables were used to show the relationships between RTI, IIS, CIS and FFS indicators across different transformation scenarios. Dec. These tables provided a holistic interpretation of reversibility, intervention intensity, cyclicity and functional compatibility within the same adaptive reuse framework.

3.3 Statistical Analysis

The study does not aim to make statistical generalisations from large-scale quantitative datasets. Instead, the analysis process focuses on comparative evaluation through parameter-based scoring systems derived from building-related data. The proposed model Deconstructs spatial, structural and material-related information into measurable evaluation indicators that can be analysed comparably between different adaptive reuse scenarios. Therefore, the analysis process primarily relies on relative comparison rather than statistical estimates.

The scoring system enables the determination of the relationships among intervention intensity, reversibility, circularity, and functional compatibility within the same structure. Thanks to this approach, adaptive reuse processes become more measurable and systematically comparable during architectural decision-making stages.

The evaluation framework also enables visual interpretation of scenario relationships through comparative matrices and indicator-based evaluation diagrams.

3.4 Sub-Sections for Different Data Types

The generated data are divided into four main categories according to the evaluation structure of the RE-USE MAP model:

spatial data,
structural data,
Material-related data,
Functional compatibility data.

Spatial data included area distributions, circulation relationships, and the organisational harmony between the existing building and the proposed new functions. Structural data focused on açıklık systems, structural protection capacity, and changes related to interventions within the building system.

Material-related data were analysed using cyclicality-oriented criteria, such as material preservation, reuse potential, and material exchange resulting from intervention. Functional compatibility data evaluated the relationship between the existing spatial configuration and the proposed adaptive reuse functions.

These data categories were processed through RTI, IIS, CIS, and FFS indicators to produce measurable adaptive reuse outcomes. The classification process also made it possible to compare different intervention approaches within the same existing structure.

The findings show that BIM-based data generation processes can support more transparent and systematic adaptive reuse assessment processes by converting building-related information into comparable computational outputs.

4. Discussion

4.1 Interpretation of Important Findings

The findings of the study show that adaptive reuse processes can be evaluated through computational systems based on measurable and comparable concrete data, rather than relying solely on subjective interpretations. The RE-USE MAP model provides a holistic assessment of reversibility, intervention intensity, cyclicity and functional compatibility in different transformation scenarios developed for the same existing structure.

One of the most important findings of the study is the clear relationship observed between intervention intensity and reversibility. Since scenarios involving lower intervention levels usually preserve the existing structural and spatial components more, stronger reversibility-oriented results have emerged, which was also predicted at the beginning of the study. In contrast, it has been observed that scenarios requiring more intense spatial changes can increase functional compatibility while simultaneously reducing the potential for reversibility.

The findings also show that adaptive reuse processes involve measurable relationships among different evaluation criteria. It has been concluded that these relationships cannot be considered independent of each other. Increasing the intensity of intervention can improve the spatial adaptation of a building to the proposed new function, but at the same time, it can increase demolition-related interventions and reduce the preservation capacity of existing building components. Therefore, adaptive reuse decisions cannot be evaluated based on a single parameter.

Another important finding is that BIM-based data generation contributes to transparency by providing concrete data for adaptive reuse assessments. Extracting measurable data directly from the Revit model allows converting spatial, structural and material-related building information into comparable evaluation outputs. This reduces reliance on intuition-based decision-making processes and supports a more systematic evaluation workflow.

4.2 Comparison with Previous Studies

The proposed model bears some similarities with previous adaptive reuse assessment studies, but also offers several methodological differences. Langston's Adaptive Reuse Potential (ARP) model focuses on evaluating the reuse potential through ageing-related indicators and ranking systems (Langston, 2012). Similarly, the adaptSTAR model or system developed by Conejos et al. (2013) proposes a multi-criteria adaptability assessment approach for existing buildings.
Although these studies have made important contributions to adaptive reuse evaluation, they are generally not focused on the comparative analysis of multiple conversion scenarios for the same structure, but rather on the suitability of the structure. In contrast, the RE-USE MAP model evaluates adaptive reuse as a decision problem through scenarios by comparatively analysing different intervention approaches through measurable structural data.
The study is also related to the reversible building design approaches developed by Durmisevic (2018), especially the views on the importance of reversible interventions and adaptive building systems. However, the proposed model differs from recycled design frameworks by integrating recycling evaluation into a broader adaptive reuse comparison system that simultaneously takes into account intervention intensity, cyclicity and functional compatibility.
Additionally, the study builds upon the BIM-based decision support discussions presented by Kamari et al. (2018). While previous BIM-oriented systems focused primarily on renovation performance and sustainability assessment, the proposed framework is specifically aimed at adaptive-reuse-oriented scenario comparison using data from the existing building model.

4.3 Strengths and Limitations

One of the main strengths of the study is that BIM-based data production and multi-criteria evaluation systems are integrated into a single adaptive reuse framework, and the source of concrete data can be controlled. The proposed methodology converts building data into measurable parameters and enables systematic comparison of different transformation scenarios.
Another important strength of the model is its scenario-based structure. The model does not evaluate adaptive reuse through a single compliance assessment and analyses how different intervention strategies affect reversibility, cyclicity, intervention intensity and functional compatibility simultaneously. This contributes to a more transparent decision-making process with concrete data during the early stages of design.
The study also reveals the potential of BIM technologies for adaptive-reuse-focused workflows. Revit-based data extraction systems support the production of measurable spatial and structural information that can strengthen computational assessment approaches.
Despite these contributions, the study has some limitations. The proposed model has been developed primarily as a conceptual and methodological model and has not yet been tested in different building typologies. Additionally, the weighting relationships between the evaluation indicators continue to adhere to the structure of the proposed scoring system.
Another limitation concerns the qualitative interpretation of certain adaptive reuse parameters. Although the framework aims to produce measurable outputs, some evaluation criteria still require design-based interpretation during the scoring process. Therefore, future studies can improve the framework's objectivity through more advanced parameter-determination systems and broader comparative datasets.

4.4 Implications and Future Directions

The proposed framework demonstrates that adaptive reuse processes can increasingly benefit from computational and data-driven decision-support systems. As adaptive reuse projects become more complex due to sustainability requirements, cyclicality-oriented design approaches and changing functional demands, the need for systematic evaluation tools in architectural practice becomes even more critical.
The RE-USE MAP framework demonstrates the potential of integrating BIM technologies into adaptive reuse-focused workflows. The ability to obtain directly measurable data from existing building models creates opportunities for more transparent and comparable transformation processes at the early design stages.
Future studies may expand the proposed framework by integrating parametric modelling systems, artificial intelligence-based optimisation tools, and environmental performance simulations. In particular, machine learning approaches can support the development of adaptive scoring systems that can analyse larger conversion datasets.
In addition, future research may test the framework in different building typologies and urban contexts to improve the adaptability and reliability of the proposed system. The integration of life cycle assessment tools and carbon-based environmental analyses can also strengthen the framework's cyclicality-oriented evaluation capacity.

5. Conclusions

5.1 Summary of Key Findings

This study proposed "RE-USE MAP," a computational evaluation and decision support model for adaptive reuse processes. This model has been developed to compare different transformation scenarios for existing structures using measurable, data-based evaluation methods.
The study has shown that adaptive reuse processes can be analysed on multiple criteria such as reversibility, intervention intensity, cyclicity and functional compatibility. By integrating BIM-based data generation with a multi-criteria scoring system, the proposed framework enables systematic comparison of adaptive reuse scenarios within the same existing structure.
The findings also revealed that different intervention strategies create measurable relationships between protection capacity, spatial adaptation and Decircularity-oriented performance. While functional compatibility may improve as the intensity of intervention increases, reversibility and protection potential may decrease. This shows that adaptive reuse

processes involve numerous interconnected parameters that should be considered together rather than evaluated in isolation.
Another important finding of the study is its demonstration of the contribution of BIM technologies to adaptive-reuse-focused decision-making processes. Revit-based data extraction workflows have enabled the transformation of spatial, structural and material-related building information into measurable evaluation outputs that support comparative architectural analysis.

5.2 Results of the Findings

The proposed framework contributes to the current adaptive reuse discussions by redefining adaptive reuse as a comparative and measurable decision problem instead of a single conformity assessment. The study shows that computational evaluation systems can support more transparent and systematic adaptive reuse processes in the early design stages.
The integration of BIM technologies into adaptive reuse workflows also highlights the increasing importance of data-driven architectural decision-making processes. By converting existing building data into evaluative parameters, the proposed model supports the development of more comparable transformation strategies.
In addition, the study contributes to the discussions of architectural transformation focused on cyclicity by holistically evaluating recyclability, intervention density and material protection within the same framework. This approach may support future adaptive reuse studies focusing on sustainable transformation processes and cyclical building systems.

5.3 Limitations of the Study

Despite the contributions of the proposed framework, the study has certain limitations. The RE-USE MAP model has been developed primarily as a conceptual and methodological framework and has not yet been tested on multiple building typologies or large-scale datasets.
Additionally, some evaluation criteria within the scoring system require interpretation during the evaluation process. Although the framework aims to produce measurable outputs, some adaptive reuse parameters remain partially dependent on design-based evaluation approaches.
Another limitation concerns the weighting relationships between evaluation indicators. The proposed Oct structure provides a comparative evaluation framework, but future studies may improve the weighting system through broader case studies and additional performance parameters.

5.4 Recommendations for Future Research

Future studies may expand the proposed framework by integrating parametric modelling systems, environmental performance simulations, and artificial intelligence-based optimisation tools. These approaches can support the development of more advanced adaptive reuse assessment systems that can handle larger datasets and more complex conversion scenarios.
Further research can also test the framework in different building typologies and urban contexts to increase the model's adaptability and reliability. The integration of life cycle assessment methods and carbon-based environmental analyses can strengthen the system's capacity for cyclicality-oriented assessment.
In addition, future studies may explore the potential of automated BIM-based data extraction workflows to improve the efficiency of adaptive reuse-oriented decision support systems. Such developments may contribute to the broader integration of computational evaluation approaches into architectural transformation processes.

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Conflicts of Interest
The author(s) report no conflicts of interest.

Data Availability Statement
The data generated and analysed during this study are included within the article. Additional materials related to the computational evaluation framework can be made available by the corresponding author upon reasonable request.

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