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Research paper

ONE ARCHITECTURAL PROGRAMME, TWO CIRCULAR CONSTRUCTION STRATEGIES: A COMPARATIVE EVALUATION OF ADAPTIVE REUSE AND CONTAINER REPURPOSING

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Abstract

The construction sector is increasingly required to transition from linear models of resource consumption towards circular approaches that extend the lifespan of existing materials and structures. Among the various circular construction strategies emerging within contemporary practice, the practice of adaptive reuse and shipping container repurposing represent two distinct approaches based on the principle of resource conservation. However, limited research has comparatively examined these strategies when applied to the same architectural programme. This study investigates the economic, technical and contextual implications of adaptive reuse and container repurposing through a comparative analysis of two café developments in Cyprus. The first case study examines the transformation of an existing commercial unit into a café, while the second investigates the conversion of three shipping containers into a café structure. A Multi-Criteria Decision Analysis (MCDA) framework is employed to evaluate the two approaches according to criteria including construction cost, implementation time, regulatory complexity, environmental performance, design flexibility and contextual integration. The findings demonstrate that neither strategy consistently outperforms the other across all evaluation criteria. The adaptive reuse project presents advantages in terms of construction cost, project duration and integration within the existing urban fabric, while the container-based project provides greater opportunities for architectural identity, modular flexibility and material repurposing. The comparison further investigates the common perception that container architecture represents an inherently low-cost circular solution, demonstrating that economic performance depends on the extent of transformation required. The study argues that circular construction strategies should not be evaluated through a single sustainability indicator, but through a holistic assessment of environmental, economic, technical and architectural considerations. By providing empirical insights into the decision-making process between alternative reuse approaches, this research contributes to the broader discussion on context-sensitive circular design strategies.

Key words: *Adaptive Reuse, Shipping Container Architecture, Circular Economy, Multi-Criteria Decision Analysis*

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1. INTRODUCTION

The construction sector generates significant environmental impacts through resource extraction, material production, construction activities and construction and demolition waste. Its predominantly linear model of extraction, use and disposal has intensified pressure on natural resources, encouraging approaches that extend the useful life of existing resources and reduce new material consumption [1,2].

Circular economy principles promote value retention through reuse, adaptation, repurposing and recovery. At the building scale, adaptive reuse extends the functional life of existing structures by introducing new uses while retaining existing fabric [3-5]. At the material and component scale, repurposing transforms existing objects into new architectural applications [6]. Shipping container repurposing combines industrial artefact reuse with modular architectural applications, although its environmental performance depends on the extent of adaptation [7,8]. Similarly, adaptive reuse depends on existing conditions, proposed use, regulations and intervention requirements [3,5,9]. Thus, circular reuse strategies do not necessarily produce equivalent economic, technical or architectural outcomes.

Despite growing research on both approaches, they are generally examined separately. Limited attention has been given to their direct comparison when accommodating the same architectural programme, although different circular strategies may preserve different forms of value and produce different economic, technical, regulatory and spatial outcomes. This study addresses this gap through a comparative analysis of two café developments in Cyprus.

2. LITERATURE REVIEW

2.1. Circular Economy in Construction

The construction sector has traditionally followed a linear model of extraction, production, use and demolition, contributing to resource depletion, waste and environmental degradation. Circular economy principles provide an alternative by retaining the value of buildings and materials through reduction, reuse, adaptation and recovery [1,2]. In construction, this transition prioritises retaining and adapting existing structures and materials, which can preserve more material value and embodied energy than demolition and replacement. Adaptive reuse is therefore a high-value circular strategy, enabling existing buildings to accommodate new functions while reducing demand for new materials [10,11].

Circular construction can also reduce embodied carbon from material extraction, processing, transportation, construction and end-of-life treatment. As operational buildings become more energy efficient, embodied impacts have gained importance, reinforcing the value of retaining existing structures where feasible [2]. Reuse, adaptation and repurposing can further reduce waste while promoting adaptability, durability and future transformation [12].

These principles are increasingly relevant amid material pressures, supply-chain disruptions and environmental demands, as circularity can reduce reliance on virgin resources while improving the efficiency and resilience of existing assets [11].

2.2. Adaptive Reuse as a High-Value Circular Strategy

Unlike conventional renovation, adaptive reuse establishes a new relationship between an existing structure and contemporary programme requirements, potentially involving changes to spatial organisation, services, environmental performance and structural components. Its principal circular value lies in extending building life rather than replacing existing structures. Retaining building fabric reduces demand for new materials, demolition waste and loss of embodied resources [2,10]. It can also preserve architectural, social, cultural and urban values while accommodating contemporary uses [3,13].

However, adaptive reuse is not inherently economically advantageous. The condition and configuration of existing buildings, alongside structural, functional and regulatory requirements, can strongly influence feasibility [3,9]. Decision-making therefore requires consideration of physical, functional, economic and regulatory criteria rather than a single performance measure, consistent with research on adaptive reuse and sustainable development [5,9].

Repurposing further distinguishes adaptive reuse from other circular transformations. This distinction is central to the present study, which compares an existing commercial unit with shipping containers accommodating the same architectural programme. The feasibility of adaptive reuse remains context-dependent, with structural, spatial, environmental and planning constraints potentially limiting new uses [3,9].

2.3. Shipping Container Repurposing as Material Circularity

Shipping container repurposing extends the life of industrial artefacts by transforming decommissioned freight containers into architectural spaces. Its potential contribution to recycling, sustainability and green architecture has been examined in previous research [7], alongside more recent studies of the carbon implications of container-based construction [8].

Containers offer standardised dimensions, structural characteristics, modularity and transportability, allowing units to be combined for different applications. Their reuse has been explored for temporary accommodation, housing, commercial uses and other forms of construction [7,14].

However, containers were designed for freight transportation rather than human occupation. Their conversion therefore requires interventions addressing structural, environmental and functional requirements. New openings may require strengthening, while the steel envelope requires appropriate insulation and treatment for thermal performance, condensation and occupant comfort. These interventions can significantly affect environmental and economic performance [7,8]. Although reuse can avoid disposal and reduce demand for some new

materials, conversion introduces additional materials, energy and construction processes, requiring a lifecycle perspective.

Container architecture may also provide a distinctive identity through its industrial character, particularly in commercial applications. Its suitability nevertheless depends on its relationship with the surrounding context and applicable planning and building regulations. Thus, shipping-container repurposing should not be considered inherently low-cost or low-carbon; its performance depends on the existing container, required interventions, intended programme and environmental and contextual conditions.

3. METHODOLOGY

This study adopts a comparative case study methodology supported by Multi-Criteria Decision Analysis (MCDA) to examine how adaptive reuse and container repurposing perform across economic, environmental, regulatory, construction and architectural dimensions. MCDA was selected because circular construction decisions involve multiple and competing criteria that cannot be adequately assessed through a single indicator. Comparative evaluation matrices therefore provide a structured means of identifying the relative strengths and limitations of each strategy.

The research combines quantitative and qualitative data. Quantitative data include construction costs, cost per square metre, project duration and intervention requirements, while qualitative data derive from the literature review, site observations and semi-structured interviews with the owners of the two establishments. This mixed-method approach captures both measurable performance and less quantifiable factors, including architectural identity, user perception, urban integration and implementation challenges. The final methodological stage involves evaluating both case studies against criteria derived from the literature, project analysis and observed challenges. The resulting MCDA matrix provides a structured comparison of the advantages and limitations of each strategy and supports the subsequent analysis of circular construction decision-making.

Table 1. Evaluation Criteria

Criterion	Description	Source
Economic performance	Construction Cost and Cost Efficiency	Case Study Data & Analysis
Construction Duration	Time Required until operation	Owner Interviews
Regulatory Complexity	Permit requirements and Challenges	Legislation Review
Environmental performance	Retention of Embodied Resources	Literature
Design Flexibility	Ability for Spatial Transformation	Case Study Data & Analysis
Urban Integration	Compatibility with Context	Site Observation, Legislation Review
Architectural Identity	Contribution to Place Character	Qualitative Assessment

4. COMPARATIVE CASE STUDIES

4.1. Case Study Selection and Context

The empirical investigation examines two café developments in the Nicosia district of Cyprus representing distinct circular construction approaches: adaptive reuse of an existing commercial unit and repurposing of shipping containers into a new café. The cases were selected to isolate the influence of construction strategy from differences in function, climate and geography. Both accommodate the same public use, operate within the same climatic context and have comparable spatial requirements, while differing in initial conditions, construction processes and relationship with their surroundings.

4.2. Case Study A: Adaptive Reuse of an Existing Commercial Unit into a Café

4.2.1 Project Overview and Context

The first case study is an existing ground-floor retail unit near Nicosia city centre, within a relatively dense area characterised by mixed urban activities and moderate pedestrian and vehicular movement. The project retained the existing building shell and adapted its spatial configuration for café use, representing adaptive reuse through functional, technical and aesthetic modifications.





Figure 1. Case study A: The unit is located near Nicosia, City Centre, Source ©Google Maps,
Figure 2. The Adaptively Reused Unit, Source © DP+Architectural Office (design), Deplot(render)

4.2.2 Transformation Process

The intervention focused on upgrading the unit to meet contemporary café requirements. Works included electrical and mechanical upgrades, new plumbing, modifications to openings and external interfaces, interior finishes, café equipment and service infrastructure, and an external seating area. The existing structural framework was retained, while building services and functionality were substantially upgraded. The refurbishment period was approximately eight months.

4.2.3 Economic Analysis

The cost breakdown of the adaptive reuse intervention, as calculated by the Quantity Surveyor (DP+ Architectural Office), is presented below.

Table 2. Case Study A: Cost Breakdown

Works	Design, Consultancy & Permits	Masonry & Plastering	Electrical Works	Mechanical Works	Plumbing	Networking	Flooring
Cost (€)	4 000,00	8 500,00	7 000,00	6 000,00	2 500,00	1 500,00	6 000,00
Works	Aluminum Openings	Carpentry	Painting	Equipment	Landscaping	TOTAL	Cost per m^2
Cost (€)	14 000,00	9 500,00	4 000,00	25 000,00	5 000,00	93 000,00	808,70

4.2.4 Regulatory Considerations

The project required compliance with planning, building and operational regulations for café developments, including consultation with the Deputy Ministry of Tourism, Public Health Services and Fire Prevention Department.

Compared with introducing a new independent structure, approval was facilitated by the existing building and its established relationship with the planning framework, making the process relatively straightforward where proposed alterations complied with applicable regulations.

4.2.5 Environmental Considerations

The principal environmental benefit derives from retaining the existing building structure, avoiding demolition and substantial new structural construction. This reduced demand for new materials and preserved embodied energy, while the limited concrete and steel interventions reduced construction-related emissions compared with new-build alternatives.

4.3. Case Study B: Shipping Container Repurposing into a Café

4.3.1 Project Overview and Context

The second case study is located on the outskirts of Nicosia, near a major transport corridor connecting Nicosia with Larnaca and Limassol. The lower-density surroundings comprise mainly residential units and undeveloped land, with limited public uses. The project converts three shipping containers into a café, introducing a new architectural object rather than adapting an existing building.





Figure 3. Case study B: The unit is located in the outskirts of Nicosia, Source ©Google Maps,

Figure 4. The Repurposed Containers, Source © Andreas Trisveis Architecture

4.3.2 Transformation Process

The conversion required substantial interventions, including structural reinforcement for new openings, mechanical, electrical and plumbing systems, thermal and environmental improvements, interior finishes, café equipment, landscaping and external seating. Although container modularity offers spatial flexibility and potential for rapid assembly, extensive intervention was required to achieve the desired comfort, functionality and architectural quality. The total construction period was approximately eighteen months.

4.3.3 Economic Analysis

The cost breakdown, as calculated by the Quantity Surveyor (DP+ Architectural Office), is presented below.

Table 3. Case Study B: Cost Breakdown

Works	Design, Consultancy & Permits	Container Purchase	Structural Modificat.	Electrical Works	Mechanical Works	Plumbing	Networking
Cost (€)	10 000,00	12 000,00	10 000,00	10 000,00	9 000,00	5 000,00	1 500,00
Works	Flooring and Finishes	Aluminum Openings	Carpentry	Equipment	Landscaping	TOTAL	Cost per m²
Cost (€)	20 000,00	17 000,00	9 000,00	25 000,00	10 000,00	138 000,00	1 631,33

4.3.4 Regulatory Considerations

The approval process was more complex than for the adaptive reuse case. The introduction of an unconventional building form required additional consideration of spatial dimensions, material performance, fire safety and building regulations. Consultation with tourism, public health and fire prevention authorities was required in both cases; however, the container project involved additional scrutiny concerning fire safety, structural modifications and compliance with building standards.

4.3.5 Environmental Considerations

The environmental rationale of container repurposing lies in extending the useful life of existing steel structures that might otherwise require recycling or disposal. Their modular characteristics also allow adaptation and integration of renewable technologies such as photovoltaic systems. However, these benefits must be considered alongside the additional materials, energy and interventions required to transform containers into comfortable and compliant architectural spaces.

5. MULTI-CRITERIA DECISION ANALYSIS & COMPARATIVE ANALYSIS

The evaluation criteria were derived from the literature review, case-study observations and practical considerations encountered during construction. They reflect key factors influencing architectural decisions between alternative circular strategies. The resulting MCDA matrix, derived from the two case studies, is presented below.

Table 4. Evaluation Criteria- MCDA Matrix

Criterion	Adaptively Reused Unit	Container Repurposing
Economic performance	●●●●●	●●●●○
Construction Duration	●●●●●	●●●○○
Regulatory Complexity	●●●○○	●●●●○
Environmental performance	●●●●●	●●●●●
Design Flexibility	●●●○○	●●●●●
Urban Integration	●●●●●	●●●●○
Architectural Freedom	●●●○○	●●●●○
Future Expansion-Potential	●●●○○	●●●●●

The comparison demonstrates that adaptive reuse and container repurposing represent distinct pathways towards circular construction. While both extend the useful life of existing resources, they preserve different forms of value. Adaptive reuse prioritises existing spatial and contextual value, whereas container repurposing creates new architectural value through the reuse of industrial artefacts and their distinctive identity.

Economically, adaptive reuse required approximately €93,000 (€808.70/m²), compared with €138,500 (€1,631.33/m²) for the container café. Although both remain below the estimated €2,000/m² cost of new construction in Cyprus, the container project was more expensive due to structural modifications, services, thermal improvements, finishes and regulatory requirements. This indicates that container repurposing may be economical compared with new construction, but its performance depends on the extent of transformation. Construction duration similarly favoured adaptive reuse, at approximately eight months compared with eighteen months for the container project, demonstrating that modular construction does not necessarily ensure faster delivery when extensive modifications and external works are required.

The strategies also differ in flexibility and contextual integration. Container repurposing provided greater freedom to combine units and create new spatial arrangements, although their narrow dimensions imposed functional constraints. Adaptive reuse was more restricted by the existing configuration but achieved stronger integration with the surrounding urban fabric. The peripheral location of the container café nevertheless supported its distinctive architectural expression.

Both strategies contribute to resource conservation by extending the life of existing buildings or materials. However, reuse must be assessed alongside the resources required for transformation, including additional materials, energy and construction processes. Overall, adaptive reuse performed better in cost, implementation time and urban integration, while container repurposing offered greater architectural freedom, design flexibility and future expansion potential. Neither strategy therefore consistently outperforms the other, reinforcing the need for multi-criteria and context-sensitive evaluation.

6. DISCUSSION

The findings demonstrate that circular construction strategies should be understood as context-dependent design decisions rather than inherently superior solutions. Both approaches extend the useful life of existing resources, but their performance depends on the relationship between the available resource, required interventions and intended architectural outcome.

A key finding is that circularity does not automatically ensure economic efficiency. The container case demonstrates how structural modifications, environmental improvements, services and finishes can increase costs, while adaptive reuse remains subject to existing spatial, structural and regulatory constraints. The comparison therefore highlights a trade-off between retaining existing building fabric and introducing greater modular and architectural flexibility.

Context also influences the suitability of each strategy. Adaptive reuse benefits from continuity with the existing urban fabric, whereas container repurposing can establish a distinctive identity through reused industrial elements, particularly where contextual constraints are less restrictive. The MCDA framework makes these trade-offs explicit and supports more informed decisions rather than identifying a universally superior approach.

7. CONCLUSIONS

This study compared adaptive reuse and shipping-container repurposing as alternative circular strategies for achieving the same architectural programme. The findings show that they are complementary approaches that preserve different forms of value: adaptive reuse demonstrated advantages in cost, implementation time and urban integration, while container repurposing provided greater design flexibility, architectural distinctiveness and modular potential.

The study also investigates the assumption that reuse is inherently economical or efficient, as transformation requirements can substantially affect project feasibility. MCDA demonstrates that circular construction involves trade-offs between economic, environmental, regulatory, spatial and architectural objectives. Consequently, strategy selection should remain context-sensitive, aligning available resources, project requirements and site conditions. Circular architecture is therefore defined not by a specific construction method, but by recognising existing value and transforming it into meaningful and resilient future use.

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