What matters when? - A comprehensive literature review on decision criteria in different stages of the adaptive reuse process

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Abstract

The decision-making process in adaptive reuse projects is often complex, involving multiple and conflicting criteria, and diverse stakeholders. The aim of this paper is to provide a state-of-the-art overview of the decision criteria throughout the adaptive reuse process. An integrative literature review with a systematic search strategy is used as a research methodology to find and structure relevant decision criteria. Three phases in which decision criteria can be used in the adaptive reuse process are substantiated(pre-project phase, preparation phase, and post-completion phase). For each phase, a lists of decision criteria is established across different categories. While this review shows similarities between the different phases, with a predominant repetition of economic and architectural categories, more specific environmental decision criteria, especially in the implementation phase, are still overlooked. This findings highlight the need for more research on circularity in the AR process, with particular attention on evaluation methods and on the implementation phase. This phase is poorly understood, yet crucial for circular practices such as disassembly. This study contributes to the growing literature on adaptive reuse by offering a more holistic outlook on the multi-criteria decision making process.

Keywords

Adaptive reuse, process, decision criteria, decision making, literature review, built environment

1. Introduction

The average lifetime of a building is only 34 years, with the most common reason for building demolition being functional obsolescence **(Liu et al., 2014)**. At the same time buildings worldwide account for 40 percent of the world's waste, 40 percent of material resource use and 33 percent of all human induced emissions **(Layke et al., 2016)**. To cope with these environmental impacts and to extend the functional lifetime of buildings, adaptive reuse has become a well-established strategy **(Langston et al., 2008)**. Adaptive reuse is defined as *"the process of extending the useful life of historic, old, obsolete, and derelict buildings, by seeking to maximize the reuse and retention of existing structures and fabrics*" **(Shahi et al., 2020)**. The term adaptive reuse emerged in the 21st century, and has its roots in the combination of 'ad' (to) and 'aptare' (fit) which can be translated to: "the process of fitting" **(Douglas, 2006)**. The classic definition focusses on the change in use; a process of converting building for a new use, different from the initial aim of its construction **(Douglas, 2006)**. Adaptive reuse therefore differs from other building adaptation practices like refurbishment, renovation and restoration where the focus lies on extending the functional lifetime of the building for the same use **(Shahi et al., 2020)**.

The adaptive reuse of buildings has many social, environmental and economic benefits. By adaptively reusing a building embodied energy is preserved **(Kumari et al., 2020)**, and the further use of operational energy is reduced **(Langston et al., 2008)**. Preventing demolition through the reuse of buildings furthermore results in environmental advantages including: reducing construction waste, consuming fewer natural resources and raw materials **(Conejos et al., 2013)**, emitting less greenhouse gases **(Yung & Chan, 2012)**, and controlling urban sprawl **(Sanchez et al., 2019)**. Other social advantages of adaptive reuse include improved safety, quality of living, occupant health, and helping restore and maintaining the identity of a building **(Shen & Langston, 2010, Aigwi et al., 2018)**. When it comes to economic advantages, adaptive reuse can lead to the increase of property value of the building and other surrounding buildings **(Sanchez et al., 2019)**, and the generation of jobs on the site and in its vicinity. **(Chan et al., 2015)**.

The decision-making process in adaptive reuse projects is often complex, involving multiple and conflicting criteria, such as economic feasibility, environmental sustainability, cultural significance, technical feasibility **(Wilkinson et al., 2014)** and the inclusion of many stakeholders **(Bullen, 2011, Douglas, 2006, Wilkinson et al., 2009)**. Multi-criteria decision making (MCDM) models have become increasingly popular in recent years for the evaluation of adaptive reuse projects **(Nadkarni & Puthuvayi, 2020)**, as they provide a structured approach to assess and compare alternative solutions, taking into account these multiple criteria **(Mardani et al., 2015)**. These models can help decision-makers to make informed decisions, by considering all relevant factors, and by integrating various forms of data and expert knowledge. There is, however, no clear consensus on the decision criteria and the decision support tool when it comes to adaptive reuse **(Mısırlısoy & Günçe, 2016b, Arfa, et al., 2022, Unver et al., 2022).**

A wide range of different MCDM methods are used in the adaptive reuse literature **(Nadkarni & Puthuvayi, 2020)**. The method, stakeholders, and criteria used in the multi-criteria decision making process for adaptive reuse are dependent on the aim and context of the application **(Li et al., 2021)**. When determining an alternative new use for a building, different decision criteria and stakeholders are involved, compared to when AR (adaptive reuse) projects are evaluated post-completion **(Nadkarni & Puthuvayi, 2020, Arfa, et al., 2022).** Although the post-completion phase in adaptive reuse is more evaluative of nature, compared to the more ex-ante decision making in pre-completion phases, it should be emphasised that ‘evaluation’ may bring up the need for further intervention of the building and consequently new decisions **(Vandesande, 2018)**. The type of decisions and the decision criteria per phase in the adaptive reuse process can therefore differ, which is understudied in the adaptive reuse literature. Many publications on decision making in adaptive reuse have focussed on specific areas of application within the AR process, but few have considered the process as a whole **(Arfa, et al., 2022)**.The lack of consensus on the decision criteria used for adaptive reuse **(Mısırlısoy & Günçe, 2016b)**, and the need to holistically approach the AR process as a whole **(Arfa, et al., 2022)**, based on the different phases of the AR process, provides the knowledge gap for this paper. The aim of this paper is to provide a state-of-the-art overview of the decision criteria for adaptive reuse throughout the adaptive reuse process and to identify potential areas for future research. The following research question is answered: *What are the criteria in decision making for the adaptive reuse of buildings during the different phases of the AR process?*

The findings of this paper contribute to the growing literature on multi criteria decision making for adaptive reuse by synthesizing the decision criteria according to the different phases of the AR process. Through this literature review, a state-of-the-art overview is provided on the decision criteria for adaptive reuse throughout the AR process, that can help stakeholders of adaptive reuse projects in structuring their decision making process.

2. Research Methodology

In this study an integrative literature review was used as a research methodology to find relevant decision criteria for the different phases in the adaptive reuse process. An integrative literature review is a useful methodology for synthesising a conceptual model for an emerging concept like adaptive reuse **(Torraco, 2005)**. In setting up the integrative literature review the guidelines by *Torraco et. al.* were followed **(Torraco, 2005),** in which a nine question checklist is presented for writing an integrative literature review. To find the appropriate literature the systematic search approach from **(Bramer et al., 2018)** was followed, and for identifying, selecting and reporting sources the PRISMA-P method by *Moher et. al.* was used **(Moher et al., 2015)**. In what follows the search strategy, screening process, and integrative analysis is summarized.

2.1 Search strategy

The reviewed literature in this paper includes: peer-reviewed journal papers, conference papers, book chapters, and grey literature. The systematic search strategy by *Bramer et. al.* was used to find appropriate search terms that match the key concepts surrounding adaptive reuse. This 15 step approach is an iterative process in which search results are evaluated and optimized accordingly **(Bramer et al., 2018).** This resulted in the following search terms (see Figure 1). A Boolean operator was then used to combine the criteria related terms, to the adaptive reuse related terms. To retrieve sources that are relevant to the research context (buildings), three linking terms were added (Building, Real estate, Property). Two databases were selected for the systematic search: *Web of Science* and *Scopus*. To identify missed articles the snowballing method was used **(Jalali & Wohlin, 2012).**

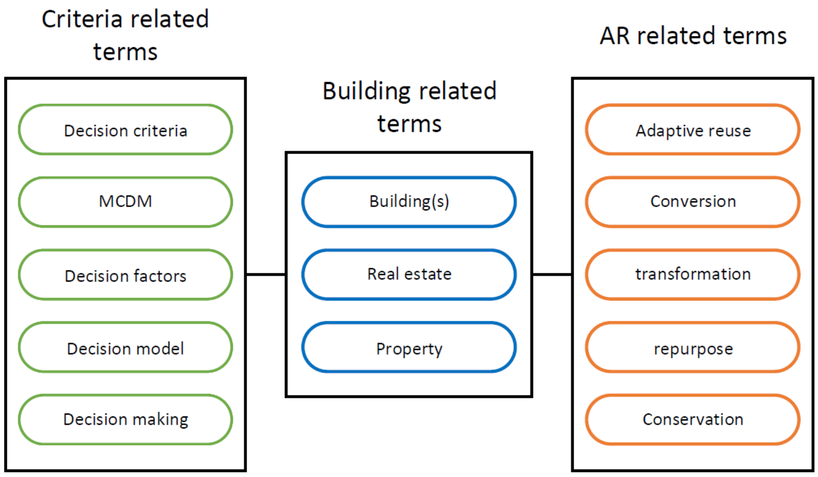


Figure 2: Used search terms

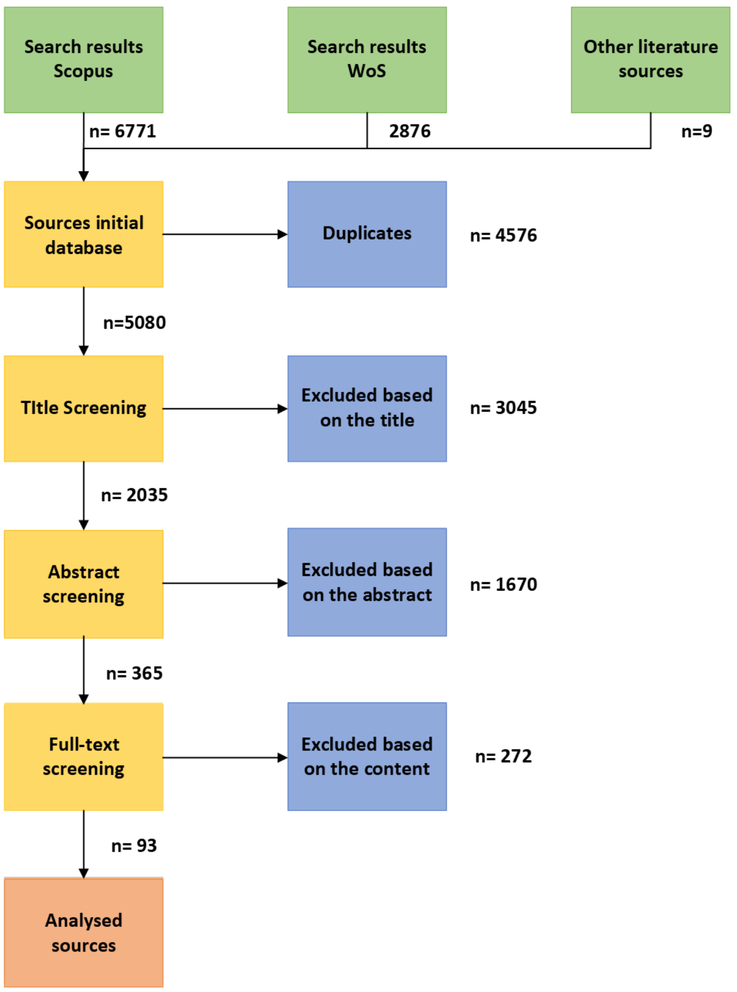


Figure 1: Screening process

2.2 Screening process

The multiple searches in the two different database resulted in an initial database containing 9656 publications. The snowballing method resulted in an additional 9 Sources. Through an extensive screening process the total number of publications was brought back to 93. The screening of papers was done in accordance with the PRISMA-P method and comprised of 4 different phases **(Moher et al., 2015)**. In the first phase duplicates sources were removed, in the second phase sources were excluded based on the screening of titles, in the third phase sources were excluded based on abstract screening, and finally sources were excluded based on a full-text screening. To include articles in the screening process the following definitions are used for 'adaptive reuse'**(Douglas, 2006)** and 'decision criteria': *"Adaptive reuse is known as the process of converting the function of an existing building into another, which is substantially different from that function, in which the building was originally designed for"* **(Douglas, 2006)**. Publications in which substantially different definitions were used were excluded, including articles that focus merely on the lifetime extension of the building without changing the function. The "decision criteria" were selected based on a broad definition of the term and can differ based on the phase in the adaptive reuse process. In the post-completion phase the function of the criteria is more evaluative of nature, whereas in the pre-project and preparation phase the criteria are used to make an ex-ante decision. Although this literature review is focussed on the decision criteria for adaptive reuse, the following 'broader' definition of "criteria" was used in the screening process to not exclude important literature: *"a principle or standard by which something may be judged or decided"* **(Oxford University Press, 2023)**. Since the aim was to identify decision criteria for adaptive reuse on a building level, publications that look at adaptive reuse on district/ neighbourhood or material/component level were excluded. Publications that only look at specific technical, financial, political, legal, or administrative criteria have also been disregarded.

2.3 Integrative analysis

A comparative analysis was conducted to find relationships and contrasts between decision criteria for adaptive reuse throughout the adaptive reuse process. *Arfa et. al.* proposed a model of practice consisting of 10 different steps in the AR process, that align with the different areas of application of MCDM models for adaptive reuse. These 10 steps are divided into four distinct phases of the AR Process: Pre-project phase, Preparation phase, Implementation phase and Post-completion phase **(Arfa, et al., 2022)**. Based on this analysis multiple lists of decision criteria for adaptive reuse were constructed, for the main phases of the AR process. Although the implementation phase is considered an important aspect in the adaptive reuse process **(Vervloed, 2013),** it is excluded in the analysis part of the literature review because none of the included papers corresponded to this phase. A plausible explanation could be that the implementation phase is characterized by the implementation of the agreed on design strategies **(Arfa, et al., 2022)**, and important decisions are therefore already made in the previous phases.

In line with the guidelines of *Torraco*, matrixes were used to structurally identify and conceptualize the decision criteria **(Torraco, 2005)**. The included literature was sorted based on their application in the adaptive reuse process. A reflexive thematic analysis through a semantic approach was used to conceptually cluster the criteria into main categories using *Miro* **(Braun & Clarke, 2012)**. Structuring criteria in a hierarchical form enhances the manageability of the data and is common in the urban regeneration literature **(Cinelli et al.,**

2020) . For the hierarchical decomposition the PESTLE framework was taken as starting point, and amended where necessary, which follows the approach of *Ikiz Kaya et al.* **(Ikiz Kaya, et al., 2021).**

3. Results

The publications that are reviewed are organised according to the AR process model by *Arfa* **(Arfa, et al., 2022)**. Figure 3 shows the analysed publications distributed over the three phases. Most publications are related to the Pre-Project phase (42) and less are concerned with the evaluation phase (15). In the following section the most important publications on decision criteria for adaptive reuse per phase in the AR process are explained, followed by an integrative list of decision criteria for this phase. Based on a thematic categorization of the criteria, objectives were formulated (following the MAVT approach **(Keeney & Raiffa, 1993)**), and per objective a set of sub-criteria was formed (Table 1-3).

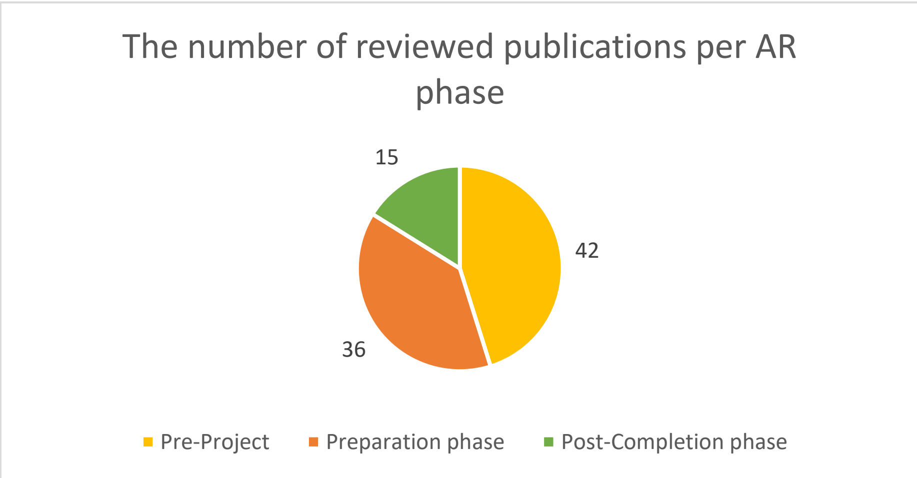


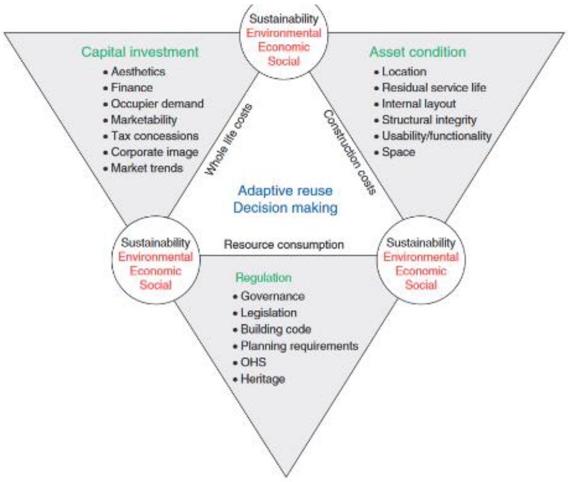
Figure 3: The number of reviewed literature in each phase of the adaptive reuse process.

3.1 Pre-Project Phase

In the Pre-Project phase the decision focusses on preserving reusing or demolishing a building **(Wilkinson et al., 2014)**. The decision to adaptively reuse the buildings has not yet been made and the phase is characterized by defining the scope of the project, as well as mapping the potential for adaptation and adaptive reuse **(Arfa, et al., 2022)**. The publications in this phase can broadly be categorized into 2 aims: criteria formulation and measuring the adaptability/ adaptive reuse potential. When deciding on preserving, reusing or demolishing the building, decision criteria are important in guiding the decision making process. In defining these decision criteria during the pre-project phase multiple methods were used.

Bullen and *Love* conducted 81 in depth interviews with adaptive reuse stakeholders to come up with a model for adaptive reuse decision making that is both grounded in practice and theory (P. Bullen & Love, 2011). This model revealed three key areas in the adaptive reuse decision making process: capital investment, asset condition, and regulation. Additionally, environmental, economic and social aspects of sustainability were also identified as being important, but were given less priority in the decision making process.

Figure 4: A model for adaptive reuse decision making by Bullen & Love (2011).



Remøy & Van der Voort used a mixed method approach to come up with risk and opportunities to support the decision making process in adaptive reuse **(Remøy & van der Voordt, 2014)**. They revealed that it is possible to generalise the opportunities and risks of conversion into critical success- and failure factors that can serve as decision criteria for the initial phase of conversion projects. Their findings show 5 important main criteria in relation to the adaptive reuse of office buildings: legal, financial, technical, functional and architectonic.

Earlier work by *Wilkinson* also focused on the adaptation potential of office buildings, in which the Preliminary Adaptation Assessment Model is introduced **(Wilkinson, 2014)**. In this extensive literature review, a list of property attributes were identified that influenced building adaptation. The property attributes were organised in 6 main categories (Economic, Physical, Location and Land Use, Legal, Social, Environmental) and combined with the six levels of adaptation, to create a holistic preliminary assessment framework for adaptation (Figure..) . Because the simple PAAM models lacks weighting of the stages and quantitative validation, a Principal Component Analysis (PCA) was performed, that condensed the number of important factors into a smaller number of all-encompassing attributes. It was revealed that ten property values accounted for seventy-percent of the original variance and therefore form the basis for the improved PAAM model. These ten property values are: building quality grade, NABERS rating (sustainbility rating), aesthetics, height, historic listing, construction type, parking, street frontage, vertical service location, and Green Star rating (sustainability rating) **(Wilkinson et al., 2014)**.

Mısırlısoy & Günce provided a comprehensive review of the factors affecting adaptive reuse decision-making to create a model that supports stakeholders in proposing adaptive reuse strategies **(Mısırlısoy & Günçe, 2016b)**. Through a literature survey and content analysis they identified a 5-step approach that is rooted in literature and validated by 16 case studies. They identified 5 important factors affecting adaptive reuse decision: actors, original function, physical character, heritage values, needs of the district, conservation actions, adaptive reuse potentials and functional changes.

The reviewed publications in the pre-project phase not only focus on defining decision criteria for adaptive reuse, but also look into ways of measuring the potential for adaptive reuse and building adaptation. When deciding on reusing, demolishing or preserving a building, the potential for adaptive reuse and a framework for measuring this potential can help decision makers in their decision making process (**Langston et al., 2008a)**. Adaptive reuse potential (ARP) describes the propensity of an asset to be recycled to perform a significantly different function while keeping the basic attributes of the asset in place **(Langston, 2014a).**

Langston came up with a model that measures the adaptive reuse potential based on the estimation of physical, economic, functional, technological, social, legal and political obsolescence **(Langston et al., 2008a)**. In order to evaluate the embedded physical life of a building the present age and projected physical life are needed to determine the 7 obsolescence factors. In the model obsolescence acts as a discount factor to discount the expected physical life of the building to arrive at the useful life of the building. A correlation was found between the expected useful life derived from the ARP Model , and the actual useful life derived from completed adaptive reuse projects **(Langston, 2014a).** The ARP framework with the seven obsolescence factors was found in several review publications in the pre-project phase.

Another model for adaptive reuse potential was proposed by *Geraedts & Van der Voordt* in the Transformation Meter **(Geraedts & Van der Voordt, 2007)**. This tool acts as a QuickScan to judge office buildings on their potential for transformation into housing. Assessing the transformation potential follows five steps*: (i) quick scan; (ii) market feasibility and location characteristics scan; (iii) transformation class determination scan; (iv) financial feasibility scan; and (v) risk assessment scan*. The criteria in the *Transformation Meter* consist of physical aspects of the building, location aspects, organisational aspects and market aspects. Some of these criteria are so called 'veto' criteria meaning that if they negatively impact transformation potential , then adaptive reuse is not feasible.

Following the thematic analysis of the semi-systematic review, 65 sub-criteria were identified in the pre-project phase. The PESTLE Framework was used as a starting point for structuring the criteria, but was amended to be appropriate for the pre-project phase. The categories Political and Legal, and Social and Cultural, were combined and the categories Architectural / Physical and Functional was added to arrive at PESTEAF. This resulted in the following list of decision criteria (Figure 4).

Figure 5: The decision criteria for adaptive reuse in the pre-project phase

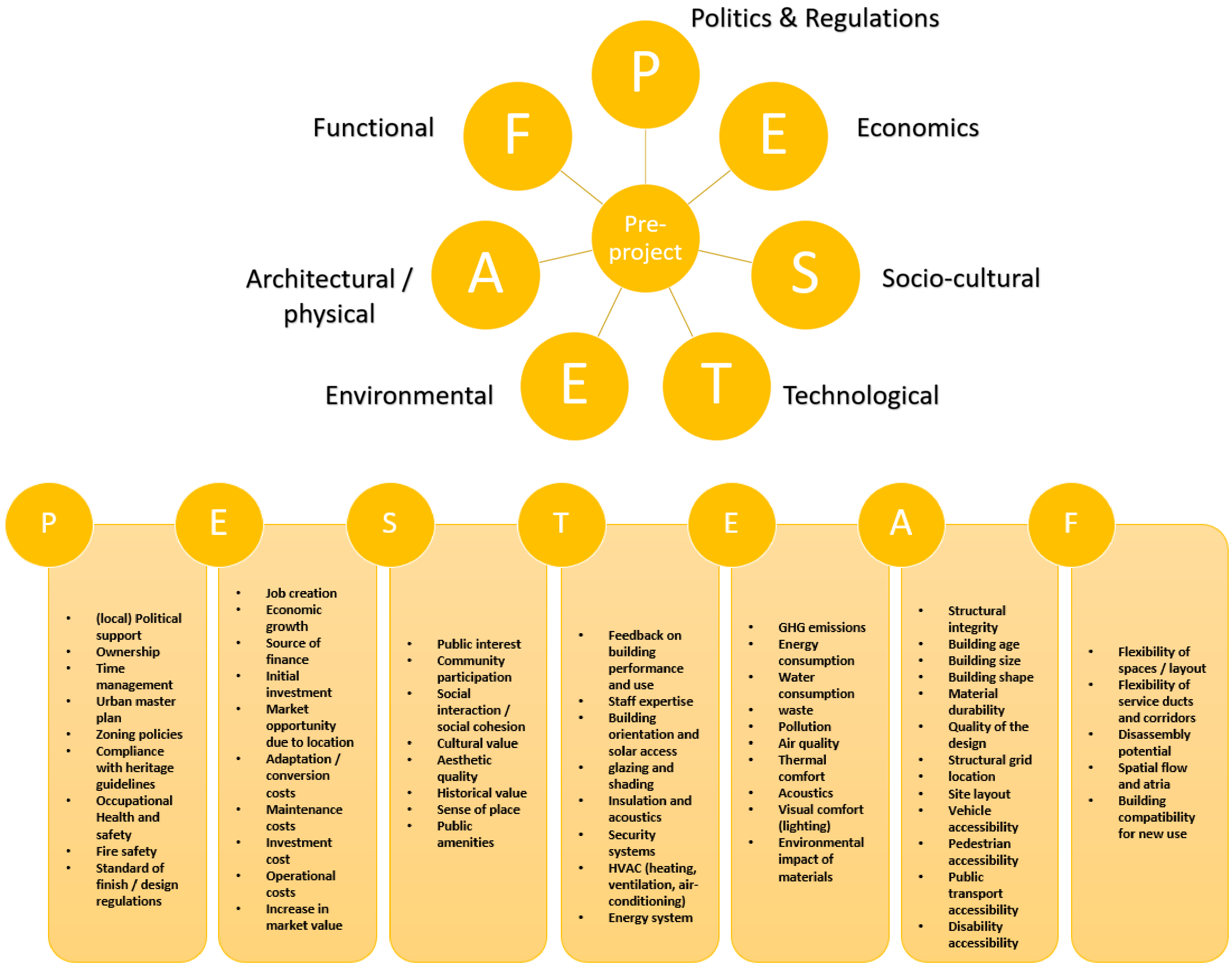


Table 1: The decision criteria for adaptive reuse in the pre-project phase

Main-Criteria	Objectives	Sub-Criteria	##	(Yang et al., 2022)	(Bansal & Chhabra, 2022)	(Ragheb & Naguib, 2021)	(Ikiz Kaya, et al., 2021)	(Mohamed & Alauddin, 2021)	(Mehr & Wilkinson, 2021)	(Milošević et al., 2020)	(Aigwi et al., 2020)	(Sharifi & Farahinia, 2020)	(Djebbour & Biara, 2020)	(Misirlisoy, 2021)	(Abdullah et al., 2020)	(Vizzarri & Fatiguso, 2019)	(Vardopoulos, 2019)	(Yoon & Lee, 2019)	(De et al., 2019)	(Kavinda & Jayalath, 2019)	(Samaranayake et al., 2019)	(Chen et al., 2018)	(Parpas & Savvides, 2018)	(Hong & Chen, 2017)	(Misirlisoy & Günçe, 2016b)	(Mohamed & Alauddin, 2016)	(Sfakianaki & Moutsatsou, 2015)	(Remøy & van der Voordt, 2014)	(Langston, 2014a)	(Langston, 2014b)	(Liu et al., 2014)	(Conejos, 2013)	(Bullen & Love, 2011)	(Bullen & Love, 2010)	(Langston et al., 2008b)	(Bullen, 2007)	(Langston & Shen, 2007a)	(Hanafi et al., 2018)	(Hsueh et al., 2013)	(Teo & Lin, 2012)	(Wilkinson, 2014)	(Baker, 2020)	(Gravagnuolo et al., 2017)	(Geraedts & Van der Voordt, 2007)
Politics and Regulations	To increase political support	(local) political support	15	x	x		x		x			x	x			x		x										x		x				x	x		x	x					x	
	To successfully manage the adaptive reuse process	Ownership	16			x	x	x	x				x						x						x	x			x			x	x	x				x			x		x	x
		Time management	6						x		x		x			x																						x		x				
	To comply with urban master plans and zoning regulations	Urban master plan	17	x		x		x	x		X				x	x			x		x				x	x		x	x			x	x					x					x	
		Zoning policies	19	x	x			x	x		X				x	x			x		x				X	x		x	x			x	x	x				x		x	x			
	To comply with heritage regulations	Compliance with heritage guidelines	19	x	x			x	x		X				x	x			x	x	x				x	x		x	x			x	x	x				x			x			
	To comply with the local building codes and regulations	Occupational Health and safety	14	x				x			X					x		x	x	x	x				x				x			x	x					x			x			
		Fire safety		x							X					x		x	x	x	x				x				x			x	x					x		x	x	x		
		Standard of finish / design regulations	19	x				x	x		X				x	x			x	x	x				x	x		x	x			x	x	x				x		x	x			
Economic	To have a positive impact on the local economy	Job creation	7			x	x				x						x	x													x												x	
		Economic growth	15			x	x						x	x			x	x				x	x					x			x			x		x			x			x	x	
	To minimize financial risk	Source of finance	15			x	x	x	x				x		x		x		x			x				x							x	x				x		x		x		
		Initial investment	9				x		x										x			x				x		x										x			x	x		
	To increase market potential	Market opportunity due to location	32	x	x	x	x	x	x		x	x	x	x	x		x	x	x	x	x		x		x	x		x	x	x	x	x	x	x	x		x	x		x		x		x

	To reduce costs	Adaptation / conversion costs	14			x	x	x	x		x					x				x			x				x	x											x	x	x	x		
		Maintenance costs	12			x								x		x			x	x			x		x	x	x							x						x		x		
		Investment cost	9			x			x							x				x			x				x	x														x		x
		Operational costs	7			x	x									x			x				x				x															x		
	To increase economic returns	Increase in market value	18					x					x	x	x		x				x	x		x	x	x	x	x						x						x	x	x	x	x
Socio- Cultural	To increase public interest and community participation	Public interest	14	x	x		x				x			x	x		x	x	x			x			x	x														x			x	
		Community participation	17	x	x	x	x	x					x		x	x	x	x				x							x						x	x	x		x				x	
	To increase social impact	Social interaction / social cohesion	17			x			x		x	x	x	x	x		x	x	x		x			x	x	x				x	x												x	
		Cultural value	18			x	x	x					x	x							x	x		x	x	x	x					x		x		x		x	x		x		x	
	To preserve the historical image of the building	Aesthetic quality	22	x		x			x		x			x			x	x		x	x	x		x	x		x	x	x			x		x		x		x		x	x		x	
		Historical value	18	x		x					x			x			x	x		x	X	x			x		x	x	x			x				x		x			x		x	
	To retain a sense of place / identity	Sense of place	15			x		x			x		x	x	x		x	x		x	x	x			x	x															x		x	
	To improve public amenities	Public amenities	17				x				x		x		x		x	x			x	x		x	x				x			x						x	x		x		x	x
Technological	To increase knowledge and expertise	Feedback on building performance and use	4	x									x																x			x												
		Staff expertise	14		x	x			x			x	x	x					x										x	x		x			x		x	x					x	
	To improve building services	Building orientation and solar access	10	x							x					x				x					x				x			x				x		x						x
		glazing and shading	6	x												x				x									x			x						x						
		Insulation and acoustics	8	x												x				x									x			x						x		x				x
		Security systems	8			x			x						x	x										x												x		x		x		
		HVAC	13			x			x						x	x										x	x	x	x			x						x		x		x		x

		Energy system	10	x		x			x						x	x										x												x		x		x		x
Environmental	To reduce the environmental impact	GHG emissions	12			x	x	x							x		x					x				x			x					x		x		x					x	
		Energy consumption	14	x		x	x								x		x			x		x				x			x			x		x		x		x		x				
		Water consumption	10					x							x		x			x		x				x								x		x		x		x				
	To reduce waste and pollution	waste	7				x										x			x														x				x		x			x	
		Pollution	13					x								x	x			x		x				x								x				x		x	x	x	x	x
	To safeguard the indoor environmental quality	Air quality	8	x							x					x				x																		x		x	x			x
		Thermal comfort	7	x												x				x								x										x		x				x
		Acoustics	8	x												x				x								x										x		x		x		x
		Visual comfort (lighting)	11	x							x					x				x							x	x	x			x						x		x				x
	To reduce material consumption	Environmental impact of materials	14	x		x	x		x						x		x							x			x		x					x		x		x	x				x	
Architectural / Physical	To safeguard the structural integrity of the building	Structural integrity	23	x		x		x		x		x			x	x		x	x	x	x					x		x	x	x	x	x	x		x		x	x			x	x		
	The physical character of the building allows for adaptive reuse	Building age	18				x			x		x			x	x		x	x		x		x				x	x		x	x		x							x	x	x		x
		Building size	22				x			x		x			x	x		x	x	x	x					x		x	x	x	x		x		x		x	x		x	x	x		x
		Building shape	21			x				x			x		x	x		x	x		x					x		x	x	x	x		x		x		x	x		x	x	x		x
	To improve the durability of the materials	Material durability	14	x							x				x	x			x	x			x				x		x			x						x			x	x		x
	To preserve the aesthetic quality of the building	Quality of the design	12	x		x			x	x				x	x					x				x										x				x			x		x	
	The location and site of the building allow for adaptive reuse	Structural grid	10	x											x	x					x			x				x	x		x	x						x						
		location	28	x		x	x	x	x	x		x		x	x	x		x		x	x		x	x	x	x		x	x	x	x	x	x		x			x		x	x			x
		Site layout	22			x	x	x		x					x	x		x		x	x			x	x	x		x	x		x	x	x	x				x		x	x			x
	To improve the accessibility	Vehicle accessibility	11	x	x	x	x									x								x				x	x									x			x			x
		Pedestrian accessibility	9		x	x	x									x		x						x					x									x			x			
		Public transport accessibility	12		x	x	x									x		x			x			x					x					x				x			x			x

		Disability accessibility	7		x				x							x		x		x									x													x		
Functional	To improve the flexibility and adaptability of the building	Flexibility of spaces / layout	23	x		x		x	x	x	x		x						x	x	x		x		x			x	x			x	x			x		x	x	x	x	x		x
		Flexibility of service ducts and corridors	15	x					x				x						x	x					x			x	x			x				x		x		x	x	x		x
	To improve the disassembly potential of the building	Disassembly potential	8	x									x							x								x	x			x						x			x			
	To safeguard the suitability of the building for a new use	Spatial flow and atria	6	x																x					x				x			x						x						
		Building compatibility for new use	21			x		x	x		x	x	x	x	x			x		x			x	x	x	x		x		x					x		x			x		x		x

3.2 Preparation Phase

The reviewed publications in the preparation phase are mostly concerned with Multi Criteria Decision Making models for the selection of the best adaptive reuse alternative. In this phase the decision to adaptively reuse the buildings has been made, and decision criteria are used to compare different options and decide on the best new use or design alternative. Most MCDM methods can broadly be classified into two parts: 1) Method for assessing criteria weights, 2) Method for ranking/selection of alternatives. These alternatives can take shape in various ways. *Haroun et. al. & Bottero et. al.* use a MCDM to find the best alternative use for (industrial) heritage buildings **(Haroun et al., 2019, Bottero et al., 2019)**, whereas *Vizzari et. al.* and *Dabouh & El Shazly* compare specific design scenarios using a MCDM model ***(Vizzarri et al., 2021)*** **(Dabouh & Shazly, 2020)**. *Langston* and *Sfakianaki & Moutsatsou* compare general intervention scenarios for adaptive reuse **(Langston, 2012, Sfakianaki & Moutsatsou, 2015)**, whereas *Miloševic* compares buildings suitable for adaptive reuse using a MCDM **(Milošević et al., 2020)**. The reviewed publications are included in the preparation phase if they presume the decision for adaptive reuse is already made, but the decision for specific alternatives or options remains.

The Multi/Multiple Criteria Decision Making (MCDM) is a scientific method for decision making to choose the best alternative, classify alternatives or rank alternatives in a preference order. MCDM methods are applied in a wide variety of fields such as engineering and urban planning, and the number of applications of these methods in the field of adaptive reuse are growing **(Nadkarni & Puthuvayi, 2020)**. Multiple interchangeable terms are used in literature such as Multiple-Criteria Decision Analysis (MCDA) and Multi-Attribute Decision Making (MADM), but are regarded as synonymous. All methods are involved that deal with a multitude of criteria in structuring and solving complex decision problems. Publications in the preparation phase use a wide variety of different MCDM methods including: AHP **(Haroun et al., 2019)**, ANP **(Wang & Zeng, 2010),** FUZZY-DELPHI **(Chen et al., 2018)**, PROMETHEE **(Bottero et al., 2019)**, A'WOT (G. Ragheb, 2021), and NAIADE **(Oppio & Bottero, 2017)**.

The iconCUR model by *Langston* is a multi-criteria decision making tool for assessing the performance of built assets **(Langston, 2012)**. The model helps deciding when to intervene, what actions to take, and what strategies might be appropriate when a building possibly needs intervention? This 3d model succeeds the earlier SINDEX model by *Langston* (Langston & Shen, 2007b), and uses 1) condition, 2) utilisation, and 3) reward, as primary criteria to map the current status of buildings in 3D spatial terms at any point in time during its life cycle. In this 3D model the x and y coordinates identify decisions for property managers, and the z coordinates the strength of those decisions. Reward in the model is based on a collective utility derived from a combination of financial, social and environmental benefits. The iconCUR assessment model in total incorporates 25 decision criteria and 11 intervention options ranging from renovation to adaptive reuse. In simple terms the following criteria outcomes relate to the respective proposed interventions:

- *Low condition and low utilisation: reconstruct or dispose*
- *High condition and high utilisation: retain or extend*
- *Low condition and high utilisation: renovate or preserve*
- *High condition and low utilisation: reuse or adapt*

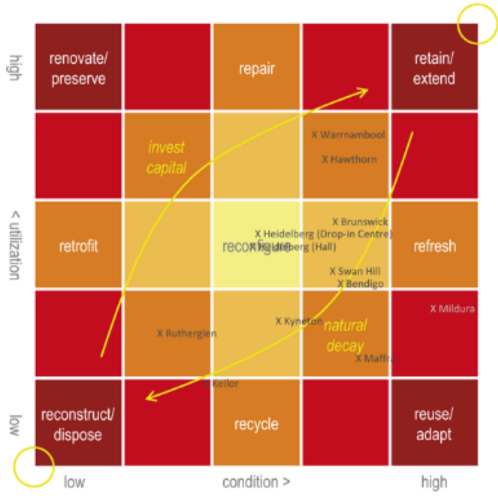


Figure 6: The iconCUR model by Langston

Haroun et al. used the Analytical Hierarchy Process (AHP) method as a Multi Criteria Decision Making model to find the best new use for the *Aziza Fahmy Palace* in Egypt **(Haroun et al., 2019)**. Four different alternative uses were ranked based on 5 main criteria: heritage value, architectural value, economic value, social value and environmental value. Through pairwise comparison the criteria were assigned weights with architectural value being deemed the most important.

A FUZZY-DELPHI method was used in the work of *Chen* as a decision making model to determine the best new use for the *Sun Yat-Sen Historical Museum* in Taiwan **(Chen et al., 2018)**. In the model 16 sub-criteria were identified organized in 5 main criteria: Economic aspects, Social aspects, Environmental aspects, Architectural aspects, and Historical Aspects.

The Novel Approach to Imprecise Assessment and Decision Environments (NAIADE), by *Dell'Ovo et. al.* was used to identify the best alternative reuse scenario for *Castello Visconteo* in Cusago in Italy **(Dell'Ovo et al., 2021)**. The NAIADE allows for capturing the interest of relevant stakeholders by letting them evaluate the degree of preference of the alternatives according to a nine-level scale. Four scenarios were assessed on the basis of 11 decision criteria that were organised according to on-site and off-site impacts. The results were tested and confirmed through a sensitivity analysis involving outside experts.

Another Multi-Criteria Decision Making model that is mentioned in multiple publications is the Multi-Attribute-Value Theory (MAVT). This decision making method addresses problems that have a finite and discrete set of alternatives that need to be evaluated based on conflicting objectives **(Ferretti et al., 2014)**. A benefit of the MAVT is that both quantitative as well as qualitative data can be handled, and that it can deal with a large number of alternatives without an increase of the elicitation effort **(Keeney & Raiffa, 1993)**. The MAVT is different than other MCDM's like the Analytical Hierarchy Process, in the formulation of objectives **(Keeney, 1996)**. The degree to which objectives are achieved is then measured through a set of attributes **(Keeney, 1996)**. Because decision makers base their preferences about the fulfilment of the objectives independently of the alternatives, additional alternatives can still be added in a later stage **(Schuwirth et al., 2012)**. *Ferretti et al.* use the MAVT to find the most suitable building for adaptive reuse, out of a list of former industrial buildings located in the municipality of Caselle in Italy **(Ferretti et al., 2014)**. The buildings are assessed based on 5 main criteria: quality of the context, economic activity, flexibility, accessibility, and conservation level.

The thematic analysis in the preparation phase resulted in 64 sub criteria divided over 7 main criteria. Again the PESTLE Framework was used as a starting point for structuring the criteria but amended to include the following main criteria: Economic, Social, Technological, Environmental, Legal, Architectural/ Physical, and Cultural.

Figure 7: The decision criteria for adaptive reuse in the preparation phase

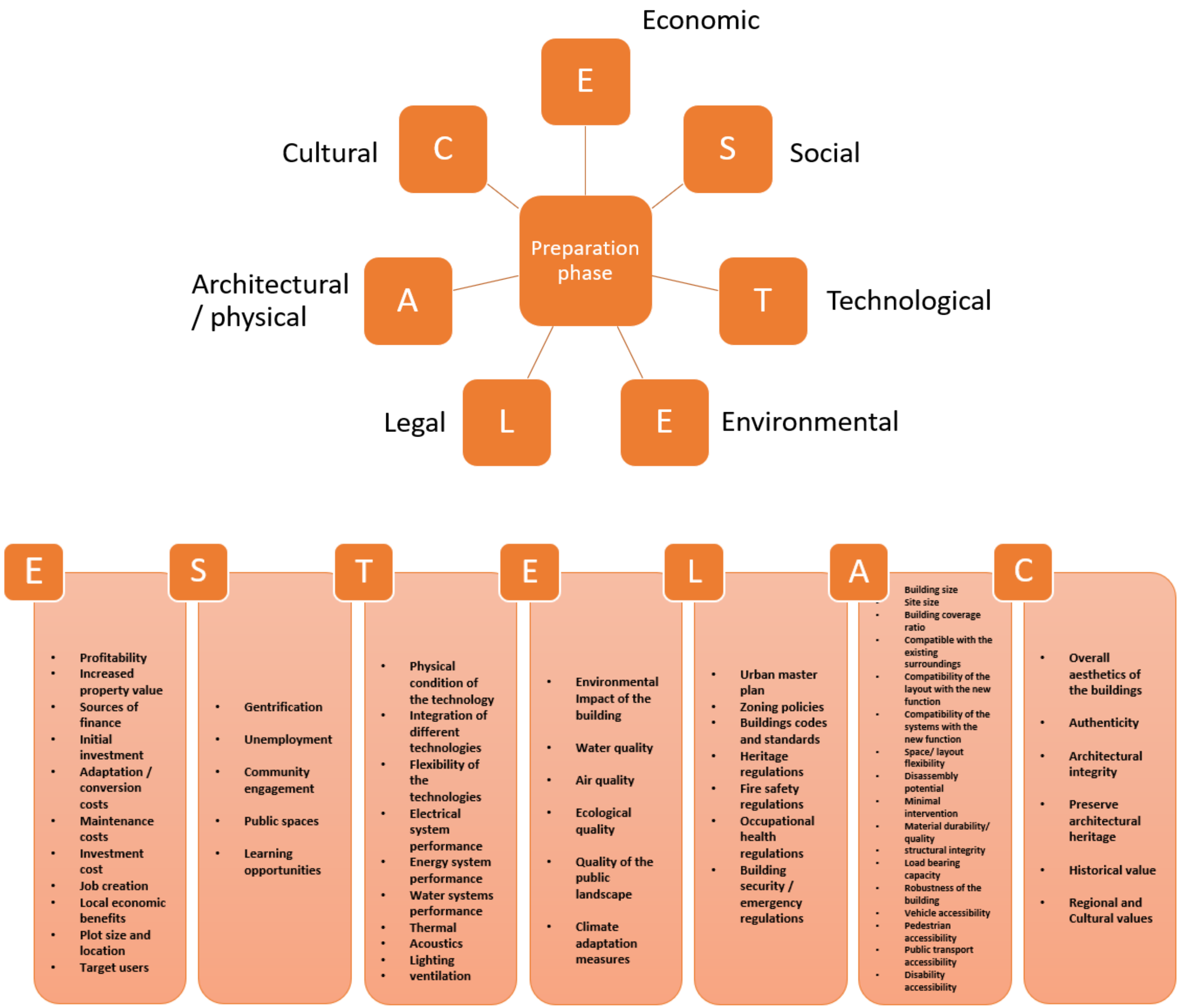


Table 2: The decision criteria for adaptive reuse in the preparation phase

Main Criteria	Objectives	Sub-Criteria	##	(Aigwi et al., 2022)	(Bottero et al., 2022)	(Abastante et al., 2020)	(Abastante et al., 2022)	(Morgante et al., 2022)	(Vizzarri et al., 2021)	(Śladowski et al., 2021)	(Ragheb, 2021)	(Della Spina, 2021)	(Vehbi et al., 2021)	(Dabouh & Shazly, 2020)	(Fedorczak-Cisak et al., 2020)	(Della Spina, 2020)	(Cerreta & Savino, 2020)	(Torrieri et al., 2019)	(Haroun et al., 2019)	(Huang & Wey, 2019)	(Bottero et al., 2019)	(Shahi et al., 2018)	(Costa et al., 2019)	(Bonci et al., 2018)	(Giuliani et al., 2018)	(Oppio & Bottero, 2017)	(Juan et al., 2016)	(Shehada et al., 2015)	(Tan et al., 2014)	(Langston, 2013)	(Hsu & Juan, 2016)	(Sharifi & Farahinia, 2021)	(Pavlovskis et al., 2019)	(Dell' Ovo et al., 2021)	(Yau, 2009)	(Turskis et al., 2013)	(Ferretti et al., 2014)	(Della Spina, 2019)	(Ribera et al., 2020)	(Wang & Zeng, 2010)
Economic	To increase financial returns	Profitability	16	x	x	x		x	x			x	x		x	x								x		x		x	x		x	x								x
		Increased property value	8	x		x				x						x					x			x				x					x							
	To minimize financial risk	Sources of finance	13								x		x			x		x		x				x	x			x	x	x	x	x								x
		Initial investment	10		x			x					x			x		x						x		x		x							x					x
	To reduce costs	Adaptation / conversion costs	10		x			x			x			x				x	x			x		x	x										x					
		Maintenance costs	10		x	x			x		x		x									x		x	x										x					x
		Investment cost	14	x	x		x	x			x	x										x		x	x	x							x	x	x					x
	To increase wider economic benefits	Job creation	14	x	x			x				x						x		x				x							x	x	x	x			x	x	x	
		Local economic benefits	18				x	x	x	x	x			x	x			x	x	x	x			x	x								x		x		x	x	x	
	To increase market potential	Plot size and location	13	x									x			x		x			x			x				x	x	x	x	x		x						x
		Target users	13	x	x							x	x					x		x				x				x	x		x	x						x		x
Social	To improve socio-economic conditions	Gentrification	6	x	x			x	x										x	x																				
		Unemployment	4					x											x	x																			x	
	To increase community engagement	Community engagement	19				x					x	x	x				x	x	x				x	x	x		x	x	x	x	x		x				x	x	x
	To improve public amenities	Public spaces	12	x	x				x	x				x						x	x			x	x							x	x	x						
		Learning opportunities	8		x					x										x								x			x		x					x		x
Technological	To increase the quality of the technology in the building	Physical condition of the technology	10												x				x		x		x			x				x	x	x				x				x
		Integration of different technologies	7														x		x				x		x					x		x				x				
		Flexibility of the technologies	9	x												x	x		x				x		x					x		x				x				
	To provide appropriate	Electrical system performance	8												x				x			x			x		x			x		x			x					

	electrical and water systems for the new use	Energy system performance	8	x				x							x							x			x		x			x					x					
		Water systems performance	5																			x			x		x			x					x					
	To safeguard healthy indoor environmental quality	Thermal	5												x							x			x		x			x										
		Acoustics	7												x						x	x	x		x		x			x										
		Lighting	7	x											x							x			x		x			x		x								
		ventilation	6												x							x			x		x			x		x								
Environmental	To reduce the environmental impact	Environmental impact	11					x	x	x					x							x		x			x		x				x	x	x					
		Water quality	3																								x							x	x					
		Air quality	4	x																							x							x	x					
	To improve the quality of the landscape	Ecological quality	11		x			x					x										x	x			x	x	x	x				x						x
		Quality of the public landscape	14		x				x				x			x					x			x			x	x	x			x	x	x			x			x
	To improve climate adaptation	Climate adaptation measures	9		x					x						x							x	x			x					x	x	x						
Legal	To comply with urban master plan and zoning	Urban master plan	8	x										x										x				x	x	x		x								x
		Zoning policies	9	x										x					x					x				x	x	x		x								x
	To comply with buildings codes and regulations	Buildings codes and standards	7	x							x			x										x				x	x	x										x
		Heritage regulations	7	x										x										x				x	x	x										x
	To comply with health, safety and security regulations	Fire safety regulations	7	x																				x	x	x				x	x	x								
		Occupational health regulations	5	x																				x			x			x		x								
		Building security / emergency regulations	7	x					x	x														x	x	x				x										
Architectural / Physical	To increase the size of the building	Building size	7						x												x							x		x	x		x							x
		Site size	8													x					x							x		x	x	x		x	x					
		Building coverage ratio	3																				x					x			x									
	To be compatible with the new function	Compatible with the existing surroundings	21		x	x			x		x	x	x	x					x					x		x		x	x	x	x	x	x	x	x	x	x		x	
		Compatibility of the layout with the new function	16						x	x	x	x	x	x					x					x	x	x				x			x	x	x	x			x	
		Compatibility of the systems with the new function	11						x	x	x	x	x	x					x					x	x	x				x										

	To be flexible and adaptable for future needs	Space/ layout flexibility	15						x	x	x		x			x	x				x		x	x		x				x	x	x					x			x
		Disassembly potential	5							x			x									x									x	x								
		Minimal intervention	6		x							x					x															x					x		x	
	To improve the physical quality of the building	Material durability/ quality	8										x								x					x		x		x	x	x								x
		structural integrity	10										x	x					x						x		x	x		x	x	x								x
		Load bearing capacity	6											x					x						x			x		x		x								
		Robustness of the building	5			x											x								x					x		x								
	To improve the accessibility	Vehicle accessibility	13	x					x		x			x					x		x			x						x		x		x	x		x	x		
		Pedestrian accessibility	11	x					x		x			x					x		x		x							x				x			x	x		
		Public transport accessibility	11						x		x								x		x		x	x						x	x			x			x	x		
		Disability accessibility	2	x										x																										
Cultural	To preserve the architectural value of the building	Overall aesthetics of the buildings	9	x					x										x		x					x		x		x		x			x	x				
		Authenticity	9			x							x						x		x							x		x			x			x				x
		Architectural integrity	9						x				x								x					x		x		x					x	x				x
		Preserve architectural heritage	15	x	x					x	x			x	x				x		x					x		x				x			x	x	x		x	
	To preserve the cultural value of the building	Historical value	16	x						x	x		x	x	x	x								x				x		x	x	x	x		x	x				x
		Regional and Cultural values	12	x						x					x	x								x				x		x	x	x	x			x		x		

3.3 Post-Completion Phase

For the post-completion phase, publications that focus on evaluating adaptive reuse projects after the conversion, were considered. This phase is considered the final step of the AR process. The evaluation in this final stage tries to identify successes and failures in order to provide feedback for future projects **(Arfa, et al., 2022).** The aim of the publications assigned to the post-completion phase roughly consist of three parts: 1) assessing the building on future adaptation, based on adaptive reuse projects, 2) evaluating the success of the adaptive reuse project and/or deriving a baseline score, and 3) determining success factors of adaptive reuse using statistical methods.

The design and functional layout of a building is an important criterion for determining adaptive reuse potentials **(Conejos et al., 2014)**. The lack of clear criteria for the optimisation of future building adaptive reuse design, resulted in the adaptSTAR framework by *Conejos* **(Conejos, 2013)**. The adaptSTAR framework takes the form of a checklist and evaluates an adaptive reuse project on a list of design criteria for future adaptive reuse. Although the tool can be used to determine adaptive reuse potential in the pre-project phase, the tool is also suitable for evaluating the success of the adaptive reuse design after completion, and is therefore placed in the post-completion phase. The adaptSTAR model has also been previously used to evaluate adaptive reuse projects post completion **(Sharifi & Farahinia, 2020)**. The model consists of 26 design criteria organized into seven categories: Physical, Economic, Functional, Technological, Social, Legal and Political.

One way of measuring the success of adaptive reuse projects is through user experiences. *Günçe & Mısırlısoy* question the appropriateness of the new functions that have been assigned to adaptive reuse projects in Nicosia, and use questionnaires to evaluate the success of these projects **(Günçe & Misirlisoy, 2019)**. Twelve adaptive reuse projects were used as case studies consisting of 6 different building uses. In total 135 questionnaires were completed, with the questions being structured according to the 25 proposed evaluation criteria. For the evaluation of the these adaptive reuse projects 5 main categories were distinguished: Socio-Cultural aspects, Economic aspects, and Physical aspects.

The determinants of a successful adaptive reuse project can be examined through the use of statistical methods. *Parpas & Savvides* use a Multiple Regression Approach to find a correlation between project variables and successful adaptive reuse projects **(Parpas & Savvides, 2020)**. A successful adaptation projects is used in this study as dependent variable and is defined as an index describing the active years of use after adaptation. For the independent variable 100 adaptive reuse projects from Cyprus are taken into account. For the independent variables 11 variables are used organised in three main categories: physical, economic and utilitarian. Results show that the following criteria are positively correlated to the success of an adaptive reuse project: construction era, number of users, location, GDPG rate, primary construction materials, type of use, and the change in use.

A comprehensive sustainable management plan for adaptive reuse projects is essential to ensure the success. *Nasr & Khalil* therefor propose an assessment strategy that offers guidelines for achieving such a comprehensive adaptive reuse project **(Nasr & Khalil, 2022).** Based on a literature review they come up with an assessment framework for adaptive reuse that they apply to 5 adaptive reuse interventions in Oman. The assessment was done based on semi-structured interviews with stakeholders, as well as onsite observation and relevant data analysis. The assessment framework consists of 30 sub-criteria divided over 5 main-criteria: social, cultural, economic, environmental, the process of preservation and the success of the new function.

The thematic analysis in the post-completion phase resulted in 61 sub criteria divided over 8 main criteria. Again the PESTLE Framework was used as a starting point for structuring the criteria but amended to include the following main criteria: Political, Economic, Social, Technological, Environmental, Legal, Architectural/ Physical, and Cultural.

Figure 8: The decision criteria for adaptive reuse in the post-completion phase

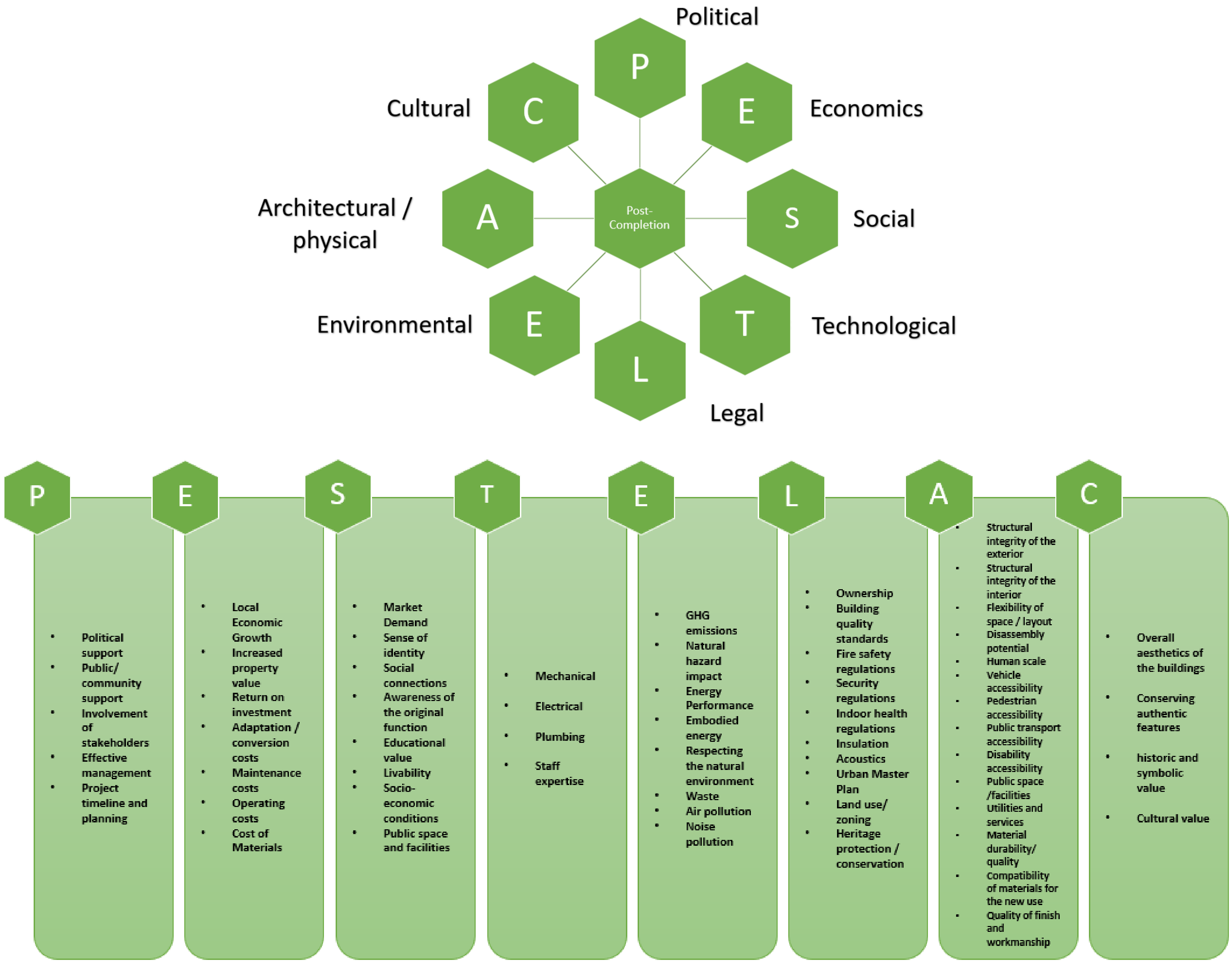


Table 3: The decision criteria for adaptive reuse in the post-completion phase

Main Criteria	Objectives	Sub-Criteria	##	(Alavi et al., 2022)	(Nasr & Khalil, 2022)	(Wang & Liu, 2021)	(Vardopoulos et al., 2021)	(Elsorady, 2020)	(Bottero et al., 2020)	(Parpas & Savvides, 2020)	(Vardopoulos, 2019)	(Günçe & Misirlisoy, 2019)	(Djebbour & Biara, 2019)	(Hanafi et al., 2019)	(Tan et al., 2018)	(Misirlisoy & Günçe,	(Conejos et al., 2015)	(Hamida et al., 2020)	(Arfa, et al., 2022)
Political	The adaptive reuse interventions was broadly supported by the public	Political support	3				x									x	x		
		Public/ community support	5					x				x				x	x	x	
	Stakeholders and citizens participated throughout the adaptive reuse process	Involvement of stakeholders	4					x					x				x		x
	The adaptive reuse project was well managed	Effective management	8	x	x	x		x					x	x			x	x	
		Project timeline and planning	4					x						x	x			x	
Economic	The adaptive reuse project had a positive impact on the local economy	Local economic growth	6		x		x					x	x			x			x
	The adaptive reuse project was financially feasible and profitable	Increased property value	2									x				x			
		Return on investment	11		x	x	x	x	x			x	x	x	x	x		x	
	The costs of the adaptive reuse project were minimized	Adaptation / conversion costs	5	x	x					x					x			x	
		Maintenance costs	4			x		x	x	x									
		Operating costs	4		x				x	x							x		
		Cost of materials	2							x					x				
	There is a clear market demand for the adaptive reuse project	Market demand	5					x						x	x	x	x		
Social	The adaptive reuse project preserves the local identity	Sense of identity	7		x	x			x			x	x				x		x
	The adaptive reuse project had a positive impact on community building	Social connections	5	x	x								x				x		x
	The adaptive reuse project contributed to raising social awareness and education	Awareness of the original function	10	x	x	x			x			x		x	x	x		x	x
		Educational value	4		x								x			x			x
	The adaptive reuse project contributed to improving the quality of life for the local residents	Liveability	4	x			x									x			x
		Socio-economic conditions	6	x	x	x							x			x			x
		Public space and facilities	4			x										x	x		x
Technological	The buildings systems are appropriate for the new use	Mechanical	6				x				x			x	x		x	x	
		Electrical	6				x				x			x	x		x	x	
		Plumbing	6				x				x			x	x		x	x	
	The people involved in the adaptive reuse project possessed the necessary skills and knowledge	Staff expertise	6				x	x						x	x			x	x
Environ mental	The environmental impact of the adaptive reuse project was minimized	GHG emissions	8			x	x	x						x	x		x	x	x
		Natural hazard impact	4		x			x						x			x		
	The operational energy of the building is minimized	Energy performance	8			x								x	x	x	x	x	x
	The embodied energy of the building (materials) is minimized	Embodied energy	8		x	x	x						x	x	x		x		x

	The adaptive reuse project had a positive impact on nature	Respecting the natural environment	9	x	x	x						x		x		x	x		x
	The waste and pollution relating to the adaptive reuse project is minimized	Waste	3		x									x	x				
		Air pollution	4			x	x							x	x				
		Noise pollution	5			x	x							x	x		x		
Legal	The ownership status of the building did not hinder the adaptive reuse project	Ownership	6				x		x					x	x		x	x	
	The adaptive reuse project complied with the building regulations and standards	Building quality standards	6				x	x	x						x		x	x	
		Fire safety regulations	6	x	x						x				x		x	x	
		Security regulations	5				x							x	x		x	x	
		Indoor health regulations	8				x				x			x	x	x	x	x	x
		Insulation	7			x	x				x			x	x		x		x
		Acoustics	6			x	x							x	x		x		x
	The adaptive reuse project suited in the urban master plan and zoning regulations	Urban master plan	7				x	x		x				x	x		x	x	
		Land use/ zoning	7				x	x		x				x	x		x	x	
		Heritage protection / conservation	11	x	x	x		x	x			x		x	x	x	x		x
Architectural / Physical	The buildings structural integrity was appropriate for the new use	Structural integrity of the exterior	10	x	x	x	x				X			x	x		x	x	x
		Structural integrity of the interior	10	x	x	x	x				x			x	x		x	x	x
	The new use/function of the adaptive reuse project is appropriate for the physical structure of the building	Flexibility of space / layout	12		x	x			x		x	x	x	x	x	x	x	x	x
		Disassembly potential	8	x		x							x	x	x		x	x	x
		Human scale	8		x	x				x		x	x	x			x		x
	The building after intervention is accessible	Vehicle accessibility	8	x		x			x		x	x			x	x	x		
		Pedestrian accessibility	9	x		x			x		x	x			x	x	x		x
		Public transport accessibility	6	x		x			x		x				x		x		
		Disability accessibility	5									x		x		x	x		x
	The adaptive reuse project is physically compatible with the existing surroundings	Public space /facilities	9		x	x				x		x		x	x	x	x		x
		Utilities and services	7			x			x					x	x	x	x		x
	The buildings materials are durable and qualitatively appropriate	Material durability/ quality	9			x	x			x	x			x	x		x	x	x
		Compatibility of materials for the new use	9	x		x		x				x	x		x	x		x	x
	The quality of the building after interventions is maximized	Quality of finish and workmanship	9		x			x		x		x		x	x	x	x		x
Cultural	The architectural values of the building are preserved	Overall aesthetics of the buildings	5			x						x		x	x				x
		Conserving authentic features	11	x	x	x		x	x			x	x	x		x	x		x
	The historic values of the building are preserved	historic and symbolic value	9	x	x	x		x				x		x	x		x		x
	The cultural values of the building are preserved	Cultural value	12	x	x	x	x	x				x	x	x	x	x	x		x

3.4 Interrelationships and contrasts of decision criteria between phases

Through a reflexive thematic analysis three lists of decision criteria for adaptive reuse were constructed for three different phases of the adaptive reuse process. The construction of these lists followed the MAVT approach **(Keeney & Raiffa, 1993)**, in which objectives were formulated based on the common criteria that were repeatedly indicated in the literature. To find interrelationship and differences in the decision criteria between phases, a comparative analysis was performed. A comparative analysis between the different lists of decision criteria indicated some notable similarities and differences further explained below.

In general the decision criteria for different phases of adaptive reuse identified in this review, show a lot of similarities. For all three phases, economic and architectural/physical aspects seem to be consistent across reviewed literature. One of the most repeated categories of decision criteria throughout the different phases is the "Economic" category. This is in line with the work of **(Mohamed & Alauddin, 2021)** and **(Mısırlısoy & Günçe, 2016b)** that also regard the economic dimension as the most vital part of an adaptive reuse project. In all three phases, the cost of the adaptive reuse project are mentioned as one of the criteria, with a distinction between different types of costs such as: adaptation costs **(Dabouh & Shazly, 2020, Alavi et al., 2022, Aigwi et al., 2020)**, maintenance costs **(Mısırlısoy, 2021, Vizzarri et al., 2021, Elsorady, 2020)** and cost of materials **(Tan et al., 2018).** The post-completion phase differs from the pre-project phase and the preparation phase pertaining to investment risk. The financial risk of the project, and the source of finance are often mentioned criteria in the first two phases **(Mehr & Wilkinson, 2021, Shehada et al., 2015, Vehbi et al., 2021)**, but are not mentioned in the post-completion phase. An explanation for this could be that in the post-completion phase the adaptive reuse project has finished, and the financial risk is therefore of less importance. An aspect that is found in all three phases is the positive impact of the project in a wider economic sense **(Vardopoulos, 2019, Pavlovskis et al., 2019 Nasr & Khalil, 2022)**. Frequently mentioned criteria are: job creation and local economic growth. The financial or economic returns of the adaptive reuse project are also mentioned in all three phases **(Hong & Chen, 2017, Ikiz Kaya, et al., 2021, Bottero et al., 2022)**. Sub-criteria that correspond to this include: return on investment **(Vardopoulos et al., 2021)** and increase in property value **(Bottero et al., 2019)**. The market opportunity / potential due to the location of the building is an often mentioned criteria in the pre-project and preparation phase **(Bansal & Chhabra, 2022, Abdullah et al., 2020, Bonci et al., 2018, Hsu & Juan, 2016)**, but is less often mentioned in the post-completion phase.

Some criteria are mentioned throughout the adaptive reuse process, but are categorized differently depending on the phase of the project. In the preparation and post-completion phase there is a clear distinction between social and cultural aspects, whereas in the pre-project phase this demarcation is less rigid. Social criteria mentioned in the preparation and post-completion phase are mostly concerned with community engagement **(Abastante et al., 2022, Alavi et al., 2022)**, socio-economic conditions **(Haroun et al., 2019, Arfa, et al., 2022)** and public amenities **(Giuliani et al., 2018, Conejos et al., 2015)**, and cultural criteria are concerned with historic, architectural and cultural values **(Shehada et al., 2015, Hanafi et al., 2019)**. In the pre-project phase these aspects are mentioned under both the social and cultural categories, and often times combined into one category: socio-cultural **(Aigwi et al., 2020, Mısırlısoy, 2021).**

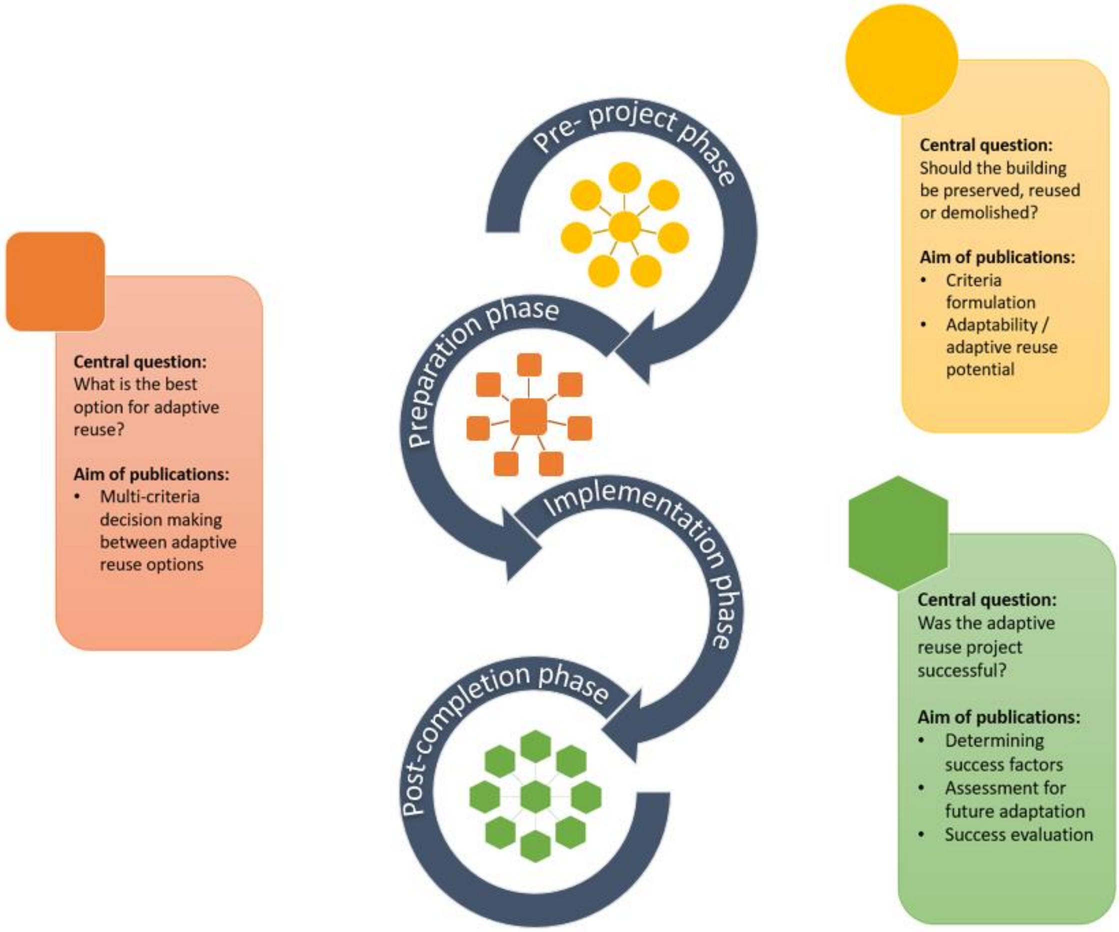
In the pre-project phase this also happens for the political and legal categories. In the post-completion phase there seems to be a clear distinction between legal aspects (aspects considering regulations, standards, urban master plans etc.) and political aspects: aspects considering political support and project management (project timeline and planning etc.). In the pre-project phase however political and legal criteria are often interchangeably used under the same category **(Aigwi et al., 2020, Mohamed & Alauddin, 2016),** and are therefore combined in to the category: Politics and regulations. For the preparation phase mostly legal aspects are mentioned (building regulations etc.), and political aspects are missing entirely.

The technological category is less mentioned in all three phases compared to the economic and architectural categories. Buildings systems and services are considered under the technological category. In the post-completion phase the technological criteria are more broadly considered compared to the pre-project and preparation phase. In the post completion phase three general buildings systems are considered as criteria: mechanical, electrical and plumbing, whereas in the pre-project phase there is a distinction of 6 sub-criteria for building services: Building orientation and solar access, glazing and shading, insulation and acoustics, security systems, HVAC, and energy system. For the preparation phase indoor environmental quality is considered more from a technical perspective, including thermal, acoustics, lightning, and ventilation in the technological category **(Sharifi & Farahinia, 2020)**, whereas for the pre-project phase it is mentioned in the environmental category **(Teo & Lin, 2012)**, and in the post-completion phase it is considered under the legal aspect **(Conejos et al., 2015)**.

For the preparation phase the environmental category is more broadly considered. Besides environmental impact, also ecological quality and climate adaptation is considered **(Juan et al., 2016, Bonci et al., 2018)**. For the post-completion and pre-project phases the environmental category is more concerned with the environmental impact **(Djebbour & Biara, 2019, Djebbour & Biara, 2020)**, pollution **(Tan et al., 2018, Hanafi et al., 2018)** and waste **(Nasr & Khalil, 2022, Ikiz Kaya, et al., 2021)**. For the pre-project phase also indoor environmental quality is taken into account for the environmental category **(Teo & Lin, 2012).**

In the pre-project phase there is a lot of emphasis on the physical and architectural decision criteria for adaptive reuse. When deciding between demolition, preservation or adaptive reuse it is important to know if the building is physically capable of undergoing a change of function **(Wilkinson et al., 2014)**. Although aspects of functionality like flexibility, and building suitability are mentioned in all three phases, in the pre-project phase these criteria are categorized separately under the "functional" category **(Yang et al., 2022, Vizzarri & Fatiguso, 2019, Remøy & van der Voordt, 2014)**, whereas for the other two phases they are mostly mentioned under the architectural/ physical category. In the preparation and post-completion phases the compatibility of the building with the local environment, is a frequently repeated aspect **(Haroun et al., 2019) (Alavi et al., 2022)**. With a focus on being compatible with the local surroundings **(Vizzarri et al., 2021)**, public spaces and facilities **(Tan et al., 2018**) and the local utilities and services **(Giuliani et al., 2018)**. In the pre-project phase there is more emphasis on if the physical character of the building allows for adaptive reuse. The compatibility of the building with the local surrounding is more generally mentioned in the pre-project phase, with the focus on if the location and site layout do not hinder adaptive reuse **(Geraedts & Van der Voordt, 2007, Hong & Chen, 2017)**. An aspects that is mentioned repeatedly throughout the AR process is the accessibility of the building **(Vizzarri & Fatiguso, 2019, Günçe & Misirlisoy, 2019, Aigwi et al., 2022).** For all three phases a distinction is made between four types of accessibility: vehicle accessibility, pedestrian accessibility, public transport accessibility and disability access.

Figure 9: The aim of the reviewed literature with regards to the different phases in the adaptive reuse decision making process.



In summary, the decision criteria for adaptive reuse show great similarities between different phases. Some subtle differences between phases are inherent to the aim of the decision in the different phases. In the post-completion phase the investment risk, source of finance and market potential of the location are of less importance because the adaptive reuse project has already been completed. In the preparation phase the lack of political criteria might be inherent to the fact that the decision for adaptive reuse has already been made, and political support has been dealt with in the pre-project phase. The greatest differences arise due to a different categorization of sub criteria over the main criteria. In the pre-project phase the social and cultural criteria showed considerable overlap and were therefore combined. The same was done for the Political and Legal criteria in the pre-project phase. For the preparation phase, criteria related to indoor environmental quality were considered from a more technical standpoint and categorized in the "Technological" category. These same criteria for environmental quality were considered from two different standpoints for the pre-project and post-completion phase.

4. Discussion

In structuring the reviewed publications according to the different phases in the adaptive reuse process, the four phases defined by *Arfa et. al.* were used **(Arfa, et al., 2022).** During the analysis part of the literature review, the implementation phase was however omitted due to a lack of publications corresponding to this phase. This phase is characterised by the execution of previously agreed on design strategies, which may explain the lack of decisions made during this phase. The duration of the implementation phase shows high correlation with the duration of the preparation phase highlighting that; the more detailed the preparation phase, the shorter and less complex the implementation phase **(Kurul, 2007)**. However *Kurul* argues that in adaptive reuse projects the complexity increases where there is a higher variance in the type of activities undertaken **(Kurul, 2007)**. Slow decision making in the implementation phase is already mentioned as an important factor for the delay in construction projects **(Carvalho et al., 2021)**, but with the rise of circular design strategies such as: design for disassembly one could argue that the complexity in the implementation phase only increases **(Rios et al., 2015)**. The lack of decision criteria for adaptive reuse in the implementation phase together with the increasing complexity of decisions in this phase in the future, highlights the need for more research into the decision criteria in this phase.

Although the differences in decision criteria between the different phases seem minimal, the way to measure these criteria may greatly differ depending on the phase in the adaptive reuse process. How to measure the criteria is an important step in the multi criteria decision making process **(Brugha, 2004)**. The performance according to the criteria can be measured through multiple measurement scales such as: nominal, ordinal, interval and ratio, both qualitative and quantitative **(Cinelli et al., 2020)**. The measurement scale and the way to evaluate the criteria is dependent on the data and information available as well as the context of the project. In the post-completion phase data on costs and local economic growth might be evaluated more quantitatively compared to the pre-project phase, because after the project is finished numerical data is available in detail. How to evaluate and measure the criteria is also dependent on the aim of the decision in the corresponding phase. In the preparation phase, different scenarios for adaptive reuse are compared to each other, which may require a more ordinal measurement scale, compared to the post-completion phase where the success of the adaptive reuse project is measured in a more broader sense. More research into how to evaluate the decision criteria per phase in the AR process is therefore recommended.

How the decision criteria are measured and evaluated is also dependent on the importance of the criteria in relation to the phase of the AR process. Investment risk and political support might be of more importance in the pre-project and preparation phase, whereas criteria like project management and planning could be more important in the post-completion phase. The difference in weighting of the decision criteria between different phases was outside the scope of this literature review, but nonetheless deserves more attention in future research.

Most decision models reviewed in this article use decision criteria to determine what the best new use or intervention action is for the adaptive reuse project. The decision options for these models are either really broad (functional use) **(Haroun et al., 2019)**, or really specific (pre-defined design options) **(Vizzarri et al., 2021)**. The IconCUR model does take into account general property management interventions, but takes a broader approach looking beyond adaptive reuse alone **(Langston & Smith, 2011)**. The results from this literature review reveal that general holistic intervention options specifically focussed on adaptive reuse, incorporating design principles are currently missing in literature. This is supported by various authors that also state the need for creating general typologies for adaptive reuse scenarios **(Pieczka & Wowrzeczka, 2021, Cleempoel, 2019)**.

Although adaptive reuse itself is considered a circular strategy, other circularity aspects seem to be lacking in adaptive reuse projects **(Bosone et al., 2021)**. The work by *Ikiz Kaya* that shows that there is still a weak connection and awareness among relevant stakeholders regarding adaptive heritage reuse and the circularity framework in adaptive reuse projects in the Netherlands (Ikiz Kaya, Dane, et al., 2021). In their research the circularity performance of adaptive reuse projects is assessed from the perspective of stakeholders, based on 23 circularity indicators grouped by: *Circularity of conservation intervention (CC)* and *Circularity of outcomes from the use (CO)*. Through a cluster analysis it was revealed that stakeholders of adaptive reuse projects only weakly recognize the correlation between the adaptive reuse projects and the circularity framework **(Ikiz Kaya, et al., 2021)**. Most of the circularity performance indicators used in their study are repeatedly found in this literature review throughout all phases of the adaptive reuse process. This indicates a possible discrepancy between circular decision criteria for adaptive reuse found throughout the adaptive reuse process, and the actual circularity performance of adaptive reuse projects. Whilst circularity might be embedded in the decision criteria and decision models for adaptive reuse, it does not transfer to actual circular strategies being implemented in adaptive reuse projects. This highlights the need for more research into the actual circularity performance of adaptive reuse projects, as well as ways to incorporate circularity strategies into adaptive reuse projects. A good starting point for this could *Foster* who came up with a comprehensive framework for circular strategies for adaptive reuse throughout the buildings life cycle **(Foster, 2020)**. These strategies could be incorporated with general adaptive reuse scenarios to give decision makers in adaptive reuse projects tangible intervention options that increase the overall circularity performance. This might bridge the gap between circular intentions in the adaptive reuse decision making process, and actual circular actions.

The results from this literature review are also in line with the results from *Foster & Kreinin*, whose study highlights that environmental indicators are rarely applied in cultural heritage adaptive reuse projects, pointing out a gap between common circularity indicators and specific indicators aimed at demonstrating the environmental advantages of adaptive reuse **(Foster & Kreinin, 2020)**. In their work four environmental indicator groups are synthesized resulting in the following four clusters: 1. Indicators of direct reductions to new natural materials extraction due to the adaptive reuse; 2. Indicators of direct reductions to energy use due to the adaptive reuse; 3. Indicators of direct environmental improvements due to the adaptive reuse; and 4. Indicators of indirect reductions to energy use or pollution due to the adaptive reuse. The four environmental indicator groups by *Foster & Krenin*, are all found in the decision criteria for adaptive reuse throughout the different phases. However looking at specific criteria some gaps can be identified. Although reduction in Greenhouse Gas emissions and energy consumptions are found in all three phases the focus on direct environmental improvements is somewhat lacking. Biodiversity, climate adaptation are only found in the preparation phase, whereas soil quality is not mentioned throughout the phases. Health and well-being are partly integrated in the three lists under indoor environmental quality aspects like air and noise quality, but a holistic focus on health is missing for all three phases. This corresponds to the work of *Bossone et. al.*, who looked at Indicators of cultural heritage adaptive reuse impacts in the post- completion phase, and also found the absence of health and well-being indicators **(Bosone et al., 2021)**. Only few publications have looked at the relationship between health and heritage regeneration **(Carone et al., 2017)**, which indicates a new interesting research intersection. In line with *Foster & Krenin* and *Bossone et. al.* this research illustrates a need for more adequate and specific environmental decision criteria for adaptive reuse, including a more holistic approach to health and well-being criteria.

The knowledge presented in this paper was limited to the reviewed literature. The limitations of this study can be linked to the subjective interpretations of the decision criteria that was noticed during the analysis part of the study. During the thematic reflexive analysis the decision criteria were clustered into main categories and objectives based on the interpretation of the author. For the clustering into the main criteria categories the extended definition framework by *Ikiz Kaya* was used but the formulation of objectives was done based on the authors judgement. Although the subjective interpretation of the author is considered a strong point of the reflexive thematic analysis **(Braun & Clarke, 2012)**, It can also lead to inconsistency and a lack of coherence when developing themes from the data **(Holloway & Todres, 2003)**.

4.1 Conclusion and recommendations for further research

The aim of this paper was to provide a state-of-the-art overview of the decision criteria for adaptive reuse throughout the AR process, in order to identify areas for future research. Three phases where decision criteria can be used in the adaptive reuse process were substantiated, and three lists of decision criteria were established. The decision criteria for adaptive reuse have been categorized and discussed in relation to these phases. The proposed lists of decision criteria per phase in the AR process, provides stakeholders with a state-of-the art overview of relevant factors to consider throughout the whole adaptive reuse decision making process. The results can also serve as a resource when considering which criteria to include in sound multicriteria decision making approaches for adaptive reuse.

The analysis of the literature has revealed that the decision criteria show a lot of similarities between the different phases in the adaptive reuse process. The most repeated decision criteria throughout the different phases correspond to the economic and architectural/ physical categories. The subtle differences that arise can be explained through the logical inherence relating to the aims of the different phases.

Based on the research findings the following recommendations for further research are provided to advance the literature on decision criteria for adaptive reuse:

- More research is needed on the differences in weighting and importance of the decision criteria of adaptive reuse between the different phases of the AR process

- More research is needed on the differences in evaluating and measuring the decision criteria per phase in the AR process.
- The implementation phase is largely overlooked with regards to adaptive reuse decision criteria. Due to the arrival of circular design practices such as design for disassembly, the complexity of decisions in the implementation phase will only increase in the future, highlighting the need for more research into the decision criteria in this phase.
- Alternatives and options considered in the multi criteria decision making models for adaptive reuse should consist of more holistic scenarios that provide a general overview of what is possible when pursuing adaptive reuse. Alternative and options that are currently used in MCDM models are either really specific (specific design options), or really broad (functional use).
- Environmental decision criteria should be considered from a more broader perspective looking at: biodiversity, climate adaptation, soil quality and health and well-being. More research is needed on the correlation between these aspects and adaptive reuse.

Finally, as stated at the beginning of the article AR can contribute to, and is therefore very much in line with CE ambitions. It is very interesting to note therefore there is a gap between theory and practice when it comes to circularity performance and adaptive reuse **(Ikiz Kaya, et al., 2021).** Although circularity aspects are embedded in the decision criteria for adaptive reuse, this is not translated into the actual circularity performance of adaptive reuse projects. More research in needed into the circularity performance of adaptive reuse projects, and the inclusion of circular strategies in holistic adaptive reuse scenarios.

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