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Bibliometric analysis of water at the intersection of environmental psychology and biophilic design

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Abstract: Water is the subject of study in many scientific fields. The relationship between water and space in architecture is connected with environmental psychology and biophilic design. Therefore, this study seeks to explore the research related to water at the intersection of environmental psychology and biophilic design, to identify current research gaps and primary authors and concepts. The method applied herein is bibliometric analysis with the science mapping technique, covering the documents held on Scopus and Web of Science Core Collection databases. The keywords *environmental psychology*, *biophilic design*, and *water* are selected for the systematically analysed scan performed in Scopus and Web of Science Core Collection databases. After collecting the bibliometric data of a total of 292 documents from the databases on 1 May 2022, the downloaded .csv and .txt data files were transferred to VOSviewer (1.6.18.0). Firstly, descriptive data was examined on the Scopus and Web of Science Core Collection databases. Secondly, visualizations were created via the science mapping techniques by VOSviewer. The selected bibliometric analysis with science mapping techniques represents co-authorship data by the authors, co-occurrences data by author keywords, citation data by documents, co-citation data by the cited references, and co-citation data by the cited authors. As a result, twelve primary authors and five concepts have been identified. The concepts for the gaps are biophilic design, biophilia, emotional design, perception, and architectural design. The critical result is that in the approach to the relationship between space and water in architecture, biophilic design has been found to be a more recent field than environmental psychology. So, the concepts ascertained in this study – and especially the newly established combinations with the biophilic architecture– are going to have a growing tendency in architecture.

Keywords:
water, biophilic design, environmental psychology, bibliometrics, VOSviewer

INTRODUCTION

Environmental psychology is one of the fields that examine human relationships with nature. Another concept that attempts to describe humans' instinctive connection with the natural world is biophilia. In the present case, biophilic design is an additional field that examines the human-nature relationship. Environmental psychology and biophilic design are the fields that are related to architecture, built environment and natural environment. So, it has been seen that water can be a common intersection point of both environmental psychology and biophilic design with an architectural approach. Within the scope of this study, water –at the intersection of environmental psychology and biophilic design– is the main focus. This work is a part of an ongoing research on perceptual and affective aspects of water in terms of biophilic design.

As a subject matter, water at the intersection of environmental psychology and biophilic design has demonstrated diversity. For instance, some studies of this intersection focused on subjective scales (Boffi, Pola, Fumagalli, Fermani, Senes, Inghilleri, 2021), while others approached the subject by focusing on the spatial scales (Beatley, Newman, 2013). Firstly, subjective scales were related to age and user profile, such as older people (Peters, Verderber, 2022), young people (students) (Peters, D'Penna, 2020), and children (Zamani, 2017). Secondly, these scales dealt with psychological health and well-being, such as restorative benefits (Gillis, Gatersleben, 2015), attention restoration (Boffi, Pola, Fumagalli, Fermani, Senes, Inghilleri, 2021), dementia and cognitive disorders (Peters, Verderber, 2022), and affective benefits (White, Smith, Humphryes, Pahl, Snelling, De-pledge, 2010). Spatial scales, on the other hand, were firstly related to design and space, such as biophilic cities (Beatley, Newman, 2013), sustainable behaviour (Corral-Verdugo, Mireles-Acosta, Tapia-Fonllem, Fraijo-Sing, 2011) and pro-ecological behaviours (Kaiser, 1998). Secondly, spatial scales were used to assess building features, such as interior-exterior space (Nevzati, Demirbaş, Hasırcı, 2021) and function (Peters, D'Penna, 2020). Further, some review studies have discussed subjective and spatial scales and provided additional investigation areas that could be considered for water at the intersection of environmental psychology and biophilic design (Gillis, Gatersleben, 2015; Jo, Song, Miyazaki, 2019; Hung, Chang, 2021).

In terms of subjective scales, the category *older people* was related to the attention restoration theory which was one of the terms that psychological health and well-being included at this intersection. Boffi, Pola, Fumagalli, Fermani, Senes, Inghilleri

(2021) presented this relation as a design method with a biophilic approach by the people's experiences in natural environments. In their study, being in contact with water or water elements –which was recognized as valuable according to the fascination factor– was evaluated positively (Boffi, Pola, Fumagalli, Fermani, Senes, Inghilleri, 2021). Similarly, Peters and Verderber (2022, p. 242) have noted that a need for research on "water feature design attributes in indoor and outdoor environmental" is related to dementia and cognitive disorders. Water and water features have a significant role for children in accessing nature, creating their own play places, imagination, and experiencing their senses (Moore, Wong, 1997; Tranter, Malone, 2004; Zamani, 2017).

In addition to the age and user profile in subjective scales, affective benefits were related to psychological health and well-being. The presence of water in both natural and built environments has a more crucial role for preference, positive affect, and restorativeness than space without water (White, Smith, Humphryes, Pahl, Snelling, De-pledge, 2010). A study examined that with a nature-based approach, affective benefits could occur which were increased by "reducing stress and negative affect" and by "increasing positive affect and well-being" (Bratman, Olvera-Alvarez, Gross, 2021, pp. 3-4). In this context, undisturbed natural environments were effective in increasing the affective benefits as they contain water. From the perspective of urban scale, natural green parks with water elements created more positive affect in users' mood as compared to other parks and squares (Rapuano, Ruotolo, Ruggiero, Masullo, Maffei, Galderisi, Palmieri, Iachini, 2022).

In terms of spatial scales, some new concepts were considered, such as biophilic cities developed based on biophilic design that would lead people "to live happy, productive, meaningful lives". While these cities "provide close and daily contact with nature", they also serve to develop awareness and care for the nature. In Beatley, Newman's study (2013, p. 3328), water is defined as one of the biophysical and essential services providing resilience benefits to the natural systems around a city. A similar study reported that the concept of sustainable behaviour influenced the happiness factor depending on the pro-ecological, altruistic, frugal, and equitable factors (Corral-Verdugo, Mireles-Acosta, Tapia-Fonllem, Fraijo-Sing, 2011). Water is one of the considered natural resources according to the pro-ecological behaviours approach which include the notions of manifestation in the form of water and power conservation (Kaiser, 1998; Corral-Verdugo, Mireles-Acosta, Tapia-Fonllem, Fraijo-Sing, 2011). A study focused on the building features, such as function and interior space with water, examining the effects of the water element in the interiors of educational buildings and the state of well-being on students, established that the feeling of being connected with nature has improved and stress has decreased thanks to the water element (Nevzati, Demirbaş, Hasırcı, 2021).

When examining review studies in this field by way of a narrative review process, articles about biophilic design and restorative environments were searched according to certain criteria in order to identify key terms. For instance, in Gillis, Gatersleben's study (2015), water is highly restorative in the built environment which emerged from the experiences of nature. The research focusing on the psychological benefits of water indicates that there is a lot of research on the psychological benefits of water, but less on the psychological well-being benefits. In this context, the findings of Gillis, Gatersleben's study (2015) are supported by another review study, which examined 37 articles on the restorative benefits of water in urban and natural environments (Jo, Song, Miyazaki, 2019). A study focused on building features and user profile found no published work on the integration of water elements into university design for the university students' health and restorative benefits, apart from individual water images or sounds according to critical review of literature (Peters, D'Penna, 2020). Yet another review study comparing subjective and spatial scales noted that there is a substantial body of literature in the field of environmental psychology where nature benefits humans, landscapes; and built environments can be designed to connect humans and nature, but there is no distinguished research in the biophilic design area that would review health benefits (Hung, Chang, 2021).

Thus, the purpose of this study is to explore the research related to water at the intersection of environmental psychology and biophilic design. Thanks to this research, current research gaps, authors, theorists, keywords, added terms, significant sources, and publications can be identified by reaching the research conducted in the selected scientific disciplines. Consequently, two research questions were identified in this study: Research Question 1: What are the current research gaps, authors, theorists, keywords, added terms, significant sources, and publications about water at the intersection of environmental psychology and biophilic design? Research Question 2: Which research areas are more recent and open to study new concepts within the lens of water in environmental psychology or biophilic design?

This study suggests which scientific field is recent and open to study new concepts and how new connections can be made with the current scientific field when water is examined at the intersection of environmental psychology and biophilic design. The workflow of the study consists of introduction, methodology, findings and conclusion. This study begins with an introduction section stating the purpose, research questions and the scope. The methodology section follows which includes the steps of the research design, bibliographic data collection and an analysis. Then, the findings are presented descriptively with the mapping techniques. The study closes with the conclusion section (Tab. 1).

METHODOLOGY

There are many methodologies of structured review of scientific literature in the scientific fields (de Bem Machado, Secinaro, Calandra, Lanzalonga, 2022). Bibliometric approaches are structured literature reviews aimed to investigate the selected research topic. Therefore, to investigate the growing interest and social networks around the topic in this study, bibliometric methods were applied. Along with the use of bibliometric analysis with science mapping techniques used in the previous scientific studies, the bibliometric methods have become more widely used with the rise of online databases (Zupic, Čater, 2015). In the former studies, the methods were related to the growth of the study areas or changes over time (Peritz, 1988) and some approaches, such as the co-citation analysis by cited references (Small, 1973), the co-citation analysis by cited authors (White, Griffith, 1981), the citation analysis by documents (Smith, 1981), the co-cited author mapping (McCain, 1986), the co-word analysis (Callon, Courtial, Turner, Bauin, 1983), and the bibliographic coupling (Kessler, 1963) were used in the scientific papers. As a result, the bibliometric analysis with science mapping techniques was found to be the suitable, fast, conceptual, intellectual (Cobo, López-Herrera, Herrera-Viedma, Herrera, 2011), and the most comprehensive (Aria, Cuccurullo, 2017) method for the discovery to be made within the scope of this study.

Tab. 1. Workflow map for this study. (Source: Katuk, Köseoğlu, 2023)

INTRODUCTION			
Purpose	Research Questions	Scope	
METHODOLOGY			
Research Design			
Bibliographic Data Collection (First Step)			
Selecting databases	Selecting keywords	Selecting criteria	Exporting the data
Analysis (Second Step)			
Selecting software	Selecting visualizations	Selecting criteria	Exporting the visualizations
FINDINGS			
Descriptive documents' findings		Science mapping: Visualizations	
CONCLUSION			
New concepts	New combinations	Primary authors	Current research gaps

In this paper, the Scopus and Web of Science Core Collection databases were selected to retrieve more scientific and systematic data from them, to compare and combine collected findings, draw a common conclusion and to establish more connections in order to examine water at the intersection of environmental psychology and biophilic design. Scopus and the Web of Science Core Collection are broad in scope; they contain important, comprehensive, and qualified indexes, because they include journals with proven scientific quality and with certain criteria (Secinaro, Calandra, Lanzalonga, Ferraris, 2022; Budler, Župič, Trkman, 2021; Martín-Martín, Orduña-Malea, Thelwall, López-Cózar, 2018; Massaro, Dumay, Guthrie, 2016; Zupic, Čater, 2015). Although Scopus and Web of Science Core Collection databases contain differences within themselves, they are multi-disciplinary (Secinaro, Calandra, Secinaro, Muthurangu, Biancone, 2021), practical in use (Falagas, Pitsouni, Malietzis, Pappas, 2008), they include peer-reviewed journals (Budler, Župič, Trkman, 2021) and are supported by bibliometric software packages (Zupic, Čater, 2015).

In addition, collecting data from Scopus and Web of Science Core Collection provides information for the analysis, such as by co-authors, cited references, citations and co-citations, bibliographic coupling, and co-word by the documents (Zupic, Čater, 2015). Moreover, Scopus and Web of Science Core Collection databases constitute bibliometric sources which have been given priority as they allow to produce scientific mapping with VOSviewer. The most recent version of VOSviewer can be downloaded from its website, and it can be used freely for any purpose (van Eck, Waltman, 2022, p. 3). Scopus includes an open-access indicator for journals in which all peer-reviewed scholarly articles are available without any restrictions (Elsevier Scopus, 2020, p. 14). Web of Science Core Collection is the world's leading citation database and includes open access journals, conference proceedings and books (Clarivate Web of Science Help, 2021). To access the Scopus and Web of Science Core Collection databases, researchers sign in in the database with the university library access and statistics system (Vetis) and log in with their username and password. It is important to provide information about the sources of data and the methodology of the study where the extracted search data is used.

The aim is to investigate the type of findings in the literature on the approach to water in environmental psychology and biophilic design. In this context, the bibliometric analysis method is considered to be quick to find these approaches. Applying the bibliometric analysis method to the collected data can determine which fields are more recent, which authors work in these fields, which keywords are used, and which references can be used. For this reason, Scopus and Web of Science Core Collection databases were scanned with the bibliometric analysis using the science mapping techniques. This study is based on a quantitative research design, and quantitative data was collected from Scopus and Web of Science Core Collection databases. Bibliometric analysis is a research method that evaluates and examines data from any discipline with quantitative analysis (Santos, Costa, Grilo, 2017; Şen, 2020; Karagöz, Savaş, 2021; Özkaraca, Halaç, 2022; Ding, Yang, 2022). For this study, a quantitative research design was developed, with bibliometric analysis and science mapping techniques (Tab. 2) to be used. In addition, the bibliometric analysis technique is considered to be an exploratory or descriptive study (Kurutkan, Orhan, 2018, p. 8).

Tab. 2. Quantitative research design for this study. (Source: Katuk, Köseoğlu, 2023)

Bibliometric Analysis with Science Mapping Techniques
Purpose: Exploring the research related to water at the intersection of environmental psychology and biophilic design and determining the current research gaps and the primary authors – concepts.
Material and Methods:
Bibliometric analysis with science mapping techniques
Sample: Documents
Data Sources: Scopus and Web of Science Core Collection
Data Visualization and Analysis Tools: VOSviewer
Selected Bibliometric Analysis Techniques:
Mapping based on co-authorship data by the authors
Mapping based on co-occurrences data by author keywords
Mapping based on citation data by documents
Mapping based on co-citation data by the cited references
Mapping based on co-citation data by the cited authors
Findings
Descriptive findings obtained from Scopus and Web of Science Core Collection
Findings According to Scientific Mapping Technique by VOSviewer: Scopus and Web of Science Core Collection
Conclusion

Primarily, scanning was performed using Scopus and Web of Science Core Collection web pages and by applying the bibliometric analysis method (Tab. 2). The keywords *environmental psychology*, *biophilic design*, and *water* are the words identified to be scanned in the Scopus and Web of Science Core Collection databases. In the documents section of the Scopus database, all fields were scanned with the code ALL ("Environmental Psychology" AND "Biophilic Design" AND "Water") in the advanced search field. In the documents section of the Web of Science Core Collection database, all fields were scanned with the code ALL=("Environmental Psychology" and "Water") OR ALL=("Biophilic Design" and "Water") in the advanced search field. There is no temporal restriction on the databases. The scanning was performed over the entire period covered by the databases. The number of documents as shown in Tab. 3 was obtained. A total of 292 documents were identified, of which 139 were found in Scopus and 153 in the Web of Science Core Collection (Tab. 3). The scanning and data download date is 1 May 2022.

Tab. 3. Scan findings in all fields. (Source: Scopus, 2022; Web of Science Core Collection, 2022). Certain data included herein is derived from Elsevier Scopus and Clarivate Web of Science. © Copyright Elsevier, Clarivate 2022. All rights reserved.

Scopus	Web of Science Core Collection
Code: ALL ("Environmental Psychology" AND "Biophilic Design" AND "Water")	Code: ALL=("Environmental Psychology" and "Water") OR ALL=("Biophilic Design" and "Water")
Scan Findings: 139 documents (2007-2022)	Scan Findings: 153 documents (1995-2022)
Scopus and Web of Science Core Collection	
Total Scan Findings: 292 documents (1995-2022)	

After scanning the bibliometric data of Scopus and Web of Science Core Collection databases on 1 May 2022, .csv and .txt data files were downloaded. Data files were transferred to VOSviewer. VOSviewer is a computer program that can create large bibliometric maps, scientific networks, graphical representation, and visualization with free access (van Eck, Waltman, 2010; Sarkodie, Strezov, 2019; Moral-Muñoz, Herrera-Viedma, Santisteban-Espejo, Cobo, 2020). In this program, "Mapping Based on Co-authorship Data by Authors" (Tab. 2), "Mapping Based on Keyword Association (Co-occurrences) Data" by the authors' keywords (Tab. 2), "Mapping Based on Citation Data By Documents" (Tab. 2), "Mapping Based on Co-citation Data By Cited References" and (Tab. 2) "Mapping Based on Co-citation Data by Cited Authors" was performed one after another (Tab. 2). In this study, including the quantitative information and visuals, such as documents and cited references, years, countries, subject areas, sources, authors and authorship, cited authors, authors' keywords and occurrences, concepts and gaps, citations and co-citations, affiliations, and sponsors in all disciplines was determined by the bibliometric analysis with the science mapping techniques.

FINDINGS

Descriptive findings obtained from Scopus and Web of Science Core Collection

By examining the information held on the Scopus and Web of Science Core Collection databases, the following descriptive findings were obtained. Eight analysis types common to both databases were identified based on scan findings in all fields. These analysis types contained information about the document types, publication years, top 15 countries or territories, top 15 subject areas, top 10 sources, top 10 authors, top 10 affiliations, and top 10 funding sponsors. Moreover, the oldest document in Scopus is dated from 2007, while the oldest document in the Web of Science Core Collection is dated from 1995.

Tab. 4. Document types according to scan findings in all fields. (Source: Scopus, 2022; Web of Science Core Collection, 2022). Certain data included herein is derived from Elsevier Scopus and Clarivate Web of Science. © Copyright Elsevier, Clarivate 2022. All rights reserved.

Scopus	Web of Science Core Collection
Document Analysis (2007-2022)	Document Analysis (1995-2022)
Article: 69	Articles: 136
Book: 22	Review Articles: 10
Book Chapter: 19	Proceedings Papers: 5
Review: 19	Book Chapters: 4
Conference Paper: 9	Editorial Materials: 1
Note: 1	Meeting Abstracts: 1

Both databases established that the number of articles as document type was the highest when scanned with the keywords *environmental psychology, biophilic design, water* (Tab. 4). When the findings were examined with the cut-off date 1 May 2022, it was observed that there are more articles in the Web of Science Core Collection (Tab. 4).

Tab. 5. Document publication years according to scan findings in all fields. (Source: Scopus, 2022; Web of Science Core Collection, 2022). Certain data included herein is derived from Elsevier Scopus and Clarivate Web of Science. © Copyright Elsevier, Clarivate 2022. All rights reserved.

Scopus		Web of Science Core Collection			
Document Analysis (2007-2022)		Document Analysis (1995-2022)			
2022: 10	2015: 10	2022: 7	2016: 13	2010: 6	2003: 2
2021: 47	2014: 3	2021: 23	2015: 12	2009: 2	2001: 1
2020: 10	2013: 5	2020: 14	2014: 7	2008: 2	2000: 1
2019: 12	2012: 4	2019: 16	2013: 4	2006: 2	1999: 1
2018: 13	2011: 3	2018: 14	2012: 3	2005: 3	1997: 1
2017: 14	2010: 2	2017: 10	2011: 6	2004: 1	1995: 2
2016: 5	2007: 1				

Again, both databases established that the number of documents was the highest in 2021 when scanned with the keywords *environmental psychology, biophilic design, water* (Tab. 5). When the findings were examined with the cut-off date 1 May 2022, it was observed that there are more new documents in Scopus (Tab. 5).

Tab. 6. Documents by top 15 country or territory according to scan findings in all fields. (Source: Scopus, 2022; Web of Science Core Collection, 2022). Certain data included herein is derived from Elsevier Scopus and Clarivate Web of Science. © Copyright Elsevier, Clarivate 2022. All rights reserved.

Scopus	Web of Science Core Collection
Document Analysis (2007-2022)	Document Analysis (1995-2022)
United States: 51	USA: 36
Australia: 19	Australia: 22
United Kingdom: 18	England: 19
Canada: 8	Netherlands: 12
China: 8	People R China: 12
Netherlands: 6	Germany: 9
Italy: 5	Spain: 9
Mexico: 5	Italy: 8
Spain: 5	Switzerland: 8
Belgium: 4	Canada: 6
France: 4	Mexico: 6
Singapore: 4	Singapore: 6
Taiwan: 4	Sweden: 6
Germany: 3	France: 4
New Zealand: 3	Colombia: 4

Further, both databases established that the number of documents by the top 15 countries or territories was the highest in the USA when scanned with the keywords *environmental psychology, biophilic design, water* (Tab. 6). When the findings were examined with the cut-off date 1 May 2022, it was observed that countries other than Belgium, Taiwan, New Zealand, Switzerland, Sweden, and Colombia were common to both databases (Tab. 6).

Tab. 7. Documents by top 15 subject areas according to scan findings in all fields. (Source: Scopus, 2022; Web of Science Core Collection, 2022). Certain data included herein is derived from Elsevier Scopus and Clarivate Web of Science. © Copyright Elsevier, Clarivate 2022. All rights reserved.

Scopus	Web of Science Core Collection
Document Analysis (2007-2022)	Document Analysis (1995-2022)
Environmental Science: 64	Environmental Sciences Ecology: 117
Social Sciences: 52	Psychology: 93
Engineering: 49	Engineering: 13
Arts and Humanities: 28	Science Technology Other Topics: 11
Energy: 25	Urban Studies: 8
Psychology: 15	Public Administration: 5
Business, Management and Accounting: 12	Water Resources: 5
Medicine: 12	Business Economics: 3
Agricultural and Biological Sciences: 11	Construction Building Technology: 3
Computer Science: 6	Geography: 3
Economics, Econometrics and Finance: 5	Agriculture: 2
Biochemistry, Genetics and Molecular Biology: 3	Architecture: 2
Neuroscience: 3	Education Educational Research: 2
Nursing: 3	Energy Fuel: 2
Chemistry: 2	Forestry: 2

Another matching result delivered by the databases was that *environmental science* had the highest number of documents by the top 15 subject areas when scanned with the keywords *environmental psychology, biophilic design, water* (Tab. 7). When the findings were examined with the cut-off date 1 May 2022, it was observed that only Web of Science Core Collection had *architecture* as a subject area (Tab. 7).

Tab. 8. Documents by top 10 sources according to scan findings in all fields. (Source: Scopus, 2022; Web of Science Core Collection, 2022). Certain data included herein is derived from Elsevier Scopus and Clarivate Web of Science. © Copyright Elsevier, Clarivate 2022. All rights reserved.

Scopus	Web of Science Core Collection
Document Analysis (2007-2022)	Document Analysis (1995-2022)
Sustainability Switzerland: 11	Journal of Environmental Psychology: 77
Frontiers in Psychology: 6	Frontiers in Psychology: 4
International Journal of Environmental Research and Public Health: 5	Journal of Cleaner Production: 4
Building and Environment: 3	Sustainability: 4
Buildings: 3	Journal of Environmental Management: 3
Journal of Cleaner Production: 3	Ecological Economics: 2
Landscape and Urban Planning: 3	Energy and Buildings: 2
Urban Forestry and Urban Greening: 3	Environment and Behavior: 2
Science of The Total Environment: 2	Landscape and Urban Planning: 2
ACM International Conference Proceeding Series: 1	Science of The Total Environment: 2

In both databases, Frontiers in Psychology, Landscape and Urban Planning, and Science of The Total Environment were among the top 10 common sources when scanned with the keywords *environmental psychology, biophilic design, water* (Tab. 8). When the findings were examined with the cut-off date 1 May 2022, it was observed that the Journal of Environmental Psychology had more documents in Web of Science Core Collection (Tab. 8).

Tab. 9. Documents by top 10 authors according to scan findings in all fields. (Source: Scopus, 2022; Web of Science Core Collection, 2022). Certain data included herein is derived from Elsevier Scopus and Clarivate Web of Science. © Copyright Elsevier, Clarivate 2022. All rights reserved.

Scopus	Web of Science Core Collection
Document Analysis (2007-2022)	Document Analysis (1995-2022)
Beatley, T.: 4	Fielding, K. S.: 4
Chang, C.Y.: 3	Williams, Nicholas S. G.: 4
Corral-Verdugo, V.: 3	Contzen, N.: 3
Desha, C.: 3	Corral-Verdugo, V.: 3
Hung, S.H.: 3	Lee, K.E.: 3
Joye, Y.: 3	Newman, P.: 3
Newman, P.: 3	Tam, K.P.: 3
Xue, F.: 3	Apaolaza-Ibanez V.: 2
Amel, E.L.: 2	Barrera-Hernandez L.F.: 2
Fraijo-Sing, B.: 2	Benavides-Castillo J.M.: 2

In both databases, the highest number of documents by the top 10 authors was four for Beatley and Fielding when scanned with the keywords *environmental psychology, biophilic design, water* (Tab. 9). When the findings were examined with the cut-off date 1 May 2022, it was observed that authors other than Corral-Verdugo and Newman were different in both databases (Tab. 9).

Tab. 10. Documents by top 10 affiliation according to scan findings in all fields. (Source: Scopus, 2022; Web of Science Core Collection, 2022). Certain data included herein is derived from Elsevier Scopus and Clarivate Web of Science. © Copyright Elsevier, Clarivate 2022. All rights reserved.

Scopus	Web of Science Core Collection
Document Analysis (2007-2022)	Document Analysis (1995-2022)
University of Washington: 6	University of Queensland: 7
Texas A&M University: 6	League of European Research Universities Leru: 6
Curtin University: 6	Hong Kong University of Science Technology: 5
University of Virginia: 4	University of Melbourne: 5
National Taiwan University: 3	Centre National De La Recherche Scientifique CNRS: 4
Queensland University of Technology: 3	Commonwealth Scientific Industrial Research Organization CSIRO: 4
University of Derby: 3	Curtin University: 4
National University of Singapore: 3	Swiss Federal Institute of Aquatic Science Technology Eawag: 4
University College London: 3	Universidad de Sonora: 4
KU Leuven: 3	University of Bern: 4

In both databases, Curtin University was among the top 10 common affiliations when scanned with the keywords *environmental psychology, biophilic design, water* (Tab. 10). When the findings were examined with the cut-off date 1 May 2022, it was observed that The University of Queensland had more documents in Web of Science Core Collection (Tab. 10).

Tab. 11. Documents by top 10 funding sponsors according to scan findings in all fields. (Source: Scopus, 2022; Web of Science Core Collection, 2022). Certain data included herein is derived from Elsevier Scopus and Clarivate Web of Science. © Copyright Elsevier, Clarivate 2022. All rights reserved.

Scopus	Web of Science Core Collection
Document Analysis (2007-2022)	Document Analysis (1995-2022)
European Commission: 2	National Science Foundation Nsf: 11
Horizon 2020: 2	European Commission: 5
Horizon 2020 Framework Programme: 2	Australian Government: 3
National Institutes of Health: 2	Australian Research Council: 3
National Natural Science Foundation of China: 2	Behavioral Studies in The Energy Water Waste and Transportation Sectors Programme of The Singapore National Research Foundation: 2
National Science Foundation: 2	Bill Melinda Gates Foundation: 2
Academy of Neuroscience for Architecture: 1	Committee for Melbourne: 2
Agentúra na podporu výskumu a vývoja: 1	Hong Kong University of Science and Technology Hong Kong: 2
Agència de Gestió d'Ajuts Universitaris i de Recerca: 1	Melbourne Water: 2
Arizona State University: 1	Swiss National Science Foundation Snsf: 2

In both databases, the European Commission and National Science Foundation were among the top 10 common funding sponsors when scanned with the keywords *environmental psychology, biophilic design, water* (Tab. 11). When the findings were examined with the cut-off date 1 May 2022, it was observed that National Science Foundation sponsored more documents in Web of Science Core Collection (Tab. 11).

Findings of the scientific mapping technique by VOSviewer: Scopus and Web of Science Core Collection

This section presents the findings obtained with the scientific mapping technique via VOSviewer. The data downloaded from the Scopus and Web of Science Core Collection databases was gradually transferred to VOSviewer. Visuals were created by progressing step by step applying the options presented in the software's interface. Co-authorship, co-occurrences, citation, and co-citation relationships were examined by various criteria.

A. Mapping based on co-authorship data by the authors

Co-authorship analysis by authors is a valid and reliable method to understand the models of scientific collaborations between authors in the specified field to identify collaboration networks and to reveal leading authors (Uddin, Hossain, Abbasi, Rasmussen, 2012; Karagöz, Savaş, 2021). In this analysis, the clusters and the cluster sizes represent the authors. The links between the clusters express the cooperation between the authors. The thickness of the line of networks increases with the total link strength between the authors.

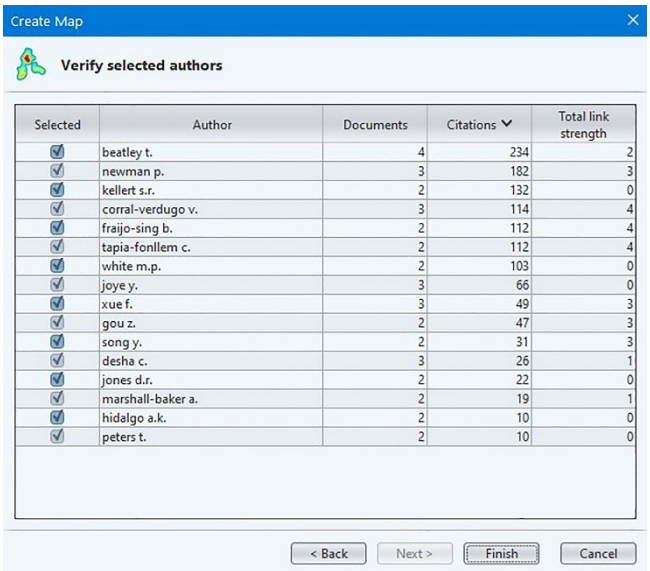
In Scopus, the minimum number of documents of an author and the minimum number of citations of an author was to set to 2 and 10 as criteria, respectively. After setting these limits, the total of 379 authors were narrowed down to 16 that met the thresholds. For each of the 16 authors, the total strength of co-authorship links with other authors was calculated. The authors with the greatest total link strength were filtered. The number of authors to be selected was 16. Before proceeding to the author relationships network mapping, the ranking according to the most cited author could be seen in the interface created by the software, as shown in Tab. 12.

In Web of Science Core Collection Data, the minimum number of documents of an author and the minimum number of citations of an author was set to 2 and 10 as criteria, respectively. After setting these limits, the total of 504 authors were narrowed down to 18 that met the thresholds. For each of the 18 authors, the total strength of co-authorship links with other authors was calculated. The authors with the greatest total link strength were filtered. The number of authors to be selected was 18. Before proceeding to the author relationships network mapping, the ranking according to the most cited author could be seen in the interface created by the software, as shown in Table 12.

Tab. 12. Interface sorted by the most cited author before mapping. (Source: Created by VOSviewer, 2022). Certain data included herein is derived from Elsevier Scopus and Clarivate Web of Science.

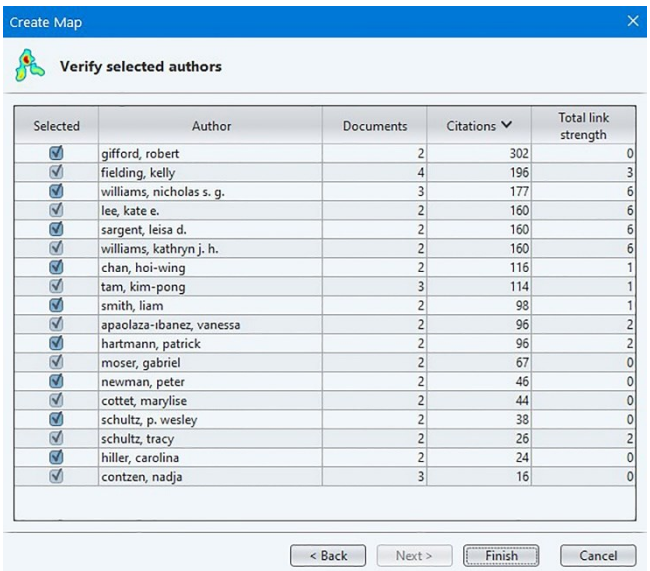
VOSviewer Interface, 2022

Scopus Data



Selected	Author	Documents	Citations	Total link strength
☑	beatley t.	4	234	2
☑	newman p.	3	182	3
☑	kellert s.r.	2	132	0
☑	corral-verdugo v.	3	114	4
☑	fraijo-sing b.	2	112	4
☑	tapia-fonllem c.	2	112	4
☑	white m.p.	2	103	0
☑	joye y.	3	66	0
☑	xue f.	3	49	3
☑	gou z.	2	47	3
☑	song y.	2	31	3
☑	desha c.	3	26	1
☑	jones d.r.	2	22	0
☑	marshall-baker a.	2	19	1
☑	hidalgo a.k.	2	10	0
☑	peters t.	2	10	0

Web of Science Core Collection Data



Selected	Author	Documents	Citations	Total link strength
☑	gifford, robert	2	302	0
☑	fielding, kelly	4	196	3
☑	williams, nicholas s. g.	3	177	6
☑	lee, kate e.	2	160	6
☑	sargent, leisa d.	2	160	6
☑	williams, kathryn j. h.	2	160	6
☑	chan, hoi-wing	2	116	1
☑	tam, kim-pong	3	114	1
☑	smith, liam	2	98	1
☑	apaolaza-ibanez, vanessa	2	96	2
☑	hartmann, patrick	2	96	2
☑	moser, gabriel	2	67	0
☑	newman, peter	2	46	0
☑	cottet, marylise	2	44	0
☑	schultz, p. wesley	2	38	0
☑	schultz, tracy	2	26	2
☑	hiller, carolina	2	24	0
☑	contzen, nadja	3	16	0

When proceeding with mapping in Scopus, VOSviewer warned that some of the 16 items in our network were not connected to each other and the larger set of connected items consisted of 4 items. When asked by the software, "Do you want to show this set of items instead of all items?", the mapping in Fig. 1 was created by answering the question with a "No". According to this mapping, there were three clusters of co-authorship: Cluster 1 (Gou, Marshall-Baker, Song, and Xue), Cluster 2 (Corral-Verdugo, Fraijo-Sing, and Tapia-Fonllem) and Cluster 3 (Beatley, Desha, and Newman) (Fig. 1). When proceeding with mapping in Scopus, VOSviewer warned that some of the 16 items in our network were not connected to each other and the larger set of connected items consisted of 4 items. When asked by the software, "Do you want to show this set of items instead of all items?", the mapping in Fig. 1 was created by answering the question with a "No". According to this mapping, there were three clusters of co-authorship: Cluster 1 (Gou, Marshall-Baker, Song and Xue), Cluster 2 (Corral-Verdugo, Fraijo-Sing and Tapia-Fonllem), and Cluster 3 (Beatley, Desha and Newman) (Fig. 1).

When proceeding with mapping in Web of Science Core Collection, VOSviewer warned that some of the 18 items in our network were not connected to each other and the larger set of connected items consisted of 4 items. When asked by the software, "Do you want to show this set of items instead of all items?", the mapping in Fig. 2 was created by answering the question with a "No". According to this mapping, four clusters had co-authorship: Cluster 1 (Lee, Sargent, Williams, and Williams), Cluster 2 (Fielding,

Schultz, and Smith), Cluster 3 (Apaolaza-Ibanez and Hartmann), and Cluster 4 (Chan, and Tam) (Fig. 2).

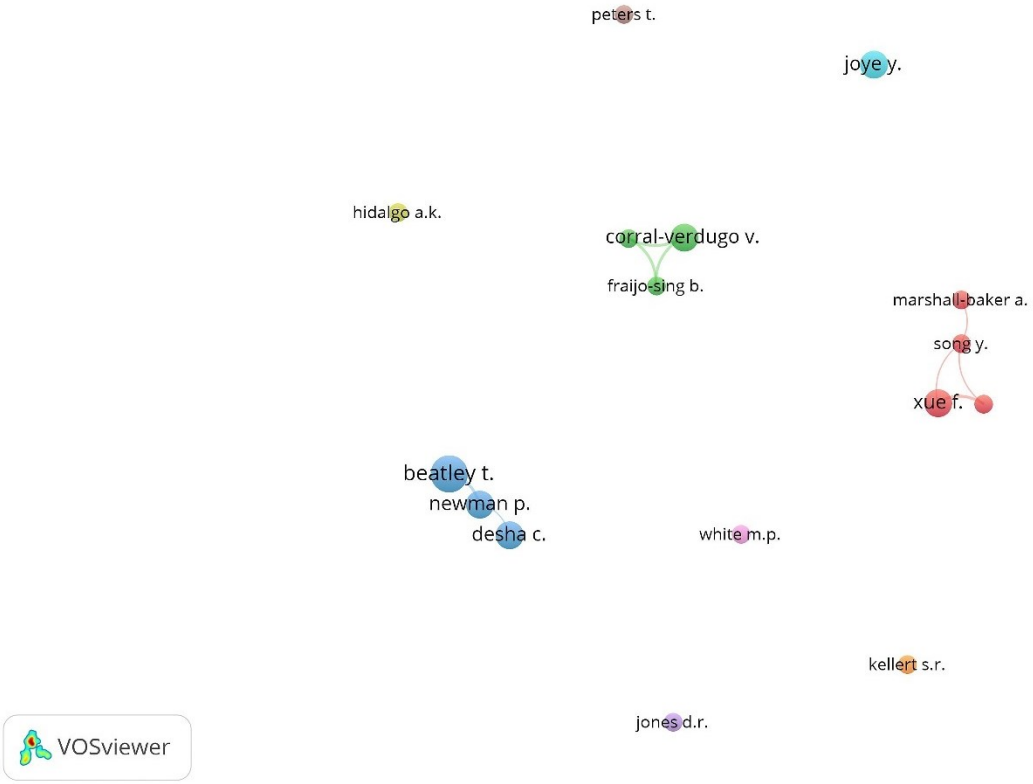


Fig. 1. Mapping based on co-authorship data in Scopus. (Source: Created by VOSviewer, 2022). Certain data included herein is derived from Elsevier Scopus and Clarivate Web of Science. © Copyright Elsevier, Clarivate 2022. All rights reserved.

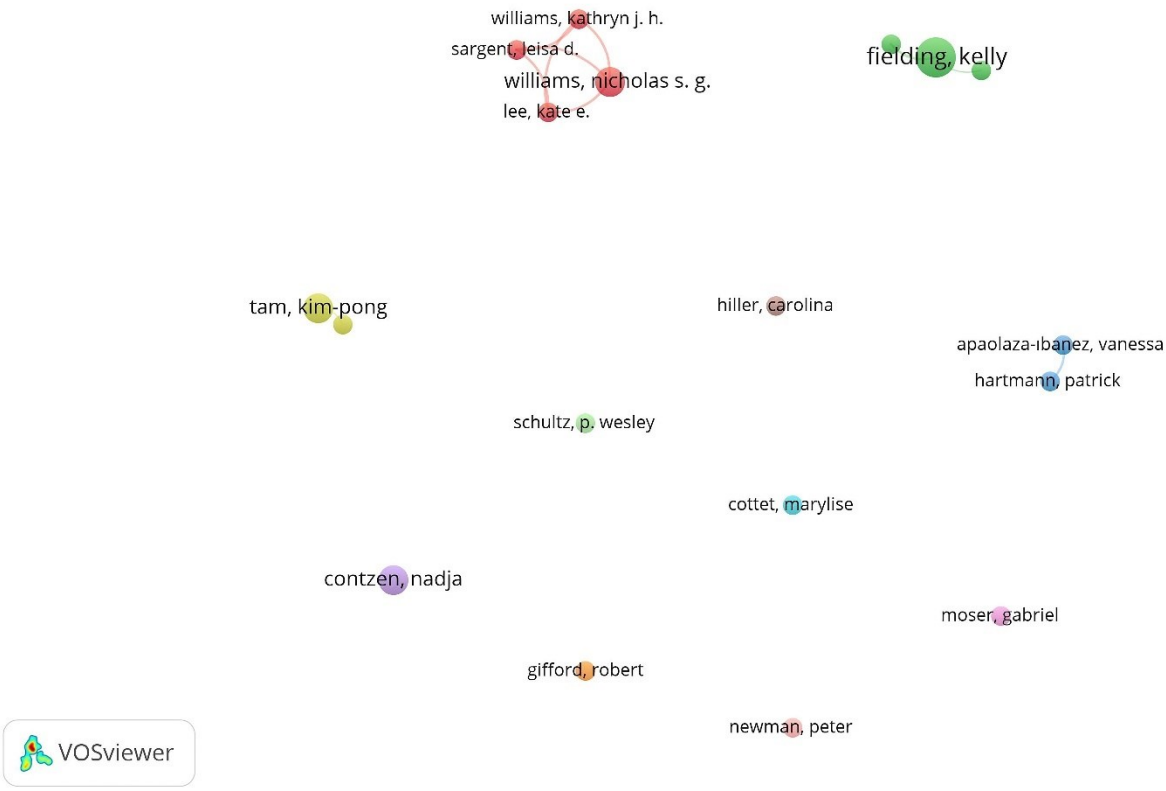


Fig. 2. Mapping based on co-authorship data in Web of Science Core Collection. (Source: Created by VOSviewer, 2022). Certain data included herein is derived from Elsevier Scopus and Clarivate Web of Science. © Copyright Elsevier, Clarivate 2022. All rights reserved.

B. Mapping based on co-occurrences data by author keywords

Co-occurrences analysis by author keywords is an exploration method to understand the concepts of scientific collaborations between author keywords in the specified field to identify themes and to reveal new study areas (Ding, Yang, 2022; Güney, Somuncu, 2020). In addition, with this analysis method, growth of the study areas, new gaps in some specific disciplines and highlighted changes over time can be understood (Peritz, 1988). In this analysis, the clusters and the cluster sizes represent the keywords. The links between the clusters express the cooperation between the keywords. The thickness of the line of networks increases with the total strength of the link between the keywords.

In Scopus, the minimum number of occurrences of a keyword was set to 2 as a criterion. After the limits, the total of 431 keywords were narrowed down to 57 that met the thresholds. For each of the 57 keywords, the total strength of co-occurrence links with other keywords was calculated. The keywords with the greatest total link strength were filtered. The number of keywords to be selected was 57. Before proceeding to the concept of network mapping, the ranking according to the most occurrences of the keywords could be sorted in the interface created by the software. This mapping shows that biophilic design and biophilia have more co-occurrences than the other keywords (Fig. 3).

The keyword that came first in this ranking was *biophilic design*; followed by *biophilia; well-being*; *sustainability*; and *built environment*. The mapping process has been completed without any warnings when proceeding with the mapping. There were 10 clusters in the co-occurrences mapping as shown in Fig. 3. These clusters were represented by circles of varied sizes and colours. Other keywords included in the clusters with the keywords *biophilic design*, *environmental psychology*, *architectural design,* and *biophilic architecture* were examined in Tab. 13.

Tab. 13. Concepts related to biophilic design, environmental psychology, architectural design, biophilic architecture clusters based on data downloaded from Scopus. (Source: VOSviewer, 2022). Certain data included herein is derived from Elsevier Scopus. © Copyright Elsevier 2022. All rights reserved.

Scopus Data		
Cluster 3	Cluster 7	Cluster 1
Architectural Design	**Environmental Psychology**	Biodiversity
Attention Restoration	Mental Health	**Biophilic Architecture**
Biophilia	Psychological Restoration	Children
Biophilic Design	Restorative Environments	Health and Well-being
Housing	Well-being	Nature
Restorative Environment		Nature-based Solutions
Thermal Comfort		Preferences
		Sense of Place
		Sustainable Development
		Urban Design

VOSviewer can also show developments over time (current trends) by overlay visualization of the keywords network mapping created in Fig. 3. In this way, the relationship of new keywords that have been used in publications recently can be seen in Fig. 4. New study areas are colour-coded with yellow and light green toned small clusters in the time mapping. The keywords *biophilic design* and *environmental psychology* were compared for developments over time. It was observed that the keyword *biophilic design* was coloured light green, while *environmental psychology* was highlighted purple.

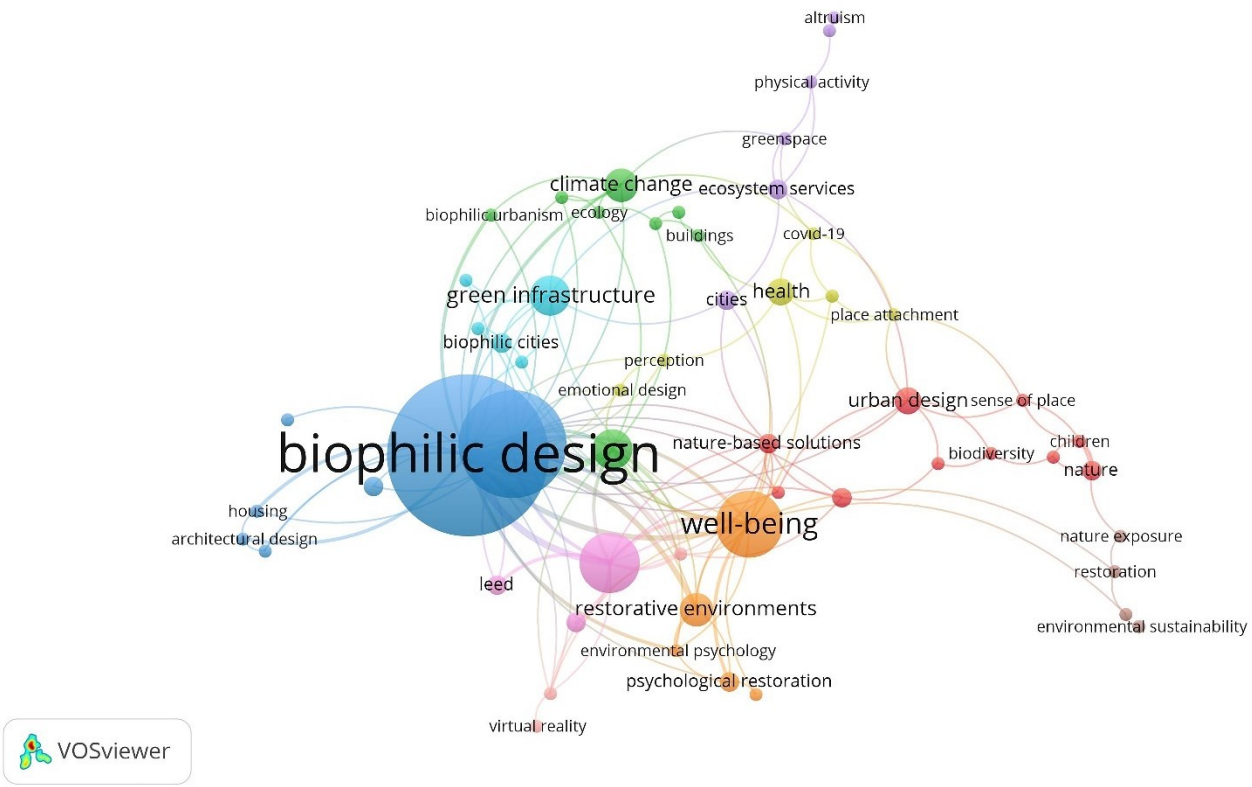


Fig. 3. Mapping based on co-occurrences data in Scopus. (Source: Created by VOSviewer, 2022). Certain data included herein is derived from Elsevier Scopus and Clarivate Web of Science. © Copyright Elsevier 2022. © Copyright Clarivate 2022. All rights reserved.

In the developments over time (current trends) by overlay visualization network map made in the VOSviewer analysis, yellow and light green tones represent new study areas. According to Scopus data, the field of *biophilic design* is a newer field of study when comparing the two fields. Therefore, concepts related to the field of biophilic design have been accepted as current research gaps. In this context, to select new concepts that can be associated with the *biophilic design* keyword, yellow and light green-coloured small clusters close to the cluster they belong to were considered (Fig. 5).

In Web of Science Core Collection data, the minimum number of occurrences of a keyword of 2 was set as a criterion. After setting his limit, 64 out of the 576 keywords that met the thresholds were selected by the software. For each of the 64 keywords, the total strength of co-occurrence links with other keywords was calculated. The keywords with the greatest total link strength were filtered. The number of keywords to be selected was 64. Before proceeding to the concept of network mapping, the ranking according to the most occurrences of the keywords can be sorted in the interface created by the software. According to this mapping, *environmental psychology* and *biophilic design* have more co-occurrences than other keywords (Fig. 6).

The keyword that came first in this ranking was *environmental psychology*, followed by *biophilic design*, *pro-environmental behaviour, water conservation*, and *disgust*. When proceeding with mapping in Web of Science Core Collection data, VOSviewer warned that some of the 64 items in our network were not connected to each other and the largest set of connected items consisted of 57 items. When asked by the software, "Do you want to show this set of items instead of all items?", the mapping in Fig. 6 was created by answering the question with a "Yes". There were 10 clusters in the co-occurrences mapping shown in Fig. 6. These clusters were represented by circles of varied sizes and colours. Other keywords included in the clusters with the keywords *biophilic design* and *environmental psychology* were examined in Tab. 14.

Tab. 14. Concepts related to biophilic design-environmental psychology clusters based on data downloaded from Web of Science Core Collection. (Source: VOSviewer, 2022). Certain data included herein is derived from Clarivate Web of Science. © Copyright Clarivate 2022. All rights reserved.

Web of Science Core Collection Data	
Cluster 5	Cluster 2
Biophilia	Air Quality
Biophilic Design	Beliefs
Built Environment	Environmental Health
Singapore	**Environmental Psychology**
Water Demand Management	Health Psychology
Well-being	Mental Health
	Sustainable Development
	Urban Heat Island

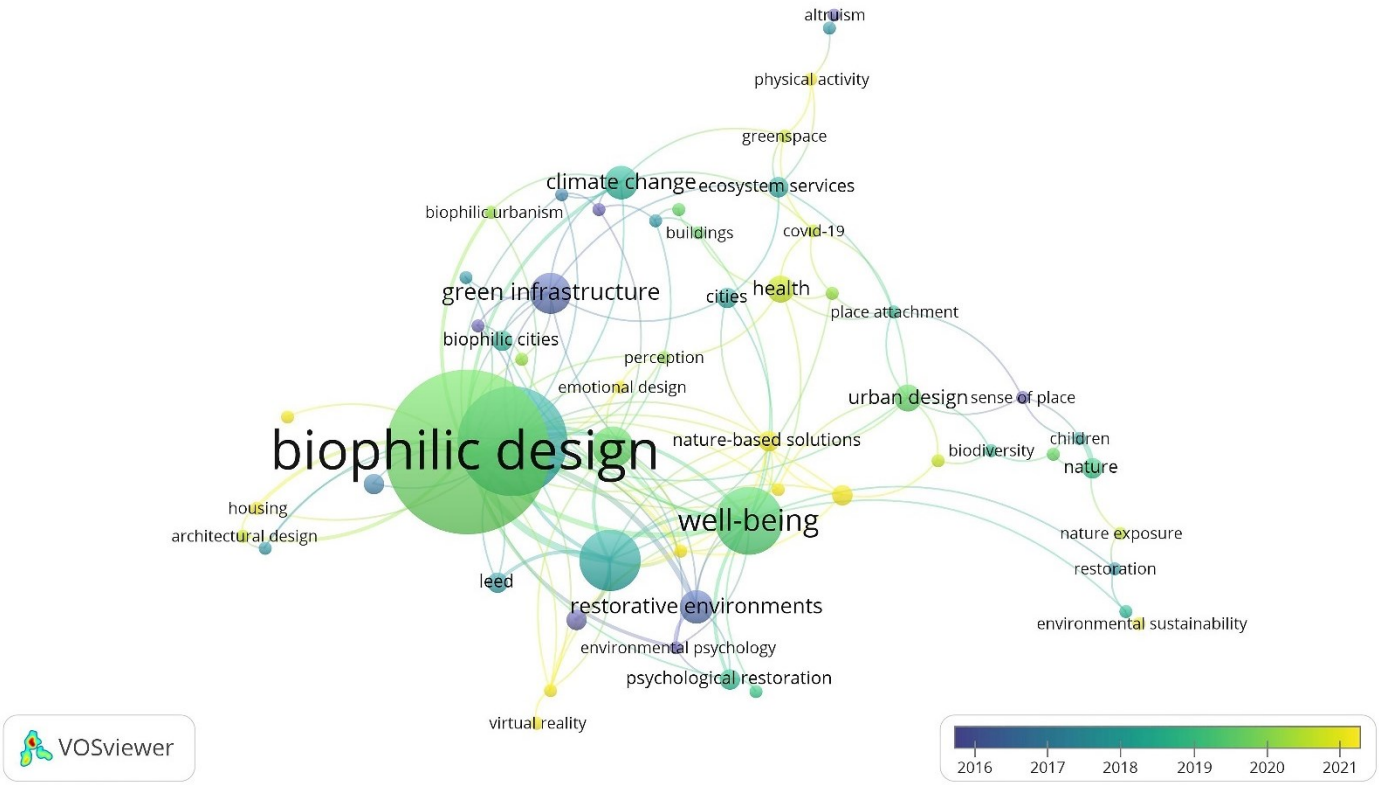


Fig. 4. Mapping based on developments over time by overlay visualization of co-occurrences data in Scopus. (Source: Created by VOSviewer, 2022). Certain data included herein is derived from Elsevier Scopus and Clarivate Web of Science. © Copyright Elsevier 2022. © Copyright Clarivate 2022. All rights reserved.

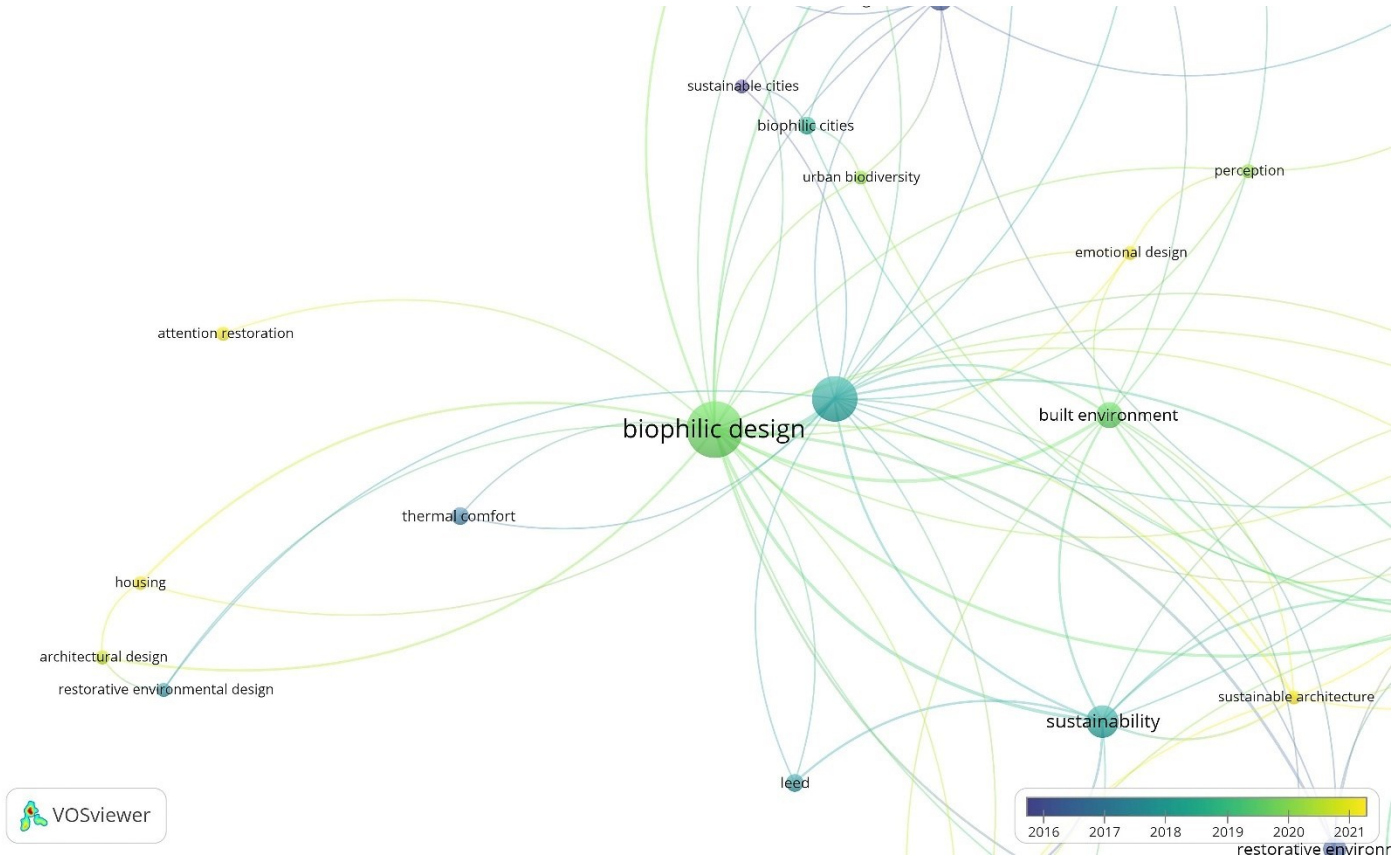


Fig. 5. Yellow and light green small clusters around *biophilic design* by overlay visualization in Scopus. (Source: Created by VOSviewer, 2022). Certain data included herein is derived from Elsevier Scopus and Clarivate Web of Science. © Copyright Elsevier 2022. © Copyright Clarivate 2022. All rights reserved.

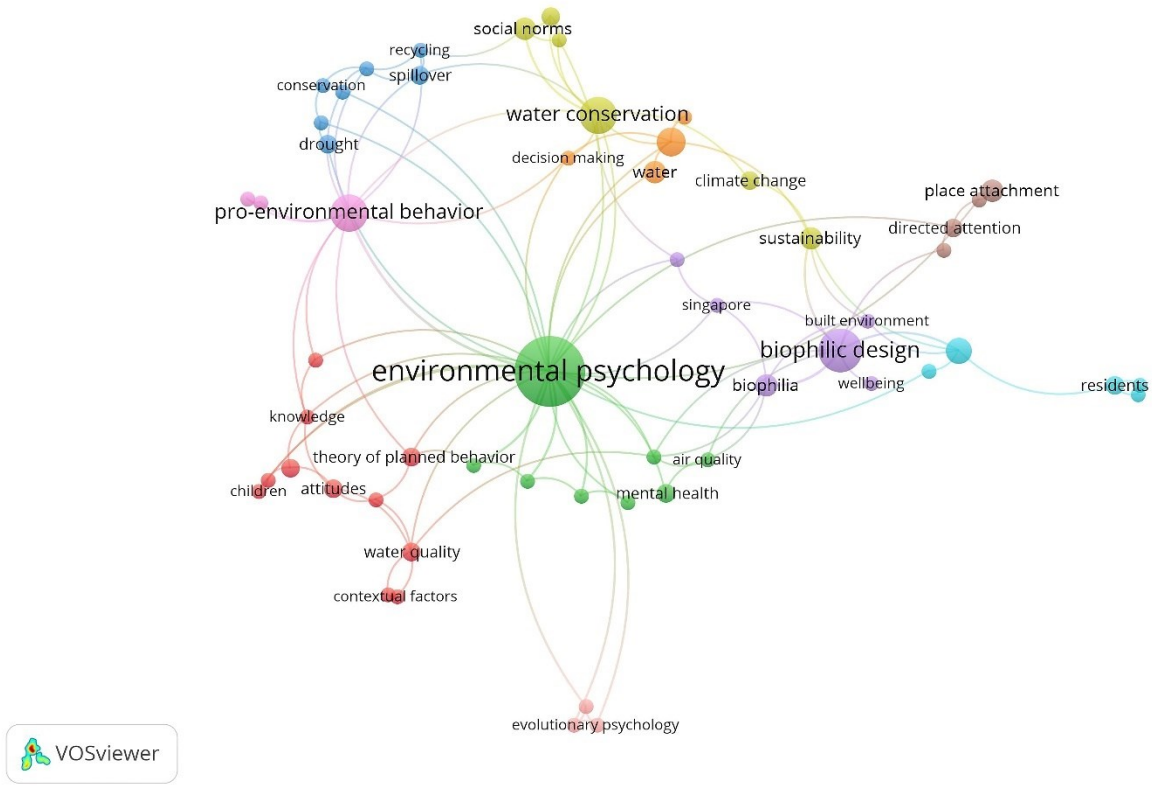


Fig. 6. Mapping based on co-occurrences data in Web of Science Core Collection. (Source: Created by VOSviewer, 2022). Certain data included herein is derived from Elsevier Scopus and Clarivate Web of Science. © Copyright Elsevier 2022. © Copyright Clarivate 2022. All rights reserved.

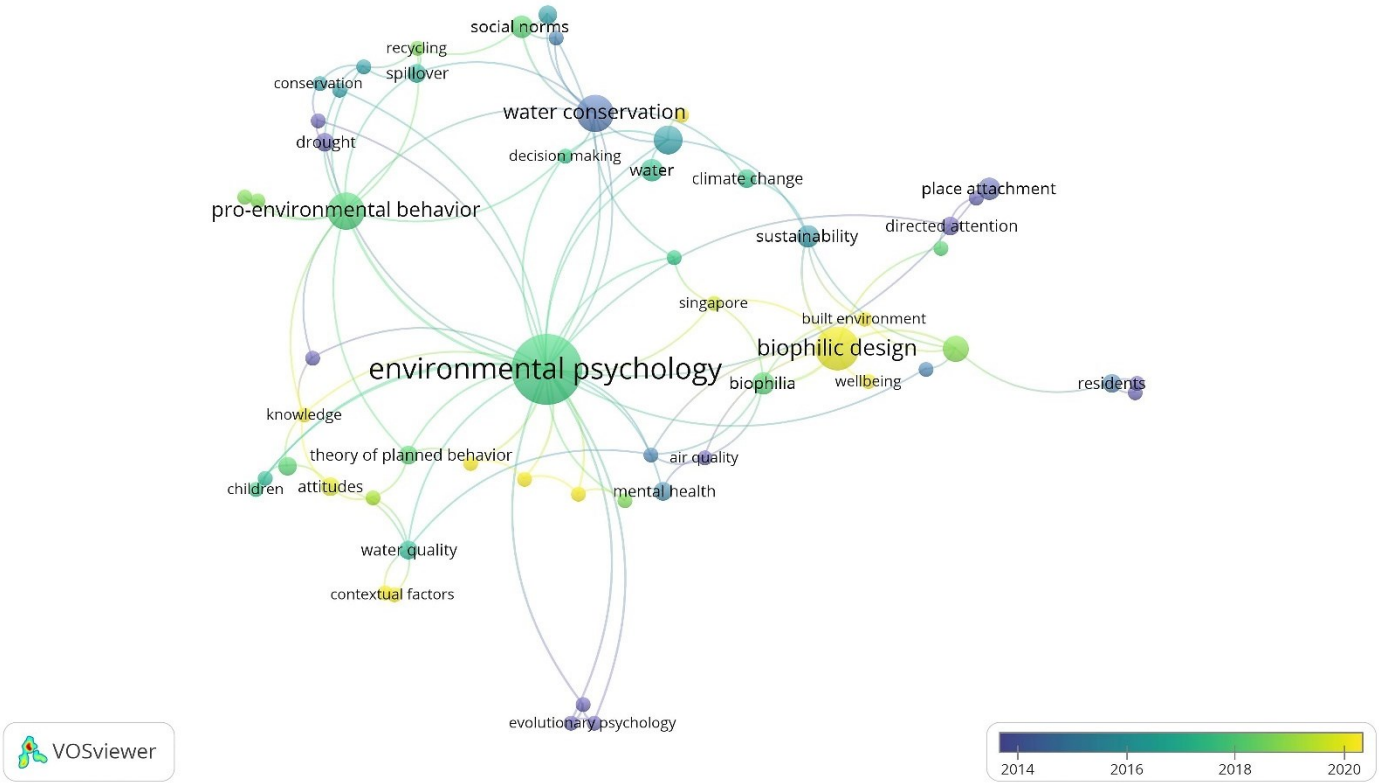


Fig. 7. Mapping based on developments over time by overlay visualization of co-occurrences data in Web of Science Core Collection. (Source: Created by VOSviewer, 2022). Certain data included herein is derived from Elsevier Scopus and Clarivate Web of Science. © Copyright Elsevier, Clarivate 2022. All rights reserved.

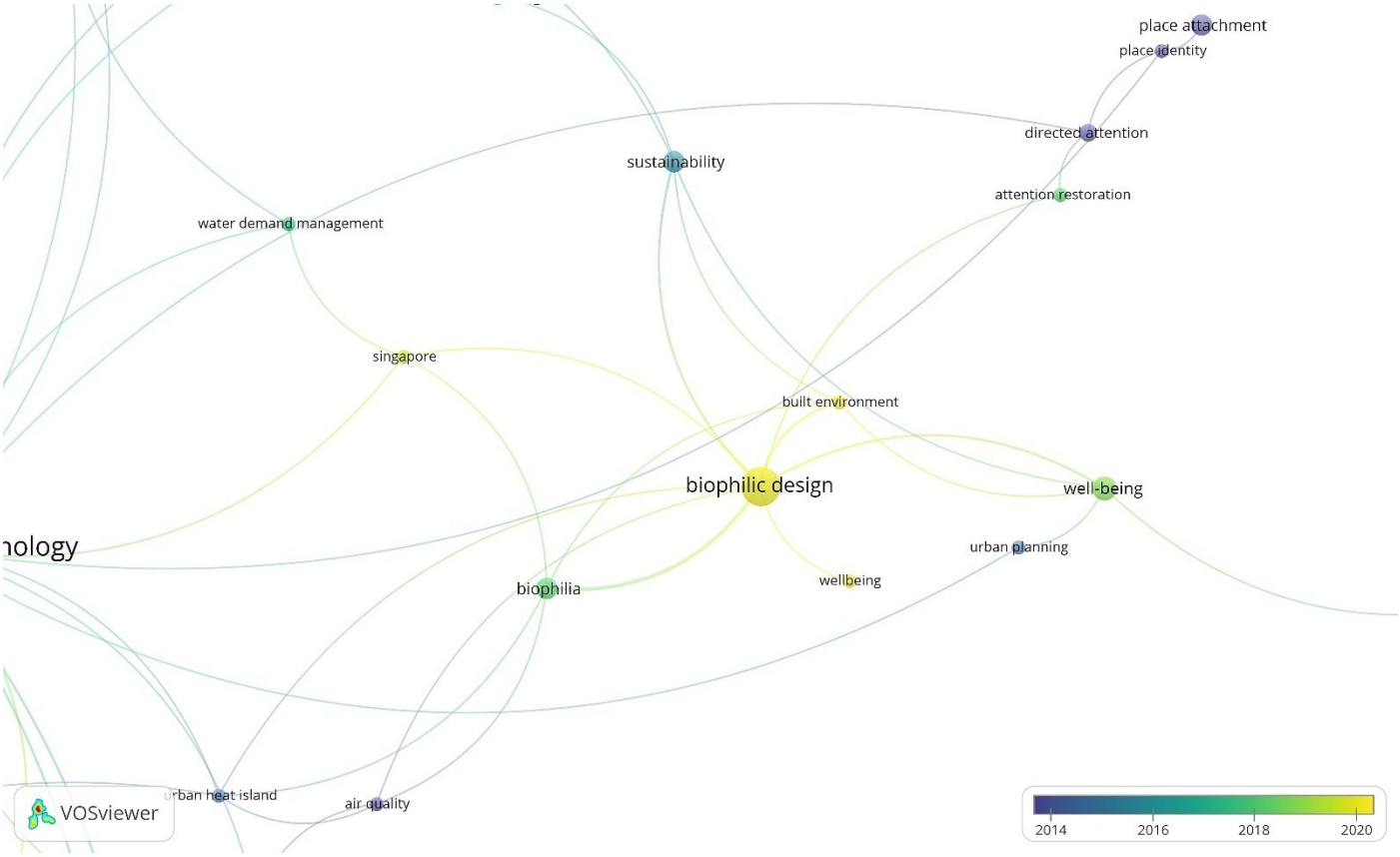


Fig. 8. Yellow and light-green small clusters around *biophilic design* by overlay visualization in Web of Science Core Collection. (Source: Created by VOSviewer, 2022). Certain data included herein is derived from Elsevier Scopus and Clarivate Web of Science. © Copyright Elsevier, Clarivate 2022. All rights reserved.

VOSviewer can also show developments over time (current trends) by overlay visualization of the keywords network mapping created in Fig. 6. In this way, the relationship of new keywords that have been used in publications recently can be seen in Fig. 7. New study areas are marked as yellow and light green-toned small clusters in the time mapping. The keywords *biophilic design* and *environmental psychology* were compared for developments over time. It was observed that the keyword *biophilic design* was coloured yellow, while the green colour-code was used for the keyword *environmental psychology*.

In the developments over time (current trends) by overlay visualization network map made in the VOSviewer analysis, yellow and light green tones represent new study areas. According to Web of Science Core Collection data, the field of *biophilic design* is a newer field of study in the comparison made for the two fields. Therefore, concepts related to the field of biophilic design have been accepted as current research gaps. In this context, to select new concepts that can be associated with the *biophilic design* keyword, small yellow clusters and light green colours close to the cluster they belong to were considered (Fig. 8).

C. Mapping based on citation data by documents

Citation analysis by documents is an exploration method to understand the relationship between the cited document and the citing document in the specified field (Smith, 1981, p. 83). In this analysis, the clusters and the cluster sizes represent the documents. The links between the clusters express the cooperation between the documents. The thickness of the line of networks increases with the total strength of the link between the documents.

In Scopus, the minimum number of citations of a document was set to 10 as a criterion. After setting the limit, the total of 139 documents were narrowed down to 37 that met the thresholds. For each of the 37 documents, the number of citation links was calculated. The documents with the largest number of links were filtered. The number of documents to be selected was 37. Before proceeding to the concept relationship network mapping, the ranking according to the most cited documents could be sorted in the interface created by the software.

When proceeding with mapping in Scopus, VOSviewer warned that some of the 37 items in our network were not connected to each other and the largest set of connected items consisted of 15 items. When asked by the software, "Do you want to show this set of items instead of all items?", the mapping in Figure 9 was created by answering the question with a "Yes". According to this mapping, the highest-ranked document was "Beatley (2013)" with 120 citations, followed by "Ryan (2014)" with 116 citations, "Corral-Verdugo (2011)" with 106 citations, "Grellier (2017)" with 93 citations, "Kellert (2012)" with 85 citations, and finally "Gillis (2015)" with 85 citations (Fig. 9).

In Web of Science Core Collection data, the minimum number of citations of a document was set to 10 as a criterion. After setting this limit, the total of 153 documents were narrowed down by the software to 83 that met the thresholds. For each of the 83 documents, the number of citation links was calculated. The documents with the largest number of links were selected, resulting in 83 documents. Before proceeding to the concept relationships network mapping, the ranking according to the most cited documents could be sorted in the interface created by the software.

When proceeding with the mapping in Web of Science Core Collection data, VOSviewer warned that some of the 83 items in our network were not connected to each other and the largest set of connected items consisted of 21 items. When asked by the software, "Do you want to show this set of items instead of all items?", the mapping in Figure 10 was created by answering the question with a "Yes". According to this mapping, the highest-ranked document was "Kaiser (1999)" with 664 citations, followed by "White (2010)" with 357 citations, "Kormos (2014)" with 298 citations, "Greaves (2013)" with 290 citations, "Voelker (2011)" with 247 citations, and finally "Kumar (2008)" (Fig. 10) with 237 citations.

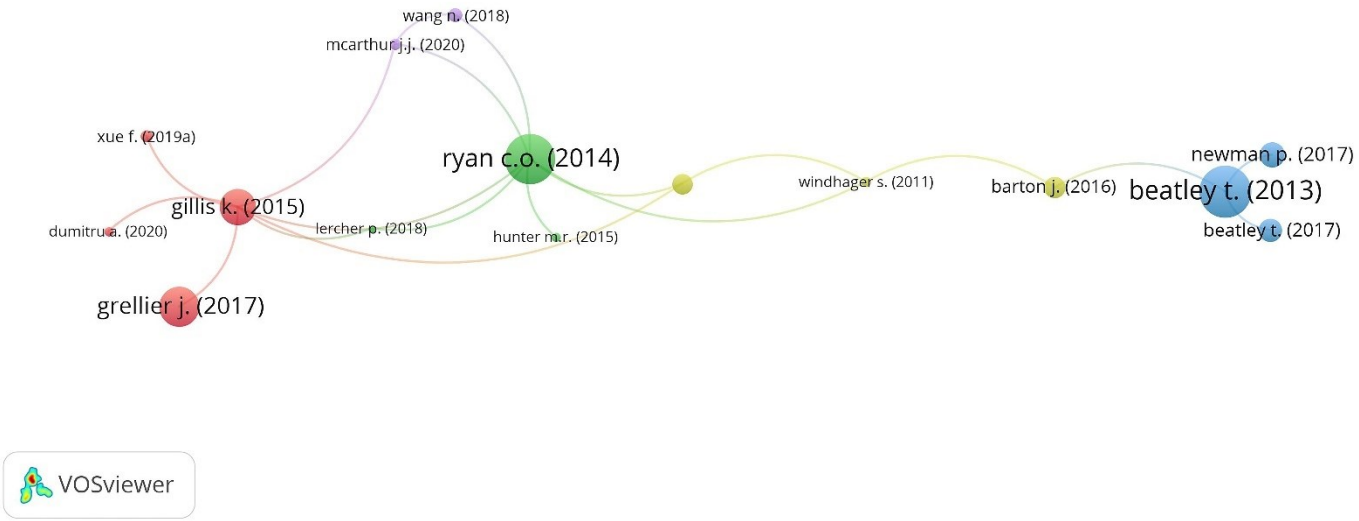


Fig. 9. Mapping based on citation data by documents data in Scopus. (Source: Created by VOSviewer, 2022). Certain data included herein is derived from Elsevier Scopus and Clarivate Web of Science. © Copyright Elsevier, Clarivate 2022. All rights reserved.

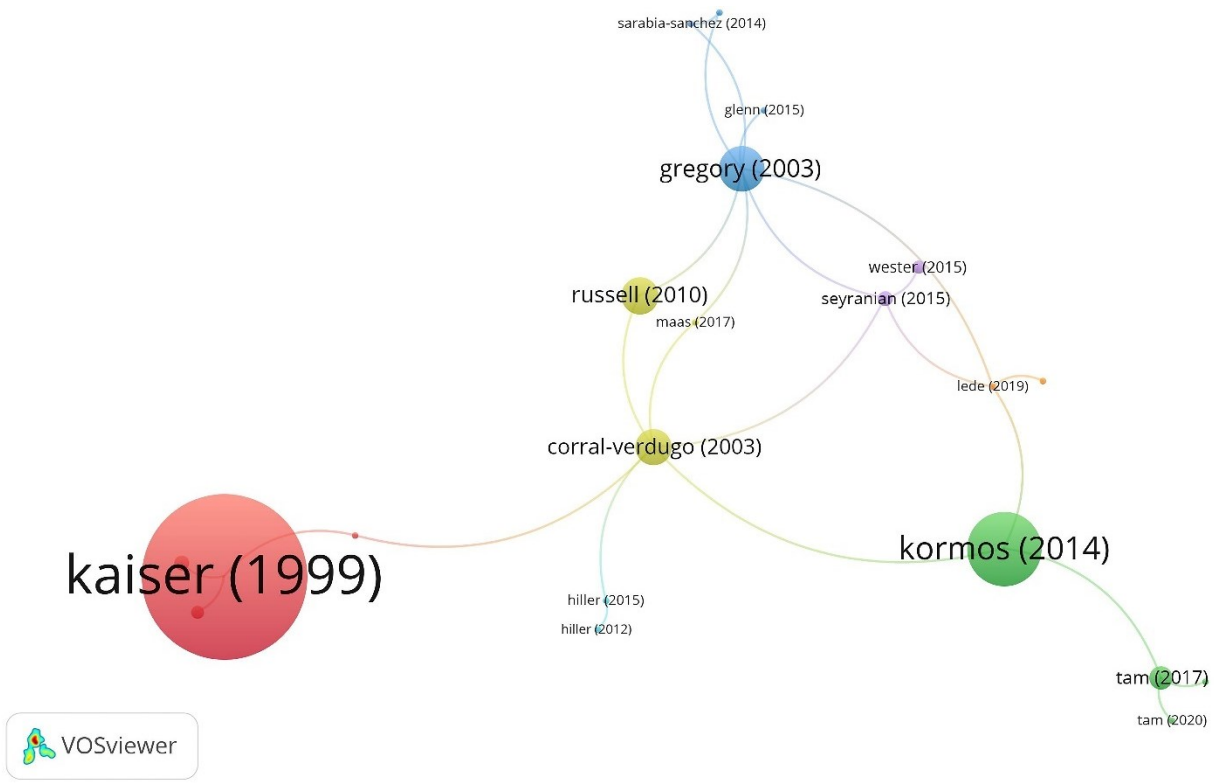


Fig. 10. Mapping based on citation data by documents in Web of Science Core Collection. (Source: Created by VOSviewer, 2022). Certain data included herein is derived from Elsevier Scopus and Clarivate Web of Science. © Copyright Elsevier, Clarivate 2022. All rights reserved.

D. Mapping based on co-citation data by cited references

Co-citation analysis by cited references is a provider method to study the specialty structure of science in the specified field (Small, 1973, p. 265). Co-citations to the 3rd document in two independent documents are examined through references cited together. In this analysis, the clusters and the cluster sizes represent the cited reference frequency. The links between the clusters denote the cooperation between the cited references. The thickness of the line of networks increases with the total strength of the link between the cited references.

In Scopus data, the minimum number of citations of a cited reference was set to 5 as a criterion. After setting this limit, the total of 24,645 cited references were narrowed down by the software to 26 that met the thresholds. For each of the 26 cited references, the total strength of co-citation links with other cited references was calculated. The cited references with the greatest total link strength were filtered. The number of cited references to be selected was 26. Before proceeding to the reference's relationships network mapping, the ranking according to the most citations could be seen in the interface created by the software, as shown in Tab. 15.

In Web of Science Core Collection data, the minimum number of citations of a cited reference was set to 8 as a criterion. After setting this limit, the total of 8,189 cited references were narrowed down by the software to 27 that met the thresholds. For each of the 27 cited references, the total strength of co-citation links with other cited references was calculated. The cited references with the greatest total link strength were filtered. The number of cited references to be selected was 27. Before proceeding to the reference's relationships network mapping, the ranking according to the most citations could be seen in the interface created by the software, as shown in Tab. 15.

When proceeding with the mapping in Scopus data, VOSviewer warned that some of the 26 items in our network were not connected to each other and the larger set of connected items consisted of 24 items. When asked by the software, "Do you want to show this set of items instead of all items?", the mapping in Figure 11 was created by answering the question with a "Yes". According to this mapping, the ranking by most cited references was as follows: 1. "Ulrich (1984) View Through A Window May Influence Recovery From Surgery" with 14 co-citations, 2. "Wilson (1984) Biophilia" with 11 co-citations, 3. "The academy of neuroscience for architecture: la jolla" with 11 co-citations, 4. "Beatley (2011) Biophilic Cities: Integrating Nature Into Urban Design and Planning" with 9 co-citations, 5. "Gillis & Gatersleben (2015) A Review of Psychological Literature on The Health and Wellbeing Benefits of Biophilic Design" with 9 co-citations, 6. "Kaplan (1995) The Restorative Benefits of Nature: Toward an Integrative Framework" with 8 co-citations, 7. "Joye (2007) Architectural Lessons From Environmental Psychology: The Case of Biophilic Architecture" with 7 co-citations, 8. Kellert (2005) Building for Life" with 7 co-citations, 9. "Hartig et al. (2014) Nature and Health" with 6 co-citations, and 10. "(2005) Ecosystems and Human Well-Being: Synthesis" with 6 co-citations (Fig. 11).

The data mapping process in the Web of Science Core Collection has been completed without any warnings (Fig. 12). According to this mapping, the first cited reference was "[no title captured]" with 27 co-citations; followed by "Ajzen (1991) The Theory of Planned Behavior" with 23 co-citations; "Stern (2000 Toward a coherent theory of environmentally significant behaviour" with 22 co-citations; "Kaplan & Kaplan (1989) The experience of nature: A psychological perspective" with 19 co-citations; "Kaplan (1995) The restorative benefits of nature: Toward an integrative framework"; with 17 co-citations; "Steg (2009) Encouraging pro-environmental behavior: An integrative review and research agenda" with 17 co-citations; "Bamberg (2007) Twenty years after Hines, Hungerford, and Tomera: A new meta-analysis of

psycho-social determinants of pro-environmental behaviour" with 15 co-citations; Ulrich (1991) Stress Recovery During Exposure to Natural and Urban Environments" with 13 co-citations; "Abrahamse (2005) A review of intervention studies aimed at household energy conservation" with 12 co-citations; and "Berto (2005) Exposure to restorative environments helps restore attentional capacity" (Fig. 12) with 10 co-citations.

Tab. 15. Interface sorted by most cited reference before mapping. (Source: Created by VOSviewer, 2022). Certain data included herein is derived from Elsevier Scopus and Clarivate Web of Science. © Copyright Elsevier, Clarivate 2022. All rights reserved.

VOSviewer Interface, 2022

Scopus Data

Create Map

Verify selected cited references

Selected	Cited reference	Citatio...	Total link strength
☑	ulrich, r.s., view through a window may influence recovery from s...	14	35
☑	wilson, e.o., (1984) biophilia, , cambridge, ma: harvard university ...	11	29
☑	the academy of neuroscience for architecture: la jolla, ca, usa	11	0
☑	beatley, t., (2011) biophilic cities: integrating nature into urban de...	9	45
☑	gillis, k., gatersleben, b., a review of psychological literature on th...	9	1
☑	kaplan, s., the restorative benefits of nature: toward an integrative...	8	26
☑	joye, y., architectural lessons from environmental psychology: the...	7	25
☑	wilson, e.o., (1984) biophilia: the human bond with other species, ...	7	22
☑	joye, y., architectural lessons from environmental psychology: the...	7	11
☑	kaplan, s., the restorative benefits of nature: toward an integrative...	7	2
☑	kellert, building for life	7	0
☑	hartig, t., mitchell, r., de vries, s., frumkin, h., nature and health (2...	6	54
☑	ulrich, r.s., view through a window may influence recovery from s...	6	32
☑	(2005) ecosystems and human well-being: synthesis, , washingto...	6	27
☑	ulrich, r.s., simons, r.f., losito, b.d., fiorito, e., miles, m.a., zelson, ...	6	23
☑	ulrich, r.s., simons, r.f., losito, b.d., fiorito, e., miles, m.a., zelson, ...	6	19
☑	berto, r., exposure to restorative environments helps restore atten...	6	18
☑	kaplan, r., kaplan, s., (1989) the experience of nature: a psychologi...	5	24
☑	kellert, s.r., wilson, e.o., (1993) the biophilia hypothesis, , washingt...	5	24
☑	hartig, t., evans, g.w., jamner, l.d., davis, d.s., garling, t., tracking r...	5	20
☑	kaplan, r., kaplan, s., (1989) the experience of nature: a psychologi...	5	15
☑	gillis, k., gatersleben, b., a review of psychological literature on th...	5	8
☑	kaplan, s., the restorative benefits of nature: toward an integrative...	5	8
☑	beatley, t., newman, p., biophilic cities are sustainable, resilient cit...	5	7
☑	ulrich, r.s., simons, r.f., losito, b.d., fiorito, e., miles, m.a., zelson, ...	5	4
☑	wilson, e.o., (1984) biophilia, , harvard university press: cambridge...	5	1

< Back | Next > | Finish | Cancel

Web of Science Core Collection Data

Create Map

Verify selected cited references

Selected	Cited reference	Cita...	Total link
☑	[no title captured]	27	60
☑	ajzen i, 1991, organ behav hum dec, v50, p179, doi 10.1016/0749-5978(9...	23	72
☑	stern pc, 2000, j soc issues, v56, p407, doi 10.1111/0022-4537.00175	22	78
☑	kaplan r., 1989, experience nature ps	19	56
☑	kaplan s, 1995, j environ psychol, v15, p169, doi 10.1016/0272-4944(95)9...	17	67
☑	steg l, 2009, j environ psychol, v29, p309, doi 10.1016/j.jenvp.2008.10.004	17	53
☑	bamberg s, 2007, j environ psychol, v27, p14, doi 10.1016/j.jenvp.2006.1...	15	61
☑	ulrich rs, 1991, j environ psychol, v11, p201, doi 10.1016/s0272-4944(05)...	13	49
☑	abrahamse w, 2005, j environ psychol, v25, p273, doi 10.1016/j.jenvp.20...	12	29
☑	berto r, 2005, j environ psychol, v25, p249, doi 10.1016/j.jenvp.2005.07.0...	10	51
☑	berman mg, 2008, psychol sci, v19, p1207, doi 10.1111/j.1467-9280.2008...	10	49
☑	wilson e.o, 1984, biophilia	10	40
☑	schwartz s. h., 1977, adv expt social psyc, v10, p221, doi [10.1016/s0065...	10	29
☑	ulrich rs, 1984, science, v224, p420, doi 10.1126/science.6143402	9	39
☑	dunlap re, 2000, j soc issues, v56, p425, doi 10.1111/0022-4537.00176	9	32
☑	gifford r, 2011, am psychol, v66, p290, doi 10.1037/a0023566	9	24
☑	cialdini rb, 1990, j pers soc psychol, v58, p1015, doi 10.1037/0022-3514....	9	22
☑	white m, 2010, j environ psychol, v30, p482, doi 10.1016/j.jenvp.2010.04...	9	21
☑	hartig t, 2003, j environ psychol, v23, p109, doi 10.1016/s0272-4944(02)0...	8	34
☑	kellert s.r., 1993, biophilia hypothesis	8	28
☑	gregory gd, 2003, j appl soc psychol, v33, p1261, doi 10.1111/j.1559-181...	8	25
☑	hardin g, 1968, science, v162, p1243, doi 10.1126/science.162.3859.1243	8	25
☑	hines j.m., 1987, j environ educ, v18, p1, doi 10.1080/00958964.1987.994...	8	25
☑	schultz pw, 2007, psychol sci, v18, p429, doi 10.1111/j.1467-9280.2007.0...	8	25
☑	corral-verdugo v, 2002, environ behav, v34, p531, doi 10.1177/00116502...	8	24
☑	dunlap re, 1978, j environ educ, v9, p10, doi 10.1080/00958964.1978.108...	8	23
☑	kollmuss a., 2002, environ educ res, v8, p239, doi [10.1080/13504620220...	8	21

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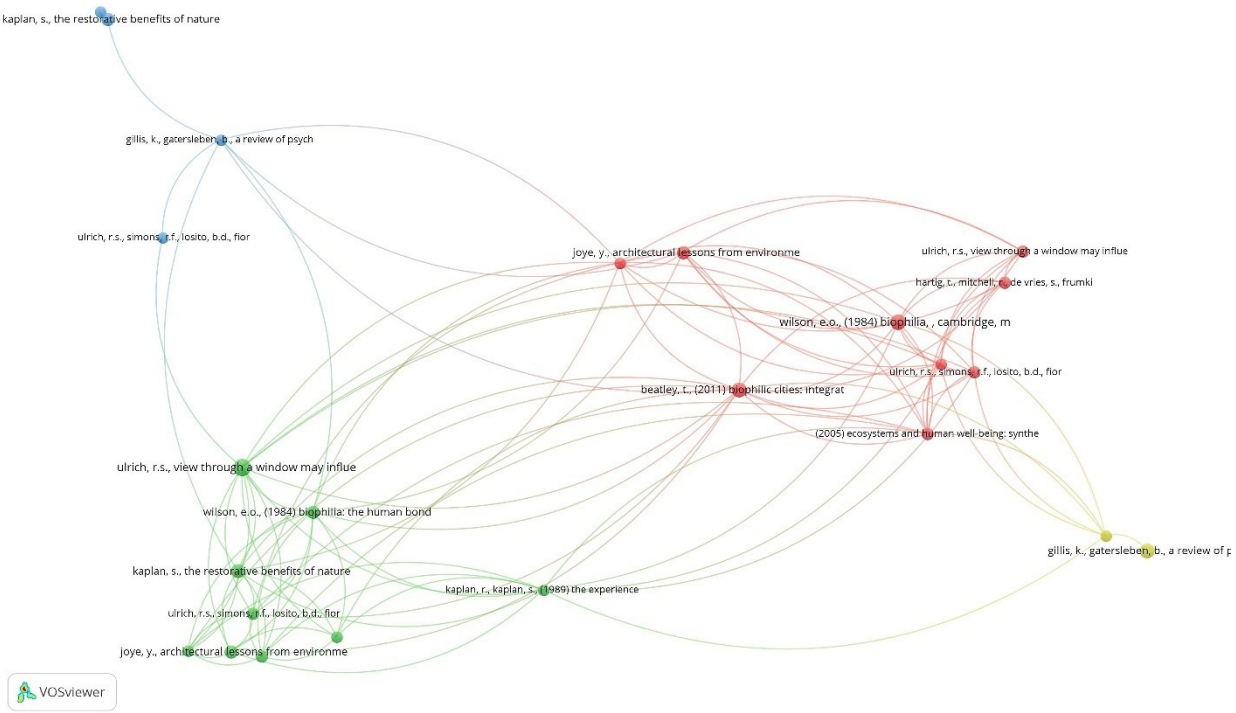

Fig. 11. Mapping based on co-citation data according to the cited references data in Scopus. (Source: Created by VOSviewer, 2022). Certain data included herein is derived from Elsevier Scopus and Clarivate Web of Science. © Copyright Elsevier, Clarivate 2022. All rights reserved.

Fig. 12. Mapping based on co-citation data by cited references in Web of Science Core Collection. (Source: Created by VOSviewer, 2022). Certain data included herein is derived from Elsevier Scopus and Clarivate Web of Science. © Copyright Elsevier, Clarivate 2022. All rights reserved.

E. Mapping based on co-citation data by the cited authors

Co-citation analysis by cited authors is used in understanding intellectual structure in science (White, Griffith, 1981, p. 163). Co-citations to the 3rd document in two independent documents are examined through authors cited together. In this analysis, the clusters and the cluster sizes represent the cited authors' frequency. The links between the clusters denote the cooperation between the cited authors. The thickness of the line of networks increases with the total strength of the link between the cited authors.

In Scopus data, the minimum number of citations of an author was set to 100. After setting this limit, the total of 30,499 authors were narrowed down by the software to 7 that met the thresholds. For each of the 7 authors, the total strength of co-citation links with other authors was calculated. The authors with the greatest total link strength were filtered. The number of authors to be selected was 7. Before proceeding to the reference's relationships network mapping, the ranking according to the most citations could be seen in the interface created by the software, as shown in Tab. 16.

In Web of Science Core Collection data, the minimum number of citations of an author was set to 20 as a criterion. After setting this limit, the total of 6,249 authors were narrowed down by the software to 20 that met the thresholds. For each of the 20 authors, the total strength of co-citation links with other authors was calculated. The authors with the greatest total link strength were filtered. The number of authors to be selected was 20. Before proceeding to the reference's relationships network mapping, the ranking according to the most citation could be seen in the interface created by the software, as shown in Tab. 16.

The Scopus data mapping process has been completed without any warnings (Fig. 13). According to this mapping, the first author was Hartig with 251 co-citations; followed by Ulrich with 194 co-citations; Kaplan, S. with 189 co-citations; Kellert with 185 co-citations; Wilson with 159 co-citations; Kaplan, R. with 125 co-citations; and Steg with 111 co-citations (Fig. 13).

Tab. 16. Interface sorted by the most cited author before mapping. (Source: Created by VOSviewer, 2022). Certain data included herein is derived from Elsevier Scopus and Clarivate Web of Science. © Copyright Elsevier, Clarivate 2022. All rights reserved.

VOSviewer Interface, 2022

Scopus Data

Create Map

Verify selected authors

Selected	Author	Citations	Total link strength
☑	hartig, t.	251	4831
☑	ulrich, r.s.	194	3369
☑	kaplan, s.	189	3339
☑	kellert, s.r.	185	2393
☑	wilson, e.o.	159	1888
☑	kaplan, r.	125	2429
☑	steg, l.	111	2841

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Web of Science Core Collection Data

Create Map

Verify selected authors

Selected	Author	Citations	Total link strength
☑	stern, pc	59	495
☑	kaiser, fg	57	901
☑	ajzen, i	52	683
☑	schultz, pw	45	355
☑	kaplan, s	44	304
☑	corral-verdugo, v	42	352
☑	kaplan, r	41	252
☑	hartig, t	39	278
☑	steg, l	34	307
☑	ulrich, rs	34	244
☑	herzog, tr	31	218
☑	dunlap, re	29	310
☑	gifford, r	29	277
☑	thogersen, j	29	224
☑	schwartz, sh	26	256
☑	kellert, sr	26	140
☑	bamberg, s	24	300
☑	han, h	23	735
☑	ulrich, rs	22	155
☑	fielding, ks	20	140

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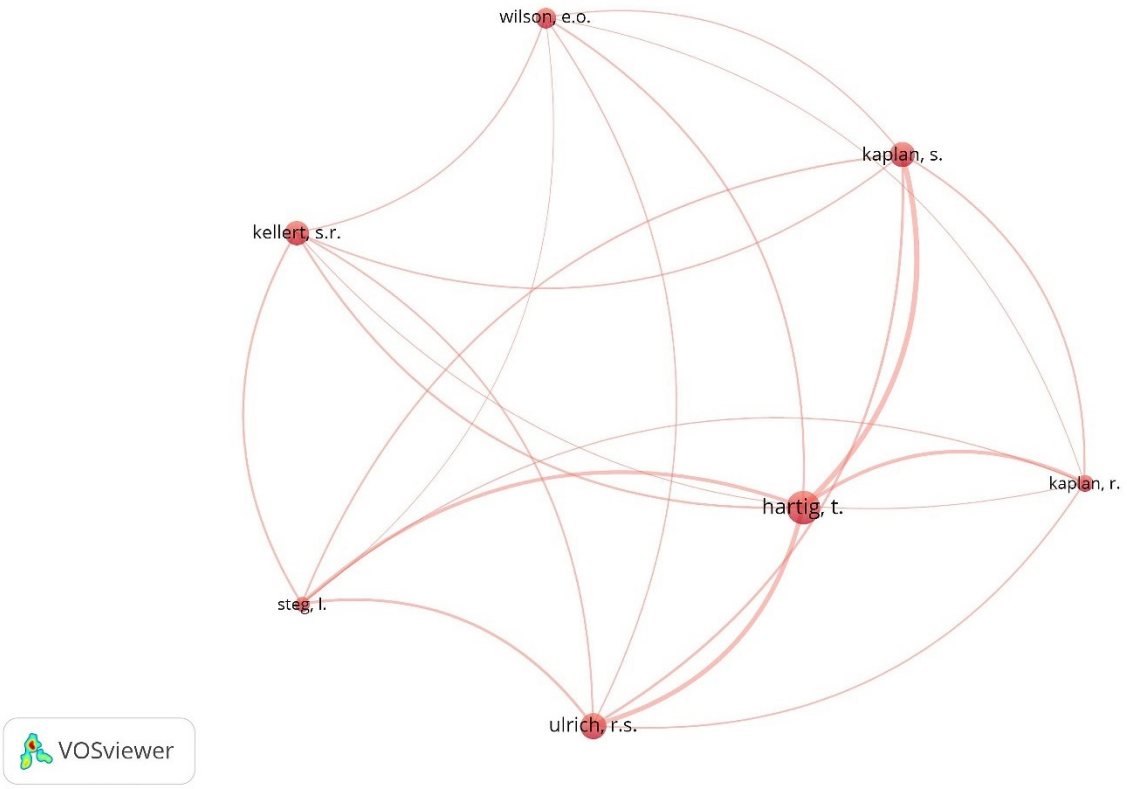


Fig. 13. Mapping based on co-citation data by cited authors data in Scopus. (Source: Created by VOSviewer, 2022). Certain data included herein is derived from Elsevier Scopus and Clarivate Web of Science. © Copyright Elsevier, Clarivate 2022. All rights reserved.

The process for mapping Web of Science Core Collection data has been completed without any warnings (Fig. 14). According to this mapping, the first author was Stern with 59 co-citations; followed by Kaiser with 57 co-citations; Ajzen with 52 co-citations; Schultz with 45 co-citations; Kaplan, S. with 44 co-citations; Corral-Verdugo with 42 co-citations; Kaplan, R. with 41 co-citations; Hartig with 39 co-citations; Steg with 34 co-citations; Ulrich with 34 co-citations; Herzog with 31 co-citations; Dunlap with 29 co-citations; Gifford with 29 co-citations; Thogersen with 29 co-citations; Schwartz with 26 co-citations; Kellert with 26 co-citations; Bamberg with 24 co-citations; Han with 23 co-citations; and Fielding with 20 co-citations (Fig. 14).

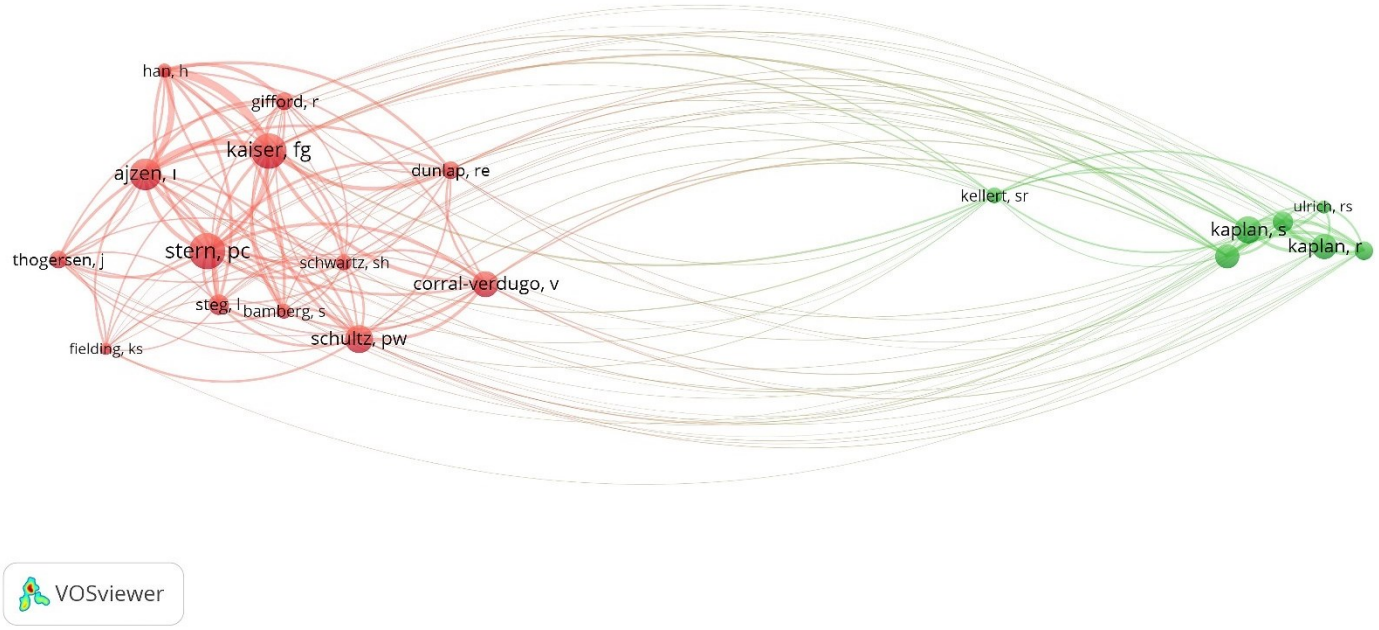


Fig. 14. Mapping based on co-citation data by the cited authors data in Web of Science Core Collection. (Source: Created by VOSviewer, 2022). Certain data included herein is derived from Elsevier Scopus and Clarivate Web of Science. © Copyright Elsevier, Clarivate 2022. All rights reserved.

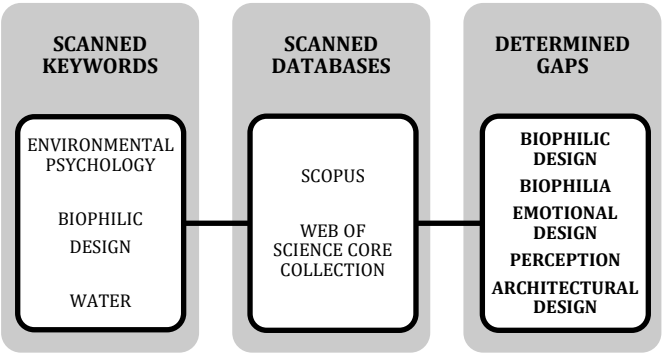
CONCLUSION

In this study, scientific papers about the water at the intersection of environmental psychology and biophilic design were examined via bibliometric data collected from Scopus and Web of Science Core Collection databases. In this context, document types, publication years, top countries, top subject areas, top sources, top affiliations, top funding sponsors, primary authors and co-authorship, author keywords and co-occurrences, citations of documents, co-citations of cited references and cited authors were evaluated based on the bibliometric data of 292 documents in total collected since 1995.

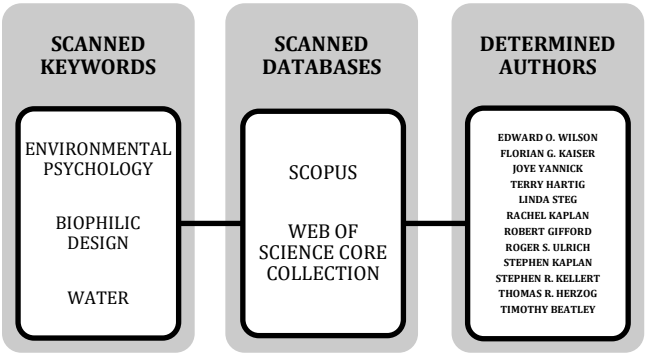
Bibliometric analysis with science mapping techniques was applied to the data downloaded by scanning with the keywords *environmental psychology*, *biophilic design*, and *water* in Scopus and Web of Science Core Collection. The concepts related to the biophilic design-environmental psychology clusters and the developments over time (current trends) by overlay visualization for the concepts were established via co-occurrence mapping. The cited authors and cited references related to the biophilic design-environmental psychology clusters were established via co-citation mapping. The documents' relationships and the authors' relationships with respect to biophilic design and environmental psychology study areas were established via "citation of documents" mapping and co-authorship mapping.

As a result of the co-occurrence mapping, current research gaps and concepts were identified based on the findings (Tab. 17). In the databases selected for scanning, the gaps determined by the scanned keywords are Biophilic Design, Biophilia, Emotional Design, Perception, Architectural Design (Tab. 17). While determining these gaps, new concepts that may be related to design and architecture were emphasized.

Tab. 17. From the Keywords to the New Research Gaps "Concepts". (Source: Katuk, Köseoğlu, 2023)



Tab. 18. From the Keywords to the Authors. (Source: Katuk, Köseoğlu, 2023)



As a result of co-citation mapping, authors and references were identified based on the findings (Tab. 18). In the databases selected for scanning, the primary authors who can be examined as reference sources determined by the scanned keywords are Edward O. Wilson, Florian G. Kaiser, Joye Yannick, Terry Hartig, Linda Steg, Rachel Kaplan, Robert Gifford, Roger S. Ulrich, Stephen Kaplan, Stephen R. Kellert, Thomas R. Herzog, Timothy Beatley (Tab. 18). When ascertaining these authors, cited references that may be related to design and architecture were emphasized.

To conclude, it was pointed out that the concepts determined from water at the intersection of environmental psychology and biophilic design research areas have just begun to be studied and there is a growing tendency. In addition to this situation, in the approach to the relationship between space and water in architecture, biophilic design has been found to be a more recent field than environmental psychology. Consequently, the concepts identified in this study and –especially the new combinations that can be established with the biophilic architecture approach– allow to design new research topics.

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