RESEARCH ARTICLE

Technology use in archeology and historical building research: A citation, bibliographic coupling, and document analysis

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Abstract

The historic heritage composes the national identity, which is a reflection of social and cultural human activities in the past. Historical buildings and archaeological sites have been exposed to many damages over time. Preservation, conservation, and restoration (PCR) projects are costly in nature as they require a high degree of expertise and know-how. Since technology increases the efficiency of construction projects, the use of technology in conservation management may have a positive impact on PCR projects. The aim of this paper is to understand the use of technology in the archeology and historical building research (AHBR) in different countries and reveal gaps and trends in the research field. This study has adopted a holistic approach with bibliometric search and scientometric analysis such as document-based citation analysis, country-based citation analysis, and country-based bibliographic coupling analysis of scholarly research that use technology in the AHBR. Data about technology use in the AHBR were collected through an examination of articles that were selected from the Scopus database. Findings demonstrate that the use of technology in the AHBR makes it possible to obtain accurate information to manage the design, visualization, and construction throughout the life cycle of the historical building to increase efficiency in PCR projects. Technological developments contribute to the transfer of cultural heritage to technological platforms for sustainable and efficient PCR of built heritage environment. Therefore, the findings of this study may contribute to picture the research trend and gaps in the field as a guide to future research.

Keywords

Technology; Archeology; Historical buildings; Scientometric analysis and mapping

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1. Introduction

Archaeological sites and historical structures are social heritage elements that form the common memory of societies. These areas, which act as a bridge between the past and the present, become the symbol of where they belong in time. Historical heritage sites, which have become the center of attention by arousing the curiosity of domestic and foreign tourists, help development in the local economy of the countries [1]. Historical heritage

provides economic and sustainable contributions to the development of countries. Countries with historical heritage are concerned about the conservation of the heritage and are exploring new ways of conservation [2]. Natural disasters, environmental factors, and people cause distortions in the historical environment over time. The PCR ensures that the deteriorated parts of the historical buildings are renewed according to the original and transferred to the future preventing more damages.

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PCR interventions should be in accordance with abstract and tangible heritage elements and living values. The historical heritage should be conserved by integrating it with today's social, cultural, and economic life [3]. Using new technologies to maintain the historical heritage will be an extra contribution to the prevention of time and economic losses [2]. In many countries such as Germany, the United States of America, England, Belgium, Israel, Australia, efforts were made to prevent economic losses in conservation management and technological tools were used.

The biggest concern about the PCR of the historical heritage is the lack of data and information in the current heritage. Conservation management in the PCR processes are complex and laborious [2]. The most important part of the PCR processes is to document and arrange the information obtained from historical and archaeological sites. At this stage, many people from different specialties work such as archaeologists, architects, engineers, historians, and restorers. Therefore, the vast amount of information obtained during the documentation has a complex character. Technology offers tools like Geographic Information Systems (GIS) that help us organize this information. GIS should not only be perceived as X, Y, Z coordinates, it should be considered as a tool to express spatial relations. In this sense, GIS are systems developed to store, retrieve, and analyze geospatial data. By adding information such as photos, text descriptions, and thematic drawings to the GIS environment, a better understanding of the tangible and abstract features of the heritage is provided. Documentation enables the transfer of cultural heritage to future generations, determination of historical problems, obtaining information about the historical place, reviving the historical and archaeological heritage [4,5].

It is important to not destroying the archaeological data, which is one of the main aims of the research, during the research of archaeological heritage. The interventions should be limited to the conservation and scientific requirements of the research. Instead of excavating

all of the archaeological sites, research should be done with less harmful techniques [6]. Remote sensing techniques, one of the innovations brought by technology, might measure changes in large areas of the earth at a low cost and without damaging historical treasure. Synthetic-aperture radar (SAR) is an effective tool for monitoring ground deformations. SAR acquires a single image by electronically combining radar images gathered by multiple smaller radar units. Thus, it is possible to collect information on objects with complex surfaces. Interferometric synthetic-aperture radar (InSAR) uses two or more SAR images to create surface deformation and digital elevation maps. It can measure changes in the millimeter scale [7]. Laser Imaging Detection and Ranging (LIDAR) is a remote sensing technology that affects the covered vegetation and forest areas. LIDAR was caused by a fundamental change in Mesoamerican archeology and made great contributions to research in forested areas worldwide [8]. Ground Penetrating Radar (GPR) is a geophysical science-based measurement device used to investigate shallow layers of underground. It allows the underground to be viewed and investigated without excavation [9].

Analyzing the rocks in the archaeological sites in Ethiopia, South Africa, and Israel, economic and cultural connections linking these regions to the vast world can be established. Morphometry is a quantitative analysis of size and shape and has been widely used in the analysis of landforms and rocks, especially since the widespread adoption of GIS and remote sensing techniques. Morphometric measurements of the seashells found on the beaches of South Africa enabled archaeologists to obtain more metric information [10].

Finding forested lands in archaeological researches in the USA made search processes difficult. The fact that most residues are located in forestland has prevented the understanding of the activities of people living in the past. Archaeological features under forest canopies have been discovered via remote sensing technologies. LIDAR, which uses light pulses to measure the height of reflective surfaces, is a remote sensing

tool. It has been proven through LIDAR that there are larger monuments and buildings than expected in dense tropical forests [11]. By transferring the data obtained by remote sensing technologies to GIS, where the fossil sites can be found has been seen more effectively. Archaeologists have made great advances in research in the areas of America with GIS and remote sensing technologies. Hidden features in known areas have been revealed with these tools [12].

The Olduvai Gorge region in Tanzania is one of the important paleoanthropological areas. The topographic features of the archaeological remains and the area in this area were integrated into GIS systems and spatial analysis of the area was made. The world-famous fossil and stone instrument records in this area constitute stratigraphic evidence. By creating a geochemical and mineral analysis of fossils and stones, geochronology is created [13]. In the past few years, 3D scanning and GIS potentials have been tested for the analysis of impact marks in percussion instruments in archaeological sites. Damage to the instruments has been identified and calculations have been made. Morphometric analyzes were obtained from the differences between the damages. Natural and anthropogenic damage tissues were distinguished by analyzing morphometric properties in terms of surface, volume, environment, and area with GIS and 3D scans. Another research is that the surface change in the tools they used to break bones was processed into GIS software using a microscope and 3D surface measurements were obtained. Thus, researchers were able to record important changes in surface topography on a micro-scale [14].

The use of technology in conservation management ensures that heritage knowledge is preserved as a whole. Technological tools used to organize documentation are Laser Scanner, Terrestrial Laser Scanner, Digital Closed Range Photogrammetry (DCRP), and Unmanned Aerial Vehicles (UAV). Photogrammetry methods provide reliable information by documenting the physical environment. DCRP measures by photographing the object directly creates the document via photos and mathematical equations.

Dangerous or inaccessible areas, a fire destroyed heritage are evaluated easily and safely with DCRP [4]. The image generated by UAV photogrammetry is the same as in the topographic map and it allows direct measurement of distances, angles, plane coordinates, and areas [15]. UAV represents an economic technology in data collection and may be equipped with high-resolution cameras to create images [16]. Photogrammetry tools produce high-resolution 3D models that reveal the main object structure. Laser scanning is another method, creates geometric models by generating dense three-dimensional (3D) point cloud data. In general, 3D objects are constituted in complete and detailed by combining digital photogrammetry data and laser scanning data [17]. Terrestrial Laser Scanner measures the 3D spatial information of the object at a distance from the ground using a laser. Superior working power and portability enable a large historical area to be scanned quickly [15].

The change of environmental conditions and the vegetation of the archaeological sites make it difficult to conduct research in these areas and may cause a lack of information. Technological advances may be used to reveal such archaeological sites and remains found in some countries. For example, a medieval temple complex has been found in research conducted in the Angkor region of Cambodia and has been the focus of most research in recent years. Based on the researches, the development process of Angkor's public architecture was understood. Remote sensing technologies are used to map the finds in Angkor. Thus, the archaeological topography of the residential complex was created almost completely, regardless of the environmental conditions and vegetation [18]. As another example; data documentation has been carried out in the archaeological areas in South America without harming the site conditions using UAVs. Data from UAVs were used to obtain a Digital Surface Model (DSM) [19]. In Africa, digital simulations have been obtained in order to better understand the ecology, behavior, and systematic of an endemic bird species [20].

Building materials determine the characteristics of the historical building. The materials used throughout history have been diversified like stone, brick, wood, concrete, etc. according to the environment in which people live. Separate solutions are produced to protect each material from deterioration [21]. Technology assists the materials to be used in the renovation and construction of the buildings by determining the properties of the materials with the developed techniques. Thermal Stimulated Luminance (TSL) and Optically Stimulated Luminance (OSL) are methods used for dating. TSL measures the radiation released by heating the substances. OSL records the radiation that occurs when its substances are exposed to light [22]. In some regions, there are historical buildings made of alloy materials. The X-Ray Fluorescence (XRF) method used to understand this alloy content is another technological method [23].

Some of the archaeological evidence is organic findings containing carbon. The density or radioactivity of the radiocarbon isotope contained in these residues can be determined and the area of the ruins and residuals can be dated. The radiocarbon dating method has been the main method used for dating archaeological and earth science events [24]. Radiometric dating is used to determine the fossilized life forms and the absolute age of the rocks. The branch of science that uses radiocarbon dating and radiometric dating methods and investigates the age determination of fossils and rocks is defined as geochronology [25].

Building Information Modeling (BIM) is one of the newest developments in the construction industry. Building Information Modeling, which has gained great attention in recent years, includes construction and post-construction process information integrated into design information [26]. BIM model gives the geometry of building elements, spatial relations, geographical information, material information, project schedule, and cost estimates. It enables the development of n-dimensional models that demonstrate the entire life cycle of a structure. In this way, the scope of the work may be easily defined [19]. BIM significantly reduces the costs

and duration of construction, minimizing the margin of mistakes during construction. 3D model, consisting of smart elements, is constructed at the beginning of the project. It is used as a knowledge exchange platform by all stakeholders [27].

Technology triggers the sustainability of historical heritage by transferring knowledge to the future in a unique way [28]. The Historic Building Information Modelling (HBIM) platform was developed as an extension to BIM, and transfer the archeological sites and historical buildings to the digital environment with 3D modeling. The HBIM model occurs by integrating documents acquired from photogrammetry and laser scanning into the 3D model. Conservation management data such as 3D models, programs, details, plans, and sections are organized with the HBIM platform [2]. Conservation management stakeholders may learn about the entire life cycle of the project through a single model like BIM model. The main aim of the HBIM platform is to reduce the cost of the PCR of historical buildings and to increase the efficiency of conservation management. Even if the historical structure is lost, the continuity of information and culture will be provided with HBIM [27].

Technological developments have reduced the distance between visitors and historical heritage by transferring cultural heritage to digital platforms. It contributed to the economy by creating new social, economic and cultural opportunities [28]. Virtual reality (VR) transfers users to a 3D virtual world. Users can move the virtual world without touching the real world around them, they can touch virtual objects as if they are real [29] VR that uses the 3D model produced by architects, has enabled the structures to be experienced by users before they are built. Improvements have been made in interoperability, time and cost savings, design review, safety and site applications via VR, which receives a growing interest in the AECO/FM industry [30]. Augmented reality (AR) technology combines virtual objects with the real world in a computer-generated space in real time. This allows users to see the real world in real time with virtual object information. Real and virtual environments are combined in a mixed reality (MR) system to

create a new environment where physical and digital objects coexist and interact [31]. Expanded reality (XR) is a type of reality that combines and uses the properties of VR, AR, and MR [29]

In this study, a scientometric analysis was carried out to reveal the tendency of the studies of countries on the use of technology in the AHBR in the literature. The method used in the research is explained in the next section. Then, the results obtained from the method used are explained and the trend in the literature is discussed. Finally, explanations were made with a short summary of the research conducted in the conclusion section.

2. Methodology

In this research, the trend of the use of technology in the AHBR in the literature has been demonstrated using bibliometric search and scientometric analysis such as document-based citation analysis, country-based citation analysis, and country-based bibliographic coupling analysis. Bibliometric search data were obtained from the Scopus database. The Scopus database includes more information than other databases for literature searches due to the constantly growing resource database [32].

Scientometric analysis and mapping show the relationship between different professions, authors, and articles. It limits the areas of research to determine the structure and evolution of a scientific field [33]. The VOSviewer program has been developed for the creation and viewing of scientometric analysis results in the form of maps. Vosviewer supports create maps based on keywords, authors, documents, and journal data [34]. The VOSviewer program was used to calculate and analyze the data by utilizing natural language processing and machine learning algorithms to examine the use of technology in the AHBR in the research area.

Scopus' API search is a system using Boolean Syntax and allows combining keywords with operators to refine the search for getting consolidated and relevant results. Bibliometric search was performed using the Boolean Syntax with combining words of {technology} AND

{historical building} OR {archeology} OR {archeological site} OR {historical building preservation} OR {building conservation} via the Scopus database. As a result of this research, 873 results were reached. English language limitation was implemented and 808 files were reached. 682 documents were obtained by selecting disciplines of Engineering, Computer Sciences, Social Science, Energy, Arts, and Humanities, Environmental Science, Energy, Economy, Decision Science, and Business and Management. 678 articles were reached by selecting journals, books, book series, conference proceedings. Subsequently, all data is selected for export.

Country-based citation analysis was conducted to reveal the relations of the countries to which the publications belong. The minimum number of publications belonging to one country is 10, and the minimum number of citations from one country is 1. The threshold has reached by 21 countries out of 74.

Country-based bibliographic coupling was performed to show common references in publications of countries. The minimum number of publications belonging to one country is determined 10, and the minimum number of citations from one country is 1. The threshold has reached by 21 countries out of 74.

Document-based citation analysis was done for published articles and trends of the articles and their place in the literature was determined. The minimum number of documents cited was determined as 40. The threshold net by 71 documents out of 552. 24 documents that included in the subject of research were selected.

3. Findings

3.1. Results of the country-based citation analysis

The use of technology in the AHBR is an area that develops via research conducted in different countries. The citation analysis was made to reveal the country-based impact on the literature, and the scientometric map obtained as a result of the scientometric analysis as shown in Fig. 1. As a result of the analysis, 6 clusters have occurred. Each

of the clusters was shown in a different colour. Links between circles, colors, and distance show the relationship between the country pairs. It is seen that five of these clusters are connected, one cluster is separate and distant from them.

The data obtained as a result of the analysis are listed in Table 1 are analyzed, the three countries that publish the most about the use of technology in the AHBR are United States, United Kingdom, and Germany. Total link strength reveals the strength of a country-based research link with other countries. The three countries with the highest total link strength value are respectively, the United States, Germany, and France. When the research of the three countries is examined, it is seen that computer simulations, which are the tools of modern technology, are involved in the studies and they have conducted studies on excavations in the Tanzania region.

3.2. Results of the country-based bibliographic coupling analysis

The bibliographic coupling shows the overlap in the reference lists. If there is a common publication

specified in both publications, the two publications are combined bibliographically. The common reference number of the two publications reveals the strength of the bibliographic coupling relationship between publications [35]. Bibliographic coupling analysis of the country was conducted to investigate the bibliographic coupling relationships of countries. As a result of the analysis, the network visualization map shown in Fig. 2 has been created. The five different colors shown on the map represent the five clusters formed as a result of the analysis. Each circle represents a country. The links between the circles and the distance reveal the publishing relations between the country couples.

The data obtained as a result of the country-based bibliographic coupling analysis are listed in Table 2. The total link strength value indicates the strength of the publication relationship between any two countries. The three countries with the highest total link strength value are the United States, Germany, and the United Kingdom. These countries are also the three most publishing countries for the use of technology in the AHBR.

Fig. 1 Network visualization map of the country-based citation analysis in the research field of technology use in the AHBR

Table 1 The country-based citation analysis in the research field of technology use in AHBR

Cluster	Links	Total Link Strength	Document Numbers	Average Publication Year	Average Citation	Average Normalized Citation
<i>Research Region 1</i>						
Belgium	14	59	10	2009,40	62,50	0,94
France	18	370	60	2014,22	30,52	1,71
Norway	17	170	17	2015,14	24,29	1,40
Portugal	14	66	10	2015,40	26,80	1,15
South Africa	17	235	30	2015,37	45,70	1,64
Switzerland	14	49	10	2012,80	30,30	1,56
<i>Research Region 2</i>						
Australia	18	251	45	2014,51	50,60	2,19
China	14	68	47	2014,53	11,55	0,82
Israel	15	89	21	2014,00	52,86	1,49
Japan	16	100	15	2011,00	46,87	1,46
Netherlands	15	97	14	2013,57	50,71	2,10
Russian Federation	9	13	11	2015,09	5,91	0,90
<i>Research Region 3</i>						
Canada	16	191	27	2011,67	45,52	1,41
Germany	18	526	66	2015,67	21,91	1,34
Spain	15	269	33	2015,85	24,82	1,58
United Kingdom	17	728	87	2013,56	42,22	1,81
<i>Research Region 4</i>						
Italy	15	80	63	2014,00	13,08	0,84
Poland	2	3	11	2016,27	11,36	0,49
United States	19	899	158	2012,92	45,46	1,66
<i>Research Region 5</i>						
Taiwan	5	9	14	2013,64	4,29	0,37
<i>Research Region 6</i>						
Turkey	0	0	12	2012,25	24,75	0,27

In the works of these countries; it is noticed that a wide variety of technological methods are being used for AHBR. In the archaeological studies, there are studies of the three countries' excavation site in Tanzania, but there are many studies aimed at preserving the historical heritage in their own

countries. In particular, computer simulation aimed at ensuring the continuity of the historical heritage, towards obtaining archaeological evidence accurately and completely; UAV and remote sensing technologies are abundant in academic studies.

Fig. 2 Network visualization map of the country-based bibliographic coupling analysis in the research field of technology use in the AHBR

3.3. Results of the document-based citation analysis

The network visualization map obtained from the document-based citation analysis working on the use of technology in the AHBR with the Vosviewer software is shown in Fig. 3. The lines, colors, and distance between circles represent the relationship between the documents' reciprocal quotes and document pairs. The size of the circle and the fonts represent the document's contribution to the research area. The large circle indicates that the document contributed more to the research topic. Table 3 shows the link, citation, normalized citation, and publication year data obtained as a result of the analysis of the documents. Link values show publications that are linked together. The number of citations gives the number of times the publication is displayed as a research source in documents to be published by an author.

It is seen in Figure 3 that there are 23 documents emerging in the analysis are linked to each other. The AHBR is a comprehensive subject that requires

a lot of knowledge of various expertise areas. It may be understood from the fact that research in the documents is independent of each other, yet these specialties have limited workspaces where they may work together.

The three most cited documents are “Harmand et al., 2015” [41], “Evans et al., 2013” [18], and “Yılmaz et al., 2007” [4] (Fig. 3 and Table 3). Harmand et al. [41] use the 3D scanner technology via which a 3D digital model of the historical area was obtained. In the article “Evans et al. [18], the topography of the historical area under the canopies cover was obtained in 3D via LIDAR technology. A global positioning system (GPS) antenna was used to reach absolute location information. By combining LIDAR and GPS data, the data was transferred to the Arc GIS software, so that the 3D version of the area was obtained. Yılmaz et al. [4] mention the importance of technology usage in the certification stage, which is the most important part of the restoration process of historical buildings.

Table 2 The country-based bibliographic coupling analysis in the research field of technology use in the AHBR

Cluster	Link	Total Link Strength	Document Numbers	Average Publication Year	Average Citation	Average Normalized Citation
<i>Research Region 1</i>						
China	20	5865	47	2014,53	11,55	0,82
France	20	28777	60	2014,22	30,52	1,71
Japan	20	11116	63	2014,00	13,08	0,84
Netherlands	19	2500	15	2011,00	46,87	1,46
Russian Federation	19	1274	11	2015,85	24,82	1,58
Spain	20	11160	33	2015,85	24,82	1,58
Taiwan	18	649	14	2013,64	4,29	0,37
United Kingdom	20	29660	87	2013,56	42,22	1,81
United States	20	48218	158	2012,92	45,46	1,66
Turkey	17	157	12	2012,25	24,75	0,27
<i>Research Region 2</i>						
Germany	20	35337	66	2015,67	21,91	1,34
Norway	19	13354	17	2015,24	24,29	1,40
Portugal	19	5262	10	2015,40	26,80	1,15
South Africa	19	24071	30	2015,37	45,70	1,64
<i>Research Region 3</i>						
Belgium	18	3486	10	2009,40	62,50	0,94
Israel	20	6897	21	2014,00	52,86	1,49
Switzerland	19	5010	10	2012,80	30,30	1,56
<i>Research Region 4</i>						
Australia	20	19837	45	2014,51	50,60	2,19
Poland	11	207	11	2016,27	11,36	0,49
<i>Research Region 5</i>						
Canada	19	9637	27	2011,67	45,52	1,41

In the sample study, data were obtained from the field using Photogrammetry methods. Images of a historical building damaged in a fire in Konya were obtained by DCRP. Data obtained by using mathematical equations with DCRP images has been turned into a 3D model through the Photomodeler software. Thus, if the documents are damaged again for any reason, it is possible to access the information permanently.

The chronological order of the occurrence of technologies used in the field of AHBR according to keyword co-occurrence analysis results is tabulated in Table 4. Virtual reality is the most commonly used technology in AHBR literature. The integration of the real-world environment with the digital representation of unbuilt structures is possible with VR technology.

Fig. 3 Network visualization map of the document-based citation analysis in the research field of technology use in AHBR

Table 3 The document-based citation analysis in the research field of technology use in the AHBR

Documents	Link	Citation	Normalized Citation	Publication Year
Barkai et al., 2003 [35]	1	101	3.08	2003
Bonano et al., 2000 [36]	0	49	1.14	2000
Chase et al., 2012 [37]	1	98	3.83	2012
Eren et al., 2015 [38]	1	48	1.97	2015
Evans et al., 2013 [18]	1	121	5.05	2013
Galvan et al., 2014 [39]	0	43	1.77	2014
Gravina et al., 2005 [40]	0	70	3.17	2005
Harmand et al., 2015 [41]	0	294	12.06	2015
Holen et al., 2017 [42]	0	68	6.99	2017
Iovita, 2011 [43]	0	66	4.25	2011
Kohler et al., 2005 [44]	0	71	3.22	2005
O'Connor et al., 2014 [45]	0	42	1.73	2014
Ofli et al., 2016 [46]	0	50	3.33	2016
Ott et al., 2011 [47]	0	54	3.48	2011
Pappu et al., 2011 [48]	0	102	6.57	2011
Perrault., 2012 [49]	0	41	1.60	2012
Sadier et al., 2012 [50]	0	55	2.15	2012
Schibille et al., 2011 [51]	0	42	2.71	2011
Torres et al., 2007 [52]	0	45	0.32	2007
Tryon et al., 2002 [53]	0	92	2.92	2002
Valladas et al., 2013 [54]	1	42	1.75	2013
Wang et al., 2012 [55]	1	52	2.03	2012
Yilmaz et al., 2007 [4]	0	111	0.79	2007

Table 4 The chronological order of the occurrence of technologies used in the field of AHBR according to keyword co-occurrence analysis results

Technology Type	Occurrence	Average Publication Year
Information Technology	14	2007,93
Photogrammetry	17	2010,59
Data Visualization	8	2011,75
Virtual Reality	26	2012,00
Remote Sensing	23	2012,61
Computer Simulation	10	2012,80
GIS	13	2014,08
3D Modelling	11	2014,27
Laser Applications	16	2014,50
Augmented Reality	12	2015,92
Environmental Technology	15	2016,93

Virtually created models are provided to be experienced without spending too many resources such as finances, time, human resources, etc. Everyone can access the historical sites remotely with experiencing a real-world environment integrated visual representations via this technology. Remote sensing technologies can be obtained from the data of both archaeological sites and historical buildings without damaging the historical texture. It is one of the most useful methods for collecting evidence. Photogrammetry methods are mostly used in the restoration of historical buildings. It provides digitalization of the physical information of the historical building. 3D model of historical buildings can be obtained by combining the data obtained with photogrammetry and laser applications. The use of technology has contributed to the permanent preservation and storage of the historical heritage information in recent years. In particular, it was ensured that all information related to information technologies and restoration works were collected on a single platform. It has been seen in researches that these technologies are not used much in practice yet, and studies in this field continue to be developed. The use of environmental technologies has started to ensure sustainability with the increase in environmental pollution, the change of the world

climate, and ecosystem and the increase in consumption. The historical environment is also affected by these negativities, and researchers have recently started working to ensure that these technologies are applied in the historical environment. Environmental technologies provide many benefits such as reducing material inputs and consuming energy consumption emissions. With technological methods, it is ensured that historical research is carried out at a low cost without harming the environment.

4. Discussions

The rapid development of technology day by day and its innovations to humanity cause many changes in the environment. Some of these changes affect urban settlements, and it can be said that settlement has improved rapidly, especially with the developing technology. The historic texture remains in the growing cities and often faces the danger of extinction. This danger created by technological developments can be protected with new methods provided by technology thus the continuity of historical areas can be ensured. It is possible to display historical values trapped in urban areas from platforms that everyone can easily reach now. The PCR processes of buildings have become efficient with the use of technology in

conservation management. The historical heritage can be opened to the public by renovating where it belongs, and it can be ensured that people from all over the world reach the heritage by ensuring that it is transferred to a technological platform accessible to everyone. Although the applicability and benefits of technological studies have been proved in other disciplines, the traditional methods outweigh in conservation studies.

Historical sites give information about the social, cultural, economic, and technological developments of countries, and explain the development processes of societies. Documents obtained during the preservation of historical sites are of great importance, countries make significant investments in the work done in this area. Technology contributes to practical, cheap, and harmless methods in obtaining archaeological evidence. In many developed countries in America and Europe, conservation management has started to be brought to the agenda by using technological methods. Technological methods were mostly used in the collection and editing of documents. In this sense; It can be said that GIS, remote sensing technologies, and laser scanner tools are the most used new technologies. The use of remote sensing technologies in particular has helped to uncover many undiscovered areas by minimizing environmental damage. Minimizing the damage to the environment and the evidence with technology can contribute to ecological balance. Thus, both environmental and cultural sustainability can be achieved.

4.1. Discussions of the country-based citation analysis

Many countries attach importance to studies on the conservation of historical and cultural heritage and present studies on this subject. Historical heritage elements reveal the development processes of societies. Difficult and long-term PCR works have become efficient processes with the development of technology. Countries have increased their investments for the use of technology in the AHBR. The country with the highest number of studies was the United States, not only in the archaeological

sites of its territory but also in different countries. The use of computer simulation, in particular, shows that countries have begun to develop permanent and sustainable methods to conserve heritage. New methods, such as computer simulation and 3D modeling, can be a potential that will permanently preserve the historical heritage and transfer it from generation to generation.

The tourism sector has an important attraction of historical and cultural heritage. The economic role of tourism in the development of countries cannot be ignored. Countries' research on historical heritage contributes to both economic development and cultural development. There are opinions that new methods developed by technology may create new employment areas in the tourism sector. Although the use of technology in PCR processes require investment, it can be said that the fact that this investment has an important potential in the tourism sector will be effective in the development of the country.

Many civilizations were established within the Republic of Turkey borders in the past that has led to increased diversity in cultural heritage. In addition, there are many works on the lands that the Empire had in the period of the rise in the Ottoman Empire. With the joint works to be carried out with the countries, whose works are within the borders of the Ottoman Empire. In the past, these riches can be revealed with technology and knowledge transferred to future generations. Despite there are many archaeological sites and historical buildings, the scarcity of studies on the use of technology is remarkable. When the studies are examined, it is seen that technological methods are used only in a few studies. Focusing on archaeological sites and historical structures in the country is another point of interest. In these studies, methods such as photogrammetry and laser, which are technological tools, were used. The host of many civilizations in the history of Turkey, therefore, be said that it has significant potential in terms of tourism and economic development. The lack of studies in this area causes an important gap in the literature. Ensuring the sustainability of cultures can be achieved by using more technological methods.

4.2. *Discussions of the country-based bibliographic coupling analysis*

The use of methods developed by technology has revealed an advantageous use in the AHBR. Countries have started to work differently in this area for different purposes. The work started to make the conservation management process more efficient, and it was discovered that technology provides different potentials in different sectors. For example, for the tourism industry, historical sites can be accessed from different countries, and a new branch can be added to the tourism industry. A new field can be created in learning by having fun and seeing in education.

It is seen that countries generally benefit from each other's work and even create new publications by making use of collaborative works in bibliographic coupling. The fact that most countries do little research on the preservation of the historical heritage of technology has shown little focus on this area in the literature. The fact that technological developments are mostly obtained with high wages may be a limitation in the works. In this sense, the economic level of the countries is important in the studies. When the studies are analyzed, it can be said that the countries are advancing the developments by making publications together or making use of each other's publications.

Turkey settles among the least publishing countries. There are very few publications yet regarding the technological approaches to the conservation of historical heritage. Turkey's cultural and historical heritage elements can create new job opportunities with technological methods of protection for Turkey's high level of young population. In this sense, the use of technological tools in the pre-restoration analysis processes of the buildings and in the fields for the collection of documents shows that they can be used more in future studies.

4.3. *Discussions of the document-based citation analysis*

The fact that archeology is a long-standing branch of research has led to the creation of many sub-

specialties, and separate subjects in these sub-fields have emerged. The technology has contributed to the researches in the AHBR areas separately. Areas used for the PCR of archaeological sites and historical buildings have been included in the literature as independent studies. The work of the different specialties takes place independently from each other in groups. This situation makes it difficult to examine the PCR in AHBR as a whole. In addition, most of the tools developed by technology are used to obtain evidence of heritage sites. There are very few studies on collecting data on a single platform. More use of platforms such as BIM developed by the technology can contribute to gathering and organizing many irregular data.

4.4. *Gaps and trends*

The use of technology in the AHBR is still a very new subject. PCR works begin with the historical analysis of the fields and obtaining evidence. In this process, data is collected by taking different opinions from many specialties such as archaeologists, historians, restorators, architects, and engineers. Since the studies that come out with the collection of the data belong to different specialties, they make the information complex and independent from each other. These confusions can be avoided by using technology. In light of these studies, data can be collected in a single information pool. Providing different areas of expertise to work together can help resolve information confusion. Many tools such as Photogrammetry, UAV, GPRS have enabled the information to be digitized efficiently. The information obtained can be modeled into nD using HBIM. Many studies have been carried out in order to ensure the sustainability of history after the devastating earthquake in Italy. Many countries such as Australia, the United States, and the United Kingdom also researched in this field.

Archaeological evidence focuses on the collection of data and the organization of information. In Europe, techniques such as radiocarbon and radiometric dating were used while dating the remains in countries such as Germany, Spain, Greece, and Italy. It is important that the

information obtained at this stage is complete and accurate. In addition, it is another problem that these studies take a long time. Technology can prevent loss of time and ensures that information is stored and organized completely. The computer simulations that are used in some countries such as the United States and Germany offer great potential.

Since environmental conditions make it difficult to obtain information in excavation works; remote sensing technologies and UAV operations have accelerated in Africa, Asia, South America. The introduction of many regions that could not be discovered into archeology has led to changes in the balance. In addition, the environmental damage caused by excavation works has been minimized. Given that the researchers working in these fields are collaborating in general, technology can make it possible to examine archeology as a whole. It is seen that the studies in this field will continue in the near future.

Morphometric analysis of rocks in archaeological sites has enabled archaeologists to reach accurate metric information. With the frequent use of GIS and remote sensing methods in archeology, morphometry is frequently used in the analysis of landforms. The fact that GIS and remote sensing technologies can obtain the most information from the slightest rock to the topographic features has led to popular developments. In North America, the discovery of tropical forests was made with LIDAR and GIS technologies. Again, a lot of research has been done in Tanzania recently, and spatial analysis has been provided with 3D modeling from the data obtained. It is seen that the studies here will increase in the near future.

5. Conclusion

In this study, it was aimed to reveal the scientific trend of the researches on the use of technology in the AHBR and to explain the tendency in the researches on the use of technology in different countries. Using technological developments in conservation management decreases the cost and time and increases efficiency. For this purpose, a

scientometric analysis and map of bibliometric data were obtained by country-based citation analysis, document-based citation analysis, and country-based bibliographic coupling analysis via Vosviewer software. As a result of the analysis of the countries, six clusters were formed. Turkey was found to be as a separate cluster. In document analysis, there are 29 documents. It has been observed that interconnected documents work in similar fields, while 17 independent documents contain works from different specialties.

The fact that the historical areas are attracting places for people who contribute to the increase in tourism revenues of the countries. It seems an obstacle that the PCR of historic sites is a difficult and expensive process. Countries have begun investing in PCR work to reveal their historical heritage and increase tourism revenues. The use of technology has become widespread with these investments in the PCR processes. In many countries such as the United States, the United Kingdom, Australia, Germany, Belgium, and Italy have started to use technology actively in the AHBR. It has been observed that technology increases efficiency especially in the organization of information. The technological methods used in studies in Turkey are very low. It can be said that the methods used are mostly photogrammetry and laser scanning techniques. Turkey has significant potential in terms of historical sites and building PCR studies because the land of Turkey called Anatolia hosted many civilizations in history. In document analysis, it has been observed that technology has contributed to the studies of different areas of expertise. Independent study of specialties makes it difficult to examine and investigate studies as a whole.

It is about many different experts working together in PCR processes. Developing a platform that effectively supports information sharing and collaboration is a challenge. Although the literature on this subject is extensive, technological approaches have been applied very rarely. The small number of studies and its complicated existence in the literature create difficulties. The newly improved technological tools are expensive,

creating a restriction on their use for research and implementation.

In the future, the use of technology platforms in PCR processes can provide interoperability of systems used for different areas of expertise, ensuring regularity in the work. Thus, efficiency in conservation management will increase. History and cultural studies from a number of areas for the use of technology in the PCR processes in Turkey can be increased. Benefiting from the work of different countries can provide the sustainability of cultural heritage.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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