

## A BIBLIOMETRIC ANALYSIS OF THE CONCEPTS AND METHODS USED IN THE ADAPTIVE REUSE

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### Abstract

*Adaptive reuse is the transformation of a building because of its inability to meet today's needs, bringing it into society. In the process of change and transformation, the original function of the building, building materials, and social, economic, and socioeconomic situations should be considered. Since the adaptive reuse strategy is a versatile and comprehensive concept, some terms with a similar sense are also used. Additionally, there are various methods of implementing this strategy. These methods can be traditional methods used from the past to the present, or they can be innovative methods created by combining more than one method. In this study, which concepts are used in a similar sense to the concept of adaptive reuse and which innovative methods are applied in this strategy were determined as a research question. The aim of the study is to conduct concept and method research to find an answer to the research question. This study covers the examination of adaptive reuse strategies through academic studies. At this point, the bibliometric analysis method was used. By applying the bibliometric analysis method, the concepts, and innovative methods in the titles of the academic publications examined in the Web of Science database were analysed.*

**Keywords:** *Adaptive reuse; Architectural heritage; Bibliometric analysis; Historical building*

### Introduction

Buildings are usually built for specific purposes. As the usage purposes change or disappear day by day, the needs also change. To meet these needs, functional transformation of these buildings is provided [1]. The concept of adaptive reuse emerges in the act of transforming a building from its original function to a different function. The change process is often seen as causing significant physical changes to the building [2]. Contemporary adaptive reuse practices, besides trying to ensure intellectual validity, also contribute to economic development [3]. The adaptive reuse strategy applied to historical buildings consists of comprehensive parameters. Economic, social, sociocultural, and sustainability aspects need to be considered. The preservation of the historical texture should be ensured in the transition of historical buildings to a new function because of the loss of their current function [4]. Adapting the existing building materials architectural features to the new function is one of the important steps towards sustainability. Extending the life cycle of historical buildings with the adaptive reuse strategy offers advantages in terms of saving space usage and extra costs. Adaptation and modernization of historical buildings to new functions may vary depending on the technical condition of the building, its cultural values, and other characteristic features brought by its original form [5].

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Different definitions and advantages of the concept of adaptive reuse in academic studies are given. G. Foster and R. Saleh [6] stated that adaptive reuse of architectural heritage ensures efficient use of natural resources, protection of energy systems in the building, reduction of construction and demolition waste, and minimization of greenhouse gas emissions. I. Vardopoulos [7] defined the concept of adaptive reuse as an important factor for sustainable urban development and the use of city resources. G. Assefa and C. Ambler [8] stated that adaptive reuse preserves the world's cultural heritage, supports the life cycle of materials and resources, and reduces waste by reusing structural elements and recycled materials. S.S. Lewin and C. Goodman [9] expressed adaptive reuse as what communities gain through transformative regeneration. J. Douglas [10] defines adaptive reuse as any construction work or intervention to adjust, reuse, or alter a building's capacity, function, or performance to suit new conditions or requirements. A. Chapman [11] emphasised that adaptive reuse of architectural heritage not only provides the transfer of history from the past to the future but also highlights the needs of the contemporary world.

An adaptive reuse strategy is used to reintegrate architectural heritage into society. With this strategy, a bridge is built from the past to the present, and it is ensured that the architectural building stock is maintained for future generations. In this study, the importance of an adaptive reuse strategy was emphasised, and published academic studies were examined. Academic studies were evaluated based on bibliometric analysis data. It has been determined that different architectural terms are used in the academic studies examined. The titles of academic studies were analysed, the concepts used were classified, and the most commonly used concept was highlighted. Additionally, the methods used in the adaptive reuse strategy were investigated. Innovative methods were identified and explained in which academic study and for what purpose they were used. It is aimed at contributing to the literature by compiling these methods, which constitute a reference for future studies.

## **Materials and Methods**

Bibliometric analysis is an analysis method that has increased in popularity recently [12, 13]. Academic publications made in bibliometric analysis can be classified into the categories of articles, authors, and journals [14, 15]. Bibliometric tools are used in data that are transformed into an academic structure with bibliometric research [16]. VOSviewer and biblioshiny programmes were used in the creation of this academic structure. Scientific mapping and visualisation can be done with a VOSviewer, and diagrams of parameters such as citation, country, and keywords in academic studies can be created with biblioshiny [17]. Biblioshiny is a product of the Bibliometrix R-package and is powered by Bibliometrix [18]. In this study, the links between the most cited articles were evaluated by bibliometric analysis.

Academic studies published in the Web of Science database were reviewed for bibliometric analysis on adaptive reuse. The Web of Science Core Collection database was chosen because it has an interdisciplinary scope and includes many scientific publications [19, 20]. For research in the database, "conversion" or "transformation" or "adaptation" or "renovation" or "renewal" or "refurbishment" or "remodelling" or "rehabilitation" or "regeneration" keywords have been determined. As a subject, the research was conducted with the words "adaptive reuse" or "architectural heritage" (Fig. 1). Academic studies between the years 1998 and 2022 were examined according to the year of publication. As to document type, articles, book chapters, proceeding papers, and reviews are selected. Academic studies published in English are within the scope of this study. Because of the determined criteria, 260 publications and 533 author networks were reached.

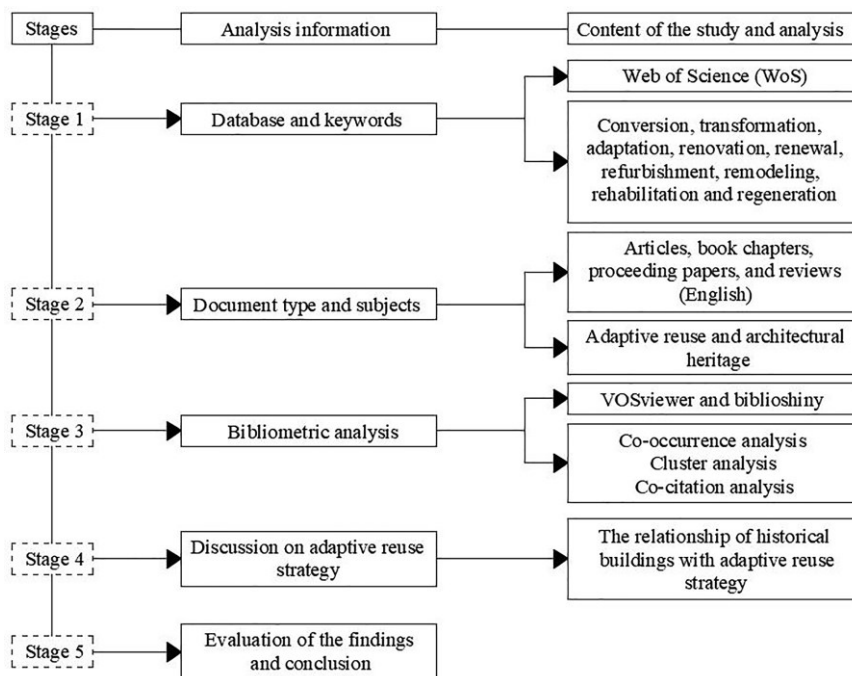


Fig. 1. Method and flow chart of the study

## Results

Scientific data were obtained by examining the characteristics of the publications with bibliometric analysis. An in-depth review of academic studies has been made, and the systematic classification of data has been presented under subheadings. Analyses were made under the subheadings of publications by years, publications per country, research areas, the total number of publications on publication platforms, authors, and the most cited publications and keywords. Most of the 260 articles obtained because of the analysis of the determined keywords were published in journals.

### *Analysis of Publications by Years*

The distribution of studies by year shows in which years the subject was popular. It can be said that this subject is a trend in the years when the publications are concentrated. The first publication was made in 1998 in the analysis, which was not restricted by the year of publication. Based on the Web of Science data, the number of publications made in 1998 was 1. There were no publications between 1999 and 2004. Until 2006, the number of publications was close to zero. Until 2010, the highest number of publications was in 2007 and there were 4. After 2010, it was seen that awareness was formed and the number of publications increased. In 2015, nine publications were made, and after this year, the number of publications increased to double digits. There were 16 publications in 2016, 17 in 2017, 14 in 2018, 28 in 2019, 42 in 2020, 55 in 2021 and 31 in a ten-month period until November 2022. In 2020 and 2021, the number of publications reached its maximum level. A continuous increase was detected between 2018 and 2021 in the number of publications, which fluctuated until 2018 (Fig. 2). The annual growth rate is seen as 15.38%. The average number of citations per year has increased as it approaches today. Until 2006, the number of citations was close to zero. Although the number of citations was 0.2 in 2007, it was 2.1 in 2009. The highest number of citations until 2010 was in 2009. As of 2010, the average number of citations per year had also increased. In this context, the average number of citations was 3.4 in 2012, 3.8 in 2018 and 4.2 in 2020. The

highest average number of citations occurred in 2020. Based on the annual publications, it has been concluded that adaptive reuse has started to gain importance since 2010, and it is a current issue in the architecture sector.

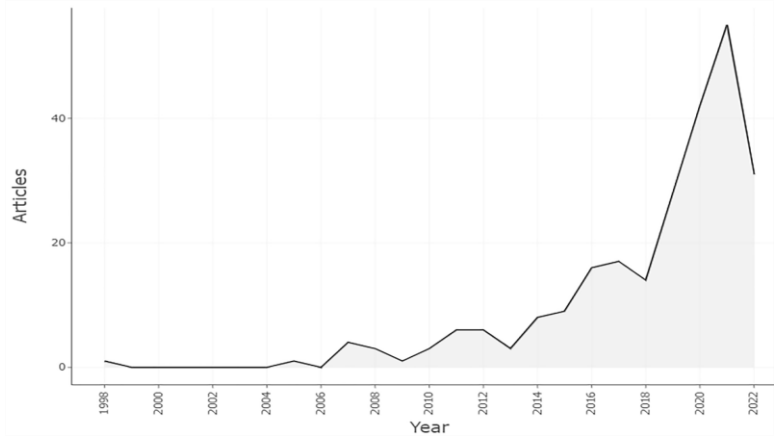


Fig. 2. Annual scientific production

*Analysis of Publications per Country*

By making a publication analysis according to the countries, it has been determined in which countries the adaptive reuse issue plays an active role. Depending on the conservation and restoration seen in these countries, the frequency of academic studies is directly proportional. In the analysis conducted according to the number of publications per country, it was observed that there are studies on the subject in 54 countries. Italy is the country with the highest number of publications, with 45 publications (Table 1).

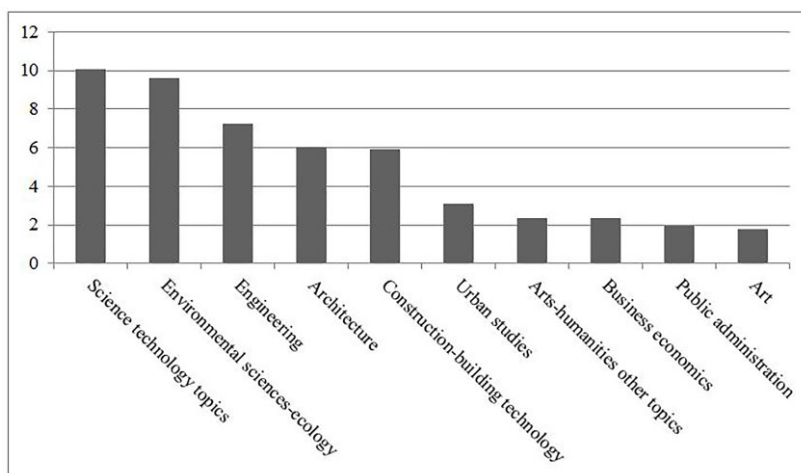
Table 1. Number of publications per country

Rank	Country	Number of articles	Country	Number of citations
1	Italy	45	China	401
2	China	28	Australia	226
3	Australia	19	Italy	223
4	Turkey	17	Austria	140
5	Malaysia	15	New Zealand	85
6	Iran	12	Greece	67
7	Poland	11	Egypt	64
8	Belgium	10	Malaysia	64
9	Egypt	10	Singapore	63
10	England	9	Spain	60
11	USA	9	Cyprus	59
12	Netherlands	8	Turkey	48
13	New Zealand	8	Lithuania	47
14	Spain	8	Serbia	44
15	Greece	6	Canada	43
16	Indonesia	6	Netherlands	41
17	Croatia	5	Poland	38
18	Serbia	5	Belgium	35
19	Austria	4	Iran	29
20	Canada	4	India	25

Italy was followed by China with 28 articles and Australia with 19 articles. Proof that scientific research is qualified depends on the number of citations. At this point, the number of citations increases the visibility of the research. Looking at the number of citations per country, China ranks first with 401 citations. Australia has 226 and Italy has 223 citation numbers. The number of countries with a publication number is 18. When the number of publications and citations is analysed, it is seen that scientific studies are concentrated in Italy, China, and Australia. Although the number of publications in Italy is higher than the number of publications in China, it has been determined that the number of citations is behind. While Austria was in nineteenth place in terms of the number of publications, it ranked fourth in the number of citations and showed a significant increase. Cyprus, which has 2 publications, is in the 28th rank in terms of the number of publications, whereas it has risen to the 11th rank in the number of citations. This shows that the publications made in Cyprus are qualified academic studies.

### ***Research Area Analysis***

Of the 260 research academic publications, 202 are articles, 46 are proceeding papers, 10 are review articles, and 2 are book chapters. As shown in figure 3, research areas covering publications related to adaptive reuse in the historical heritage have been determined. The research areas with the most academic studies are science technology topics related to 68 publications; environmental science-ecology related to 65 publications; engineering related to 49 publications; architecture related to 41 publications; construction-building technology related to 40 publications; urban studies related to 21 publications; and related to 16 publications. It consists of arts-humanities topics, business economics related to 16 publications, public administration related to 13 publications, and art branches related to 12 publications. Looking at the percentages in terms of record count among 130 articles, science technology topics (10%), environmental science-ecology (9.6%), engineering (7.2%), architecture (6.6%), construction-building technology (5.9%), urban studies (3.1%), arts-humanities (2.3%), business economics (2.3%), public administration (1.9%), and increased 1.7% are the research areas with the most publications. As a multidisciplinary field, the discipline of architecture is fed by other fields. The field of construction-building technology is seen as the closest science to architecture and constitutes the category that has the most impact on the field of architecture.



**Fig. 3.** Percentage rates of research areas considering data from the Web of Science database

***Analysis of Total Publications on Publication Platforms***

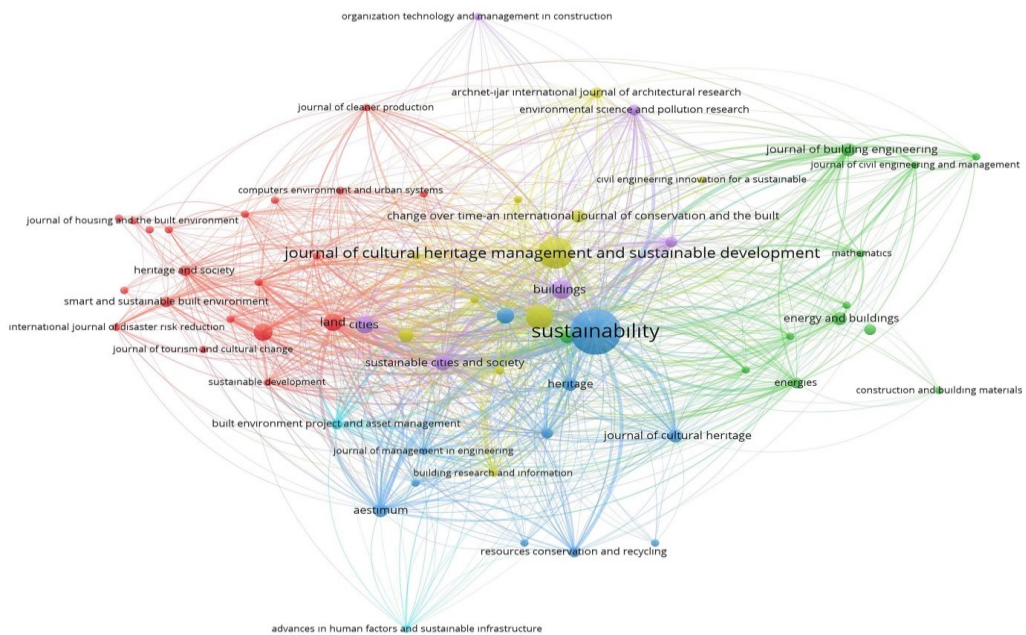
Determining the publishing platforms with the highest number of publications in the literature studied is important in terms of understanding the journals and other publishing platforms where the research topic is most appropriate. The 260 research articles were published on 145 different publishing platforms. At the top of the list is the Sustainability Journal, with 33 publications and 402 citations (Table 2). This journal publishes articles dealing with various issues related to sustainability. This journal is followed by the Journal of Cultural Heritage Management and Sustainable Development (16 publications, 57 citations) and the International Journal of Building Pathology and Adaptation (10 publications, 49 citations). Although the number of publications is the same, the number of citations for the articles in the Cities journal differs according to the articles in the Environment-Behaviour Proceedings and Land Journals. Although there are three publications on adaptive reuse in the Journal of Cultural Heritage, there is a high rate of citations. It has been determined that the citation rate in the proceeding papers is low compared to the journals.

**Table 2.** Journals in which articles were published

<b>Academic journals</b>	<b>Number of articles</b>	<b>Number of citations</b>
Sustainability	33	402
Journal of Cultural Heritage Management and Sustainable Development	16	57
International Journal of Building Pathology and Adaptation	10	49
Buildings	6	13
Cities	5	183
Environment-Behaviour Proceedings Journal	5	5
Land	5	8
Journal of Architectural Conservation	4	27
Sustainable Cities and Society	4	151
Aestimum	3	23
Change Over Time-An International Journal of Conservation and The Built Environment	3	5
Energy And Buildings	3	125
Facilities	3	140
Habitat International	3	172
Heritage	3	22
Journal of Building Engineering	3	28
Journal of Cultural Heritage	3	223
Applied Sciences	2	8
Archnet-Ijar International Journal of Architectural Research	2	21
Built Environment Project and Asset Management	2	28

There are 110 publication platforms with 1 publication number. There are 35 publication platforms with at least 2 publication counts. In figure 4, the total number of publications on publication platforms is presented by visualization. Articles in Land and Computers, Environment and Urban Systems, and the Journal of Heritage Tourism were mostly published around 2022. Articles in Sustainability, Applied Sciences, Environmental Science and Pollution Research, and the Journal of Cleaner Production were mostly published in and around 2021. Articles in Cities, Journal of Cultural Heritage Management and Sustainable Development, and Symmetry are mostly published in and around 2018. Journal of Cultural Heritage, Built Environment Project, and Asset Management, Change Over Time: An International Journal of

Conservation and the Built Environment, Habitat International, International Articles in the Journal of Hospitality Management, and International Development Planning Review were mostly published in and around 2015. When we look at the citation networks of the journals with each other, the Sustainability journal comes to the fore.



**Fig. 4.** Links of journals by total number of publications on publishing platforms

### *Analysis of Authors and Most Cited Publications*

The academic publications evaluated on adaptive reuse consist of 533 authors. The number of authors of academic publications with one author is 65; the number of authors of academic publications with more than one author is 468. There are 467 authors with one academic publication, 36 with two academic publications, 18 with three academic publications, 7 with four academic publications, 4 with five academic publications, and 1 with six academic publications. Edwin H.W. Chan 268, Esther H.K. Yung 250, Gillian Foster 140 and Craig Langston are the authors with the highest number of citations with 134 citations. Table 3 presents the authors with the highest number of academic publications because of the analysis between 1998 and 2022. In 2020, article trends and consistency seem to intensify.

**Table 3.** Top 20 authors with the highest number of citations

Rank	Author	Total citation	Total document	H-index	Rank	Author	Total citation	Total document	H-index
1	Edwin H. W. Chan	268	5	4	6	Peter Love	85	2	2
2	Esther H. K. Yung	250	5	4	7	Itohan Esther Aigwi	79	5	4
3	Gillian Foster	140	4	4	8	Marta Bottero	79	5	4
4	Craig Langston	134	6	5	9	Jason Ingham	78	4	4
5	Sheila Conejos	87	3	3	10	Ioannis Vardopoulos	76	4	3

Rank	Author	Total citation	Total document	H-index	Rank	Author	Total citation	Total document	H-index
11	Alessandra Oppio	65	3	3	16	Kağan Günçe	47	3	3
12	Peter Bullen	58	1	1	17	Olga Filippova	46	3	3
13	Temitope Egbelakin	55	2	2	18	Robyn Phipps	46	3	3
14	Michael Y. L. Chew	50	2	2	19	Damla Mısırlısoy	42	3	2
15	Chiara D'Alpaos	50	2	2	20	Stephen Wei-Hsin Wang	42	1	1

Seventy-five publications, including articles published in 2022, have not yet been cited. There were 57 articles that were cited at least 10 times. The number of articles cited at least 20 times is 27. There are 13 academic publications with over 30 citations (Table 4). Two articles with more than 100 citations were identified. E.H. Yung and E.H. Chan [21] is the most cited article within the scope of this research. Foster [22] and I. Vardopoulos [7] are other academic publications with high citation counts. When the first 20 most cited articles analysed are evaluated, 18 of them are articles and 2 of them are review articles as document types. From this perspective, it is seen that the citation rate of the review article, proceeding papers, and book chapter publications is low in the general table.

**Table 4.** Analysis of the 20 most cited academic publications

Reference	Title	Document type/method	Number of citations
E.H. Yung and E.H. Chan [21]	Implementation challenges to the adaptive reuse of heritage buildings: Towards the goals of sustainable, low carbon cities	Article/literature review and interviews	161
G. Foster [22]	Circular economy strategies for adaptive reuse of cultural heritage buildings to reduce environmental impacts	Article/systematic literature review and synthesis methods	106
I. Vardopoulos [7]	Critical sustainable development factors in the adaptive reuse of urban industrial buildings. A fuzzy DEMATEL approach	Article/a Fuzzy-DEMATEL analysis	60
G. Bullen and G. Love [23]	A new future for the past: a model for adaptive reuse decision-making	Article/interviews and content analysis	58
E.H. Yung <i>et al.</i> [24]	Adaptive reuse of traditional Chinese shophouses in government-led urban renewal projects in Hong Kong	Article/literature review, technical assessment, qualitative analysis, and ARP model	48
S.W.H. Wang [25]	Commercial Gentrification and Entrepreneurial Governance in Shanghai: A Case Study of Taikang Road Creative Cluster	Article/an analysis of Shanghai's urban restructuring and a case study of Taikang Road Creative Cluster	42
M. Yıldırım [26]	Assessment of the decision-making process for re-use of a historical asset: The example of Diyarbakir Hasan Pasha Khan, Turkey	Article/a simple technique for adaptive reuse that proposes to assist decision makers who have difficulty making decisions	40
C.S. Chen <i>et al.</i> [27]	Evaluating the adaptive reuse of historic buildings through multicriteria decision-making	Article/the integrated multicriteria decision-making method (a literature review, case analysis, and the fuzzy Delphi method)	39
D.A. Elsorady	Assessment of the compatibility	Article/literature review, semi-structured	37



Reference	Title	Document type/method	Number of citations
[28]	of new uses for heritage buildings: The example of Alexandria National Museum, Alexandria, Egypt	interviews, and and the case study	
S. Conejos <i>et al.</i> [29]	Designing for better building adaptability: A comparison of adaptSTAR and ARP models	Article/a new the adaptSTAR model with design-ratio tool and Langston's ARP model	37
M. Bottero <i>et al.</i> [30]	Ranking of Adaptive Reuse Strategies for Abandoned Industrial Heritage in Vulnerable Contexts: A Multiple Criteria Decision Aiding Approach	Article/multiple criteria approaches and a new application of the Preference Ranking Organization Method for Enrichment of Evaluations (PROMETHEE)	36
S. Conejos <i>et al.</i> [31]	Governance of heritage buildings: Australian regulatory barriers to adaptive reuse	Article/a qualitative approach (multiple case studies, building plan appraisals, field observation, and interviews)	34
I.E. Aigwi <i>et al.</i> [32]	Efficacy of adaptive reuse for the redevelopment of underutilised historical buildings: Towards the regeneration of New Zealand's provincial town centres	Article/A focus group workshop	32
Z. Morkūnaitė <i>et al.</i> [33]	A Bibliometric Data Analysis of Multi-criteria Decision Making Methods in Heritage Buildings	Review/a bibliometric data analysis	29
K. Günçe and D. Mısrılısoy [34]	Assessment of Adaptive Reuse Practices through User Experiences: Traditional Houses in the Walled City of Nicosia	Article/the literature survey, site surveys, and user experiences	28
K. Dyson <i>et al.</i> [35]	Critical success factors of adapting heritage buildings: an exploratory study	Article/an exploratory approach and semi-structured interviews	28
P. Love and P.A. Bullen [36]	Toward the sustainable adaptation of existing facilities	Article/a public review with the National Australian Built Environment Rating System (NABERS)	27
K.Y. Chong and A.S. Balasingam [37]	Tourism sustainability: economic benefits and strategies for preservation and conservation of heritage sites in Southeast Asia	Review/systematic literature review (peer-review journals, industrial report, documentary analysis, books and working paper)	26
A. Martinez-Molina <i>et al.</i> [38]	Assessing visitors' thermal comfort in historic museum buildings: Results from a Post-Occupancy Evaluation on a case study	Article/post-occupancy evaluation process with micro-climate monitoring and questionnaire surveys	26
R.R. Nadkarni and B. Puthuvayi [39]	A comprehensive literature review of Multi-Criteria Decision Making methods in heritage buildings	Article/a bibliometric analysis	25

The most cited publications are shown in figure 5 with the network visualisation map. Five different clusters appear, and studies that refer to academic studies with high citations are also seen in the network. Top citations and networking provide potential citations for future work. The contents of academic publications that received more than 40 citations were examined, and the subjects they specialised in were deepened.

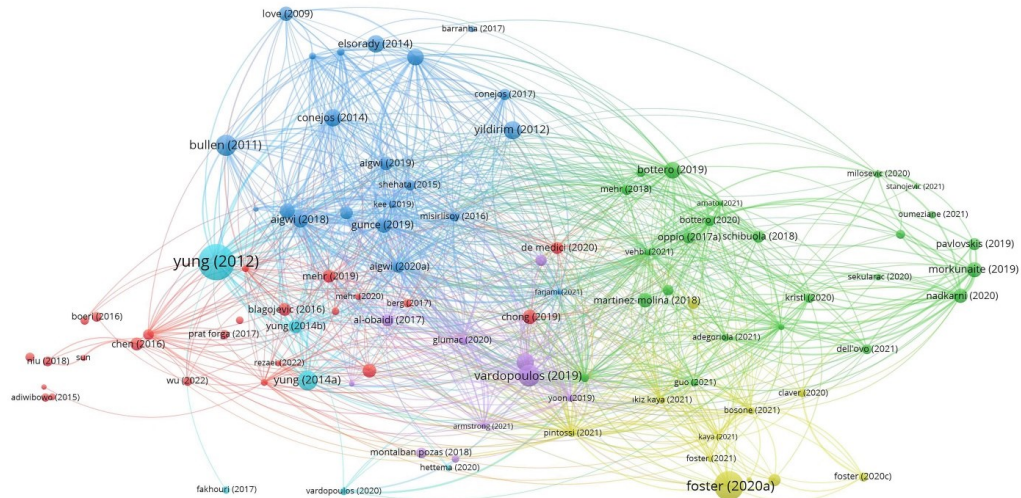


Fig. 5. The most cited publications

**Keyword Analysis**

In the analysis created for the keywords summarising academic publications, it was aimed to investigate the scientific outputs and determine the trends in adaptive reuse in the historical environment. In the analysis, word clusters and the connections between them are shown. With the maps of word clusters, the topics used in potential applications and studies were determined (Fig. 6).

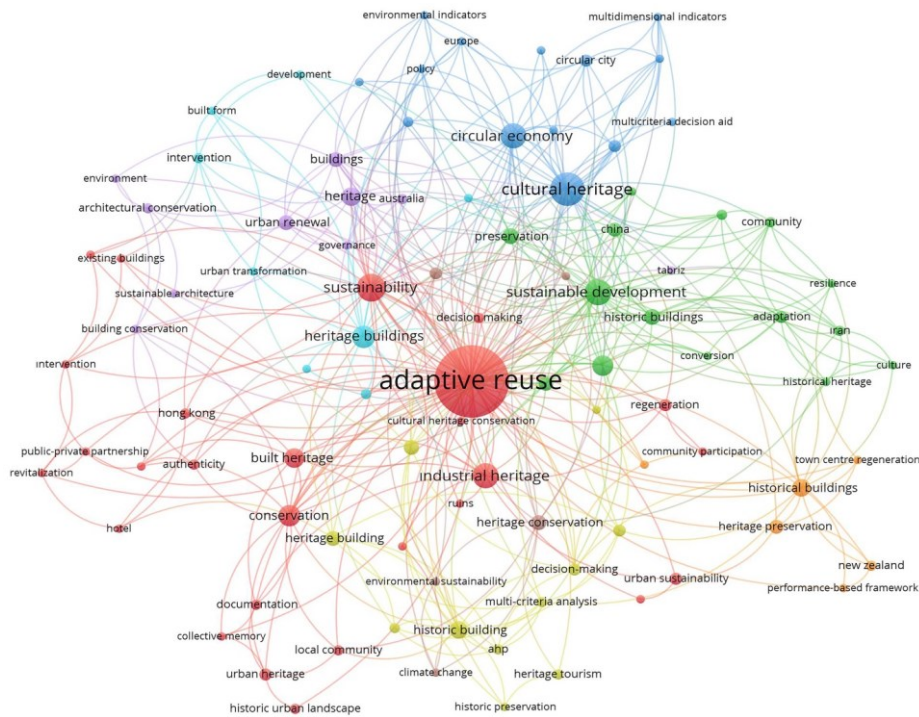


Fig. 6. Comprehensive keyword map

Clusters arranged according to colour were evaluated. Cluster 1 is the red zone with 20 common words. This cluster consists of adaptive reuse, authenticity, built heritage, collective memory, community participation, local community, conservation, decision-making, documentation, energy efficiency, historic urban landscape, industrial heritage, intervention, property management, regeneration, revitalization, ruins, sustainability, urban heritage, and urban sustainability terms. Cluster 2 is the green zone of 13 common words. This cluster consists of adaptation, architecture, community, conversion, culture, heritage management, historic buildings, historical heritage, industrial archaeology, industrial heritage, preservation, resilience, and sustainable development terms. Cluster 3 is the blue region containing 12 common words. This cluster consists of architectural heritage, built environment, circular city, circular economy, cultural heritage, cultural landscape, environmental indicators, impact assessment, intrinsic value, multicriteria decision aid, multidimension indicators, and policy keywords. Cluster 4 is the yellow region consisting of seven common words. This cluster consists of heritage building, heritage tourism, historic preservation, multi-criteria analysis, AHP, post-occupancy evaluation, and thermal comfort terms. Cluster 5 is the purple region that covers four common words. This cluster consists of architectural conservation, environment, governance, and urban renewal keywords.

When the words in the titles of academic publications are examined, the most commonly used word is "heritage." This word has been used 127 times. This word is "adaptive" with 120 times, "reuse" with 118 times, "buildings" with 59 times, "industrial" with 39 times, "urban" with 38 times, "historic" 37 times, "cultural" 36 times, "sustainable" 30 times, "building" 23 times, "city" 23 times, "study" with 23 times, "historical" with 18 times, "regeneration" with 18 times, and "development" with 16 times. Another application used in keyword analysis is the three-field diagram method.

The Three-Field Diagram shows the connections between the concepts by providing an examination of the hierarchical order in the research. Together with the diagram, links between authors, countries, keywords, titles, abstracts, sources, references, and cited sources can be created in triple combinations. In figure 7, the hierarchy between the keywords in the academic studies along with the countries of the 15 most cited authors on the research topic is revealed.

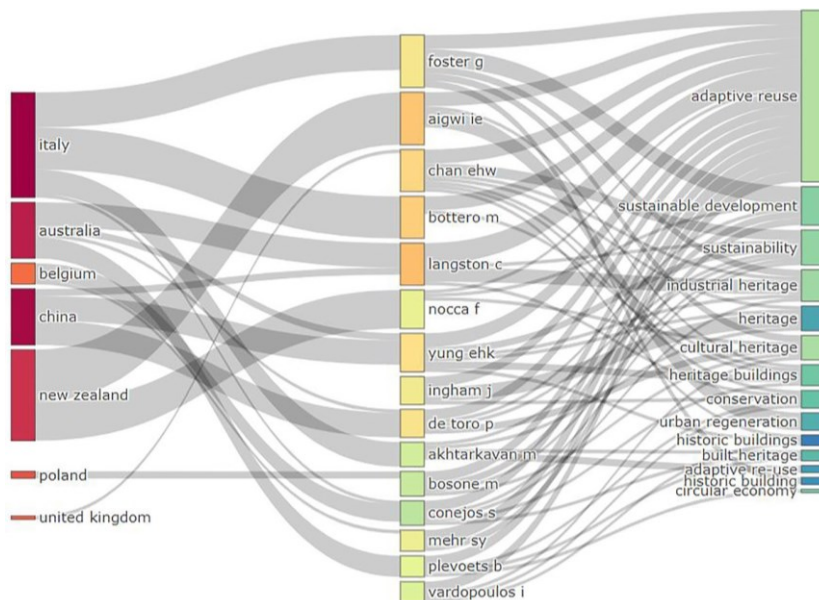


Fig. 7. Relationship between countries, highly cited authors, and keywords

In terms of countries, Italy, China, and Australia are the countries with which the authors interact the most. These countries are followed by Belgium, New Zealand, Poland, and the United Kingdom. Looking at the most popular keywords, adaptive reuse, sustainable development, sustainability, industrial heritage, and cultural heritage come to the fore. Circular economy is the least emphasised keyword in the academic studies of the most cited authors. This chart contains reference information for future studies on adaptive reuse.

### Discussions

The subject of adaptive reuse consists of extensive and comprehensive studies. In addition to the social, economic, and political dimensions of the buildings, architectural and aesthetic issues are also important. In the transformation of a historical building, the texture of the built environment, the preservation of existing structural materials, and the new systems to be integrated should be compatible with the old systems. Projects that provide structural integrity fulfil the basic condition of transferring them to future generations. In the academic studies examined, the projects that were renewed and brought to society were evaluated. In these studies, it has been observed that different concepts are used in different titles. Although the concept of adaptive reuse is the most commonly used term, it has been seen that alternative concepts are also derived. The concepts used in the titles of academic studies are given in Table 5. It has been determined that the concepts of re-use, (re)use, and reuse are mostly used after adaptive reuse. These two concepts were followed by the use of renewal and regeneration. Refurbishment stands out as the least used word. Looking at these data, it is concluded that the word "reuse" is used the most. It has been observed that the concept of "Adaptive reuse" is used the most in general terms.

**Table 5.** Terms used in the titles of the academic studies examined

Term	Reference
Adaptive reuse	E.H. Yung and E.H. Chan [21]; G. Foster [22]; I. Vardopoulos [7]; P. Bullen and P. Love [23]; E.H. Yung <i>et al.</i> [24]; C.S. Chen <i>et al.</i> [27]; M. Bottero <i>et al.</i> [30]; S. Conejos <i>et al.</i> [31]; I.E. Aigwi <i>et al.</i> [32]; K. Günçe and D. Mısırlısoy [34]; B. Plevoets and J. Sowińska-Heim [40]; I.E. Aigwi <i>et al.</i> [41]; E. Eray <i>et al.</i> [42]; S. Yazdani Mehr [43]; M. Cerreta <i>et al.</i> [44]; S. Niu <i>et al.</i> [45]; I. Vardopoulos <i>et al.</i> [46]; Takva <i>et al.</i> [47]
Re-use, (re)use, reuse	M. Yıldırım [26]; N. Rezaei <i>et al.</i> [48]; N. Lynch [49]; R.S. Adiwiwowo <i>et al.</i> [50]; J. Claver <i>et al.</i> [51]; D.M. Milošević <i>et al.</i> [52]; I. Grigorescu <i>et al.</i> [53]
Adaptation, adaptability, adaptivity	C. Conejos <i>et al.</i> [29]; K. Dyson <i>et al.</i> [35]; P. Love and P.A. Bullen [36]; S. Conejos <i>et al.</i> [54]
Conservation	K.Y. Chong and K.S. Balasingam [37]; H. Chung [55]; F. Nocca <i>et al.</i> [56]; T. Kwanda [57]; D. Jato-Espino <i>et al.</i> [58]
Renewal	S.S. Lewin and G. Goodman [9]; M.R. Blagojević and A. Tufegđić [59]; P. Guo <i>et al.</i> [60]; W. De Jonge [61]; M. Niehaus <i>et al.</i> [62]; W. Huang <i>et al.</i> [63]
Conversion	M. Pavlovskis <i>et al.</i> [64]
Regeneration	L.F. Girard <i>et al.</i> [65]; M. Sun and C. Chen [66]; I.E. Aigwi <i>et al.</i> [67]; A. Gravagnuolo and M. Varotto [68]; Y. Zhang <i>et al.</i> [69]; M. Swensen <i>et al.</i> [70]
Revitalization, revitalisation	L. Ren <i>et al.</i> [71]; H. Hou and H. Wu [72]
Refurbishment	Ž. Kristl <i>et al.</i> [73]

Different techniques are used in the adaptive transformation of historical buildings. In addition to comparative analysis, static and dynamic calculations, and energy analysis, multi-criteria decision-making methods have been developed. These methods consist of a combination of two or more methods. The methods developed for adaptive reuse in academic studies are shown in table 6, and these methods are explained by specifying what they are. In the decision-making

criteria, analyses are carried out according to the information received from literature studies, surveys, or stakeholders involved in the project. Since these methods can be used for future studies, they are reference studies.

**Table 6.** Innovative methods used in academic studies

Reference	Method	Description of the method
I.Vardopoulos [7]	A fuzzy-DEMATEL approach	As a tool for future decision-making, fuzzy-DEMATEL analysis and important factors affecting local sustainable development were determined through adaptive reuse projects.
E.H. Yung <i>et al.</i> [24]	The ARP model	An ARP model has been developed in which physical, economic, social, functional, technical, legal and political criteria are used in the application of adaptive reuse for the examined shop houses.
C. Conejos <i>et al.</i> [29]	The adaptSTAR model	The adaptSTAR model was developed to support the sustainable built environment, measure the feasibility of adaptive reuse technique for future buildings, and enable planning of long-lasting buildings for building designers. To verify the tool, the results were compared with the ARP model developed by Langston.
M. Bottero <i>et al.</i> [30]	The Preference Ranking Organization Method for Enrichment of Evaluations (PROMETHEE)	PROMETHEE aims to support the design and implementation of adaptive reuse strategies of abandoned industrial heritage. It establishes the relationship between tangible and intangible effects. This method is a helpful method for multi-criteria decisions.
I.E. Aigwi <i>et al.</i> [41]	A performance-based Multiple Criteria Decision Assessment (MCDA)	MCDA was used to balance the different interests of all stakeholders involved in adaptive reuse design in the decision-making process and to prioritize historical buildings that are suitable for adaptive intervention.
M. Pavlovskis <i>et al.</i> [64]	A three-dimensional digital model by applying BIM, an expert survey method, and the multiple criteria decision making (MCDM) method	Photogrammetry and 3D model (with Agisoft Photoscan, Autodesk ReCap and Autodesk Revit programs) were created by selecting a case study. Based on the model, the conversion alternatives and decision-making criteria of the selected building were determined. In addition, expert survey method was used. It is concluded that rational transformation decisions will be made with the proposed integration of modern digital technologies and decision-making models.
M. Bottero <i>et al.</i> [74]	The A'WOT analysis and a multi-criteria decision aiding approach	A multi-criteria decision aiding approach to support the restoration and conservation of cultural heritage assets and to rank valorization strategies is presented. With the A'WOT analysis, it is aimed to design and implement alternative management strategies of abandoned cultural heritage assets. A'WOT analysis is a combination of Analytic Hierarchy Process (AHP) and Strengths, Weaknesses, Opportunities and Threats (SWOT) Analysis.
I.Vardopoulos <i>et al.</i> [46]	PESTLE (the Political, Economic, Technical, Social, Legal, and Environmental aspects), SWOT, and AHP	Indicators obtained as a result of the combination of PESTLE framework and SWOT analysis with literature research were evaluated using AHP. Evaluations were made about adaptive reuse with the integration of multiple decision-making techniques.

Looking at the developed methods, it has been observed that they are generally supported by statistical data. Awareness is also created with these methods, which shed light on the development of adaptive reuse projects and the determination of their deficiencies. As a result of the analyses made on the transformed projects, the advantages and disadvantages are clearly seen. Sustainable parameters can be emphasised in addition to their architectural aspects, with the multidimensional approach of buildings.

## Conclusions

The adaptive reuse strategy ensures the efficient use of resources and sustains the transfer of architectural heritage to future generations. It revitalises the building by conserving the original texture of the building. An active built environment is created by bringing historical

buildings that have lost their original function to the economy. There are also studies on the transformation of these buildings in academic studies. In academic terms, various studies have been published on the basis of the definition, development, and methods of adaptive reuse strategies. It has been observed that different production systems and techniques are used in publications that are generally based on a case study. The historical building stocks of the countries also highlight the potential in that region, and studies are concentrated in these regions. With the development of academic studies that feed each other, there is a transition from traditional analysis methods to innovative analysis methods.

2021 is the year in which the most academic studies on adaptive reuse were made. At this point, it is seen that the adaptive reuse strategy is one of the trending topics today, depending on the analysis. At this point, it can be said that the academic studies brought to the literature are also reference studies for future studies. The most academic studies have been done in the journal *Sustainability*, and this journal ranks first in the highest number of citations. When the content of academic studies in which architectural heritages are analysed in the context of adaptive reuse strategy, it has been determined that different concepts are used in the titles. While the word "Heritage" is the most used word, the concept of "Adaptive reuse" is the most used term. When method analysis was performed, innovative methods using more than one method were determined. These methods are fuzzy, AHP, ARP, and adaptSTAR models; PROMETHEE, MCDA, and MCDM methods; SWOT and A'WOT analyses; and PESTLE. It is envisaged that these methods can be used for future studies and that more complex analysis methods will emerge by developing these methods.

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