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A Review

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Tectonic Approach in Landscape Architecture: A Review

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Abstract

Tectonic theory is an integrative philosophy that examined the relations formed between design, construction, and space while create or experience architecture. Various tectonic perspectives since 1852 considering 'space' as an important parameter in tectonic were reviewed. This study aimed at proposing a new definition of landscape tectonics and exploring ways of developing new related aspects in future research. Hence, in order to promote new aspects of landscape, the tectonic approach was first subdivided into distinct concepts and a systematic analysis of the literature was then conducted to identify the knowledge gaps. A descriptive-relative study was, further, carried on including a bibliometric methodology collecting qualitative and quantitative methods of 54 articles; and the related themes and trends were determined via a qualitative comparison of the co-occurrence of the term maps. Moreover, the cluster maps from the VOS viewer program revealed the coalescence of the concepts. Finally, the most frequently cited keywords, along with the ones encoded from the articles, were pointed out based on the Web of Science (WoS) database. Based on this database, the most cited keywords were configuration, distribution pattern, land and fragment; whereas encoding the articles pointed out the terms architecture, building, space, material and environment. This study, therefore, proposes a new definition of landscape tectonic. Investigating new interactions between keywords and areas of tectonic and opened a new page for the development of the new aspects of this field in future researches.

Keywords: review; landscape layers; knowledge gaps; space; VOS Viewer

Citation

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Enfoque tectónico en la arquitectura del paisaje: una revisión

Resumen

La teoría tectónica es una filosofía integradora que examina las relaciones que se forman entre el diseño, la construcción y el espacio al crear o experimentar la arquitectura. Se revisaron varias perspectivas tectónicas desde 1852 considerando el "espacio" como un parámetro importante en la tectónica. Este estudio tuvo como objetivo proponer una nueva definición de tectónica del paisaje y explorar formas de desarrollar nuevos aspectos relacionados en futuras investigaciones. Por lo tanto, para promover nuevos aspectos del paisaje, el enfoque tectónico primero se subdividió en conceptos distintos y luego se llevó a cabo un análisis sistemático de la literatura para identificar las lagunas de conocimiento. Se realizó además un estudio descriptivo-relativo incluyendo una metodología bibliométrica recogiendo métodos cualitativos y cuantitativos de 54 artículos; y los temas y tendencias relacionados se determinaron mediante una comparación cualitativa de la coexistencia de los mapas de términos. Además, los mapas de conglomerados del programa de visualización VOS revelaron la fusión de los conceptos. Finalmente, se señalaron las palabras clave más citadas, junto con las codificadas en los artículos, a partir de la base de datos Web of Science (WoS). Según esta base de datos, las palabras clave más citadas fueron configuración, patrón de distribución, terreno y fragmento; mientras que la codificación de los artículos señalaba los términos arquitectura, edificación, espacio, material y medio ambiente. Este estudio, por tanto, propone una nueva definición de paisaje tectónico. Investigar nuevas interacciones entre palabras clave y áreas de tectónica y abrió una nueva página para el desarrollo de nuevos aspectos de este campo en futuras investigaciones.

Palabras clave: revisión; capas del paisaje; lagunas de conocimiento; espacio; VOS Viewer

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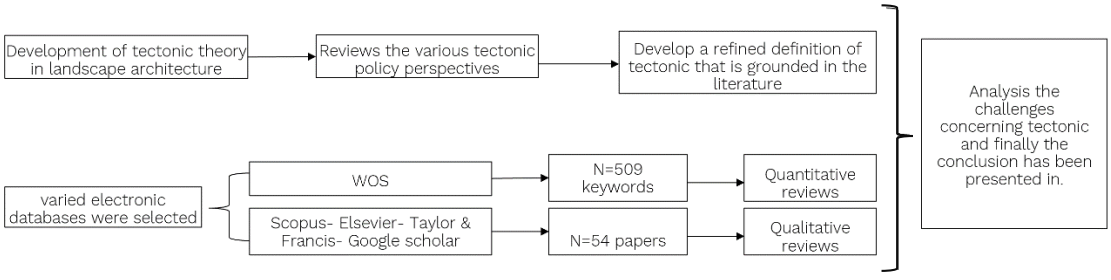
1. Introduction

The term 'tectonics' originates from the Greek word 'tekton', which means builder or carpenter. With regard to the creation of artistic work, it later evolved to include the meaning of the process of creation (Liu and Lim, 2006). The research on architectural tectonics has begun since the mid-nineteenth century (Anderson, 1977; Ballantyne, 2013; Frampton, [1995]2001; Frascari, 1984; Gregotti, 1983; Schwarzer, 1993; Sekler, 1965; Semper, 1989; Vallhonrat, 1988). Semper's alternative history was developed by describing an alternative, construction-based origin points for the discipline (Semper et al. 2011) into a new theory of style (Semper and Mallgrave, 2004). His ideas catalyzed an ideological shift that Schmarsow has fully described (Mallgrave, 1996). A century later, Frampton's tectonic theory was introduced to architects via constructive practice to achieve ideological goals (Frampton, (1995) 2001). This historical progress has transformed architecture from a discipline that the past has absorbed into one that is excited about the future potential (Mallgrave, 1996). Although Semper's ideas considered space a primary concern of architecture to take the place of symbolic form, in 1893, Schmarsow discussed the possibility of studying architectural history to create space (Porter, 2005). Frampton brought the ideas of Semper back into architectural discourse through the tectonic theory, which he developed in Tectonic Culture Studies: The Poetics of Construction (Broughton, 2012). Along with the advent of fabrication technologies for digital design, a similar context has emerged in contemporary architecture. The tectonic theory has a transformative role in the history of architecture, showing the significance of this theory for landscape architecture (Frampton, [1995] 2001).

As the analytical framework of the current research is demonstrated in Figure 1, this research is concerned with:

- Proposing the development of tectonic theory in landscape architecture;
- Reviewing the various tectonic policy perspectives since 1790, when Kant (2017) laid the groundwork for the separation of the aesthetic qualities of architecture from its purpose-driven nature–an initial catalyst for the development of tectonic thought (Schwartz, 2016);
- Scrutinizing 54 selected articles in order to find out keywords through the process of analytical encoding;
- Pointing out the years of publication, citations, and keywords' correlations;
- Presenting the issues and challenges concerning tectonics and the related conclusion.

Figure 1. **Analytical Framework of the Research**



Source: Authors, 2019.

1.1 Main body: Development of Tectonic Theory in Landscape Architecture

According to Steenbergen, Reh (2003), and Steenbergen, (2009), four categories of landscape architectonic are basic form, spatial form, symbolic form, and programmatic form. These categories systematically communicate the different aspects of landscape architectonic form and its perception. In the current study, the spatial form, which explains the function and form of the three-dimensional landscape space, was specifically taken into account.

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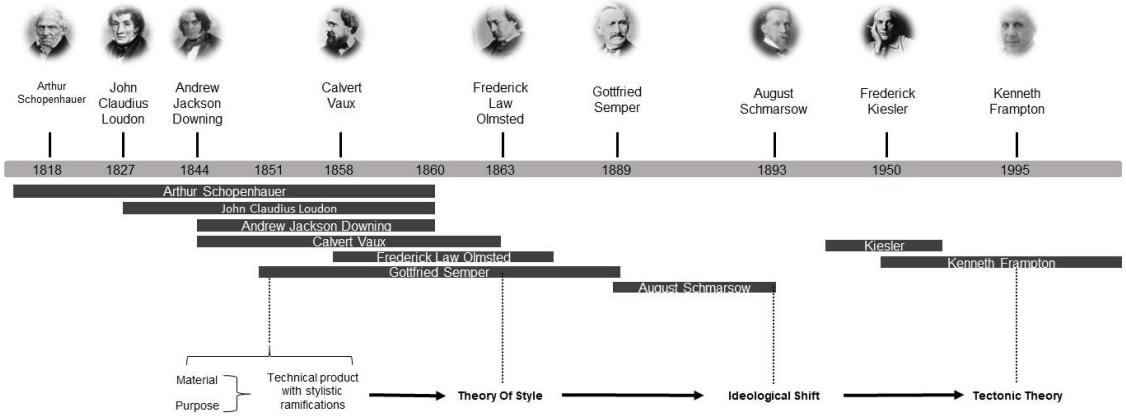
Figure 2. **Author's diagram developed from Broughton 2012**



Source: Authors, 2019. Note: Developed from Broughton (2012), illustrates some of the figure scholars having worked on the related field.

- *Existing Definitions of Tectonics and Special Area:*

Human experience and physical space play roles in the comprehension and cognition of a place acknowledged by Frampton (Broughton, 2012); therefore, the necessity for various deliberate aspects of 'space' and expressions in the landscape is considered. So far, various reviews have been conducted to include almost all aspects of tectonics in landscape architecture and to be more explicit in summarizing the theories expressed over time. Even as the basis for future research, they have tried to investigate the gaps and compare existing studies regarding the expressed theories. Table 1 highlights the theorists, the years of publication, and the theories underpinning their research.

Table 1. **Definitions of Spatial Tectonics**

Year	Theorist	Theory
1790	Kant	The groundwork was set for separating the aesthetic qualities of architecture from its purpose-driven nature. Finding the initial catalyst for the development of tectonic thought (Kant, 2017; Schwartz, 2016).
1818	Schopenhauer	Architecture develops a relationship with the fundamental forces of nature (Schopenhauer, 1966).
1825	Loudon	MYTH OF ORIGIN, as the basis for the tectonic theory of landscape architecture, changes the definition of landscape gardening as an imitative art (Antonetti, 2012; Loudon, 1827)
1835	Schinkel	Masking or concealing construction is an architectural error. Two essential elements are the historical and the poetic ones. The architecture was centered on the spatial distribution, and the construction was the result of the distribution, and it was aligned with the spatial requirements of the program (Frampton, [1995] 2001; Schwartz, 2016; Frampton, 2002).
1852	Botticher	In-between space A new spatial system or future style must be created through a new structural principle. Social operations of building play a key role in the definition of space (as cited in Ballantyne 2013; Frampton [1995] 2001; Schwartz 2016)
1860	Muller	"Tektonische as applying to a series of art forms" (Schwartz, 2016).
1863	Semper	Theory of style (Semper and Mallgrave, 2004).
1873	Vischer	Empathy is derived from tectonic thought carrying concerns for space, construction, and the expression of the built form (Schwartz, 2016).
1886	Wolfflin	Tectonics can be manipulated to solicit empathetic reactions and heighten immaterial events' experiences (Schwartz, 2016).
1893	Schmarsow	Architectural history could be studied in space creation (Mallgrave, 1996). Spatial depth.

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1950	Kiesler	The vision for an 'organic' paradigm of 'elastic' construction technology built on the principles of continuity, mobility, flexibility, multiplicity, and interactivity; and effects of time and motion built on spatial perception, bio-mimetic forms, and creating synthetic relationships between humanity, technology, and nature (Phillips, 2008). 'Endless' spatial concepts embodying a new spatial form. Responsive architecture could be expanded and contracted simultaneously in a single continuous form concerning various spatial needs (Phillips, 2017).
1951	Semper	The joint as the basic factor in tectonics: Textile arts were considered of primary importance in developing his style theory.
1951	Giedion	The concept of space and time (Giedion, 1951).
1963	Arendt	Architecture is finally seen in the public space (Arendt and Canovan, 2018).
1965	Sekler	Architecture became visible through tectonics and intensified a kind of reality experience, which relates to the forms of a building. The structure could be realized through construction as an intangible concept, and visual expression could be admitted through tectonic (Sekler, 1965).
1965	Rudolph	Endlessness is one of the few original concepts. The continuous space that moves in complex ways opens up views (Phillips, 2017).
1971	Giedion	Architecture can reflect an art form as a new form of modern technology (Giedion, 2009).
1971	Gehl	Even in the space between buildings, the landscape is urban life that should be considered the most active and dynamic area (Gehl, 2011).
1977	Venturi	Internalization of space. Confliction between inside and outside calls for the apparent contradiction in architecture (Venturi, [1977] 2008).
1977	Heidegger	Architecture can reflect a new form of modern technology and becomes an art form (Katona, 2010).
1977	Eyck	The continuity of space and the elimination of spatial articulation between the inside and outside: Transition between inside and outside must be defined through in-between space (Frampton, [1995] 2001).
1977	Arnheim	Integrating inside and outside is the most important and intrinsic characteristic of the architectural space. This linkage is unique to architecture-enclosure of space (Arnheim, 2009).
1980	Norberg-Schulz	Exploring the relation of inside and outside in architecture as the primary essence. Human emotions regarding how space was enclosed. Phenomenologically, the focus is on the 'inside' and internalization of space, and the spiritual landscape is the origin of style and architecture. There is a lack of phenomenological landscape analysis (Norberg-Schulz, 1980).
1983	Gregotti	The spatial idea that is indifferent to the site is considered the worst enemy of modern architecture.
1983	Deleuze	Folding space defines a new relationship between vertical and horizontal, object and context, and outside and inside. Architecture is an effective tool for controlling space (Buchanan and Lambert, 2005).
1983	Van der Laan	As the smallest space in an architectonic sense, the space cell can be either large or small, according to the demands that are put upon it (Voet, 2012).
1984	Frascari	An approach beyond construction to the epistemological aspects of tectonics with the idea of "interpreting and constructing the interpretation". (Frascari, 1984)
1986	Foucault	Architecture is not just an element in space; it is immersed in the context of social relations (Foucault, 1984), and also is an effective tool for controlling space.
1987	Grutter	Space is not an enclosure that is confined to a sphere or area. It is the between space (Grutter, 2006).
1987	Zube, Simcox & Law	Landscape design research is considered a tool for spatial composition knowledge through systematic landscape design research (Nijhuis, 2015; Zube et al., 1987).
1988	Koh	Spatial conjugation is an important issue in architecture and landscape. In the built environment, with the continuation of the inner space/outer space (space and landscape), the aesthetic experience improves and the sense of place (Koh, 1988).
1988	Vallhonrat	It was about the tectonic impact on structure and construction techniques (Vallhonrat, 1988).
1989	Correa	Opening to sky spaces means that space should propitiate with climate (Correa, 1989).
1990	Harvey	Marginal role of landscape architecture in the density of space & time (Harvey, 1991).
1990	Lazzaro	Explicit landscape architectonic forms and types of space as the critical areas of landscape design for architectonic landscape design (Lazzaro, 1990).

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1992	Lefebvre	Architecture is an effective tool for controlling space (Lefebvre, 2016).
1992	Kwinter	Epigenetic landscape model describes the effects of contingency on form development (Kwinter and Boccioni, 1992).
1994	Eisenman	Architecture can be conceptualized as a continuous surface with continuity between inside and outside (Leupen, 2006).
1995	Johnson	Landscape as a border (Johnson, 1994).
1995	Frampton	Poetics of construction: The built invariably comes into existence out of the constantly evolving interplay of three converging vectors, i.e., the topos, the typos, and the role of tectonics in the definition of space. Tectonics does not necessarily notice any particular style; it serves to counteract the current tendency of architecture to derive its legitimacy from some other discourse in conjunction with the site and the type (Frampton [1995] 2001). The relationship between architecture and sit and architecture and people are also part of classical tectonics (Frampton, [1995] 2001).
1996	Zonneveld	Landscape as a process, which is considered a holistic and dynamic system, layers an entity in which different processes and systems influence each other and imply the process rather than the result (Zonneveld, 1996).
1996	Walker & simo	Space was the unifying mediator that was re-discovered (in-between space) in modern landscape architecture, and people were no longer just landscape viewers; instead, by interacting with space, they became modern landscape actors (Walker and Simo, 1996).
1996	Mallgrave	The potential of architectural definition as space creation (Mallgrave, 1996).
1997	Gideon	The distinction between inside and outside (Giedion, 2009).
1997	Simonds	The spatial construction of spaces, paths, edges, and thresholds establish spatial relationships such as sections and views (Starke and Simonds, 2013).
1998	Casey	Phenomenal view of space (Casey, [1998] 2013).
1998	Beckmann	Introducing 'antitectonics' to develop classical design and constructional thinking boundaries for the digital architectural age (Beckmann, 1998).
1998	Collins	Concepts of space and time: Einstein's theory of relativity and avant-garde art, space & geometry, four-dimensional space, & Zen Buddhism space (Collins, 1998).
1999	Lefebvre	Interactions between inside and outside (Lefebvre, 2016).
1999	Gardner	Architectonic could be an ability to think and design in space and time or an architectural capacity to develop and deploy spatial intelligence (Gardner, 2000; Gardner, 2011; Nijhuis, 2015)
2000	Frampton	The role of landscape and its significance in architecture, the priority of landscape design on the design of buildings in the form of independent and aesthetic objects and the unifying and liberating factor in landscape design. Greening the world should be preceded by constructing building materials (Frampton, 2000).
2000	Moore	Creating a place through a landscape (Moore et al., 2000)
2000	Hunt	Explicit landscape architectonic forms and types of space as the key areas of landscape design for architectonic landscape design (Hunt, 2000).
2001	Lawson	A comprehensive perceiving space is not limited to mere sensory perception (Lawson, 2001).
2001	Motloch	Creating spatial relations. Spatial sequencing (Motloch, 2000).
2001	Dee	Organizing physical space in the landscape is a process of change in the earth's crust, vertical layers, and sky (Dee, 2001).
2002	Swaffield	The landscape concept is synonymous with space (Swaffield, 2002).
2003	Steenbergen	Knowledge of spatial design is at the core of landscape architecture to define landscape designs as architectonic compositions (Steenbergen et al., 2003).
2003	Steenbergen & Reh	By studying the tectonic landscape, the possible relationships between conceptual thinking and the three-dimensional aspect can be achieved – Frankl's architectural theory was adapted to the landscape –a series of layers, forms, spatial shapes, and metaphorical forms have been created and explain the landscape as the combination and overlapping of these four layers (Steenbergen and Reh, 2003).
2004	Beim	Aesthetic and hidden goals of construction (Beim, 2004).
2004	Gao	Sorting out some of the digital tectonics' phenomena (Gao, 2004).
2004	Dee	Spatial design knowledge is at the core of landscape architecture. Skills development could explore and define landscape designs as architectonic compositions. Paths and edges are critical in the spatial construction of landscape architecture spaces (Dee, 2004).

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2005	Bishop & Lange	Landscape design research is a tool for knowing spatial composition through systematic landscape design research (Bishop and Lange, 2005).
2005	Liu & Lim	Architectural design can be tectonically evaluated regarding the new tectonics since tectonic factors and frameworks are related to structures and design processes (Lim and Liu, 2005).
2006	Galí-Izard & Harris	Bionic tectonic. Textile matrix (Gali-Izard, 2006).
2006	Hensel & Menges	Architectural response to environment: proposed a design method based on tectonic and form-finding due to the effect of different material systems and environmental and climatic factors (Hensel and Menges, 2007).
2007	Franck & Lepori	Human actions and behaviors have spatial forms and occur in space (Franck and Lepori, 2007).
2007	Thrift & May	Introducing the concepts of time and space together, across consideration of space as a static category (May and Thrift, 2001).
2007	Nilsson	Cornell defines tectonic as “clearly constructed with building elements and parts, either necessary or only figurative” (Nilsson, 2007).
2008	Nesbitt	Buildings are concentrated as single objects that cannot be read by their context and are suspended in a timeless, uniform, modern open space (Nesbitt, 2008).
2010	Marrati	Textiles are porous and flexible, suitable for the integration, response, and even structuring of landscape contingency, the natural cyborg (Marrati, 2010).
2010	Hester	A penetrating boundary for making the difference between inside and outside. The new tectonic expresses that architectural design from a personal or Socio-cultural view can be tectonically evaluated (Hester, 2010).
2011	Rizzuto	The direct impact of tectonics culture on continuous architectural discourse: construction and text (Rizzuto, 2010).
2011	Spuybroek	Using digital technology to analyze the traditionally rigid tectonic process converted into something flexible (Spuybroek, 2011).
2011	Gardner	Architectonic recognized landscape design research as a vehicle for acquiring knowledge of spatial composition. It could be a theme for developing and deploying spatial intelligence (Gardner 2011).
2012	Booth	Spatial design knowledge is at the core of landscape architecture, defining landscape designs as architectonic compositions (Booth, 2011).
2012	Nijhuis & Bobbink	Landscape architectonic design includes separating design objects from a specific design context independent of a specific situation in spatial terms. Architectonic landscape design can be regarded as research (Nijhuis and Bobbink, 2012).
2012	Oxman	Tectonics is a fundamental concept that defines the relationship between architectural design structural and material characteristics (Oxman, 2012).
2012	Pallasma	Role of different senses in sensory perception of space: The most durable memories of space are often by the space's fragrance (Pallasma, 2012).
2013	Bell	“From the inside out”, space and path are important structural components of landscape architecture (Bell 2013).
2013	Crysler	Landscape design reflects two prominent features of modern architecture in the post-World War era: space and structure (Crysler, Cairns, and Heynen, 2013).
2015	Ozola	The human scale in the spatial composition of the tectonic landscape means that it is possible to mix organically, cover all components of spatial expression, and guarantee an adequate perception of the spatial composition (Ozola, 2015).
2015	Nijhuis	Landscape design research is known as a tool for knowledge of spatial composition via systematic landscape design research (Nijhuis, 2015).
2015	Hillier	The common factor is both ideas of buildings & communities in space (Hillier, 2015).
2016	Addington & Schodek	Associating integrative material design with smart materials and technologies, tectonic, and related work (Addington and Schodek, 2016).
2016	Schwartz	Tectonic is interpreted as the product of an idea that proves the complexity of tectonics. The tectonic theory is an integrative philosophy that examines the relationships between design, construction, and space during the development or experience of architecture. It will play a key role in developing the built environment to understand the connection between the physical acts of construction and occupation in our built environment (Schwartz, 2016).

Source: Data adapted from authors, 2019.

An additional timeline, which is shown in Figure 3, was carried out to identify relevant theories that have been published.

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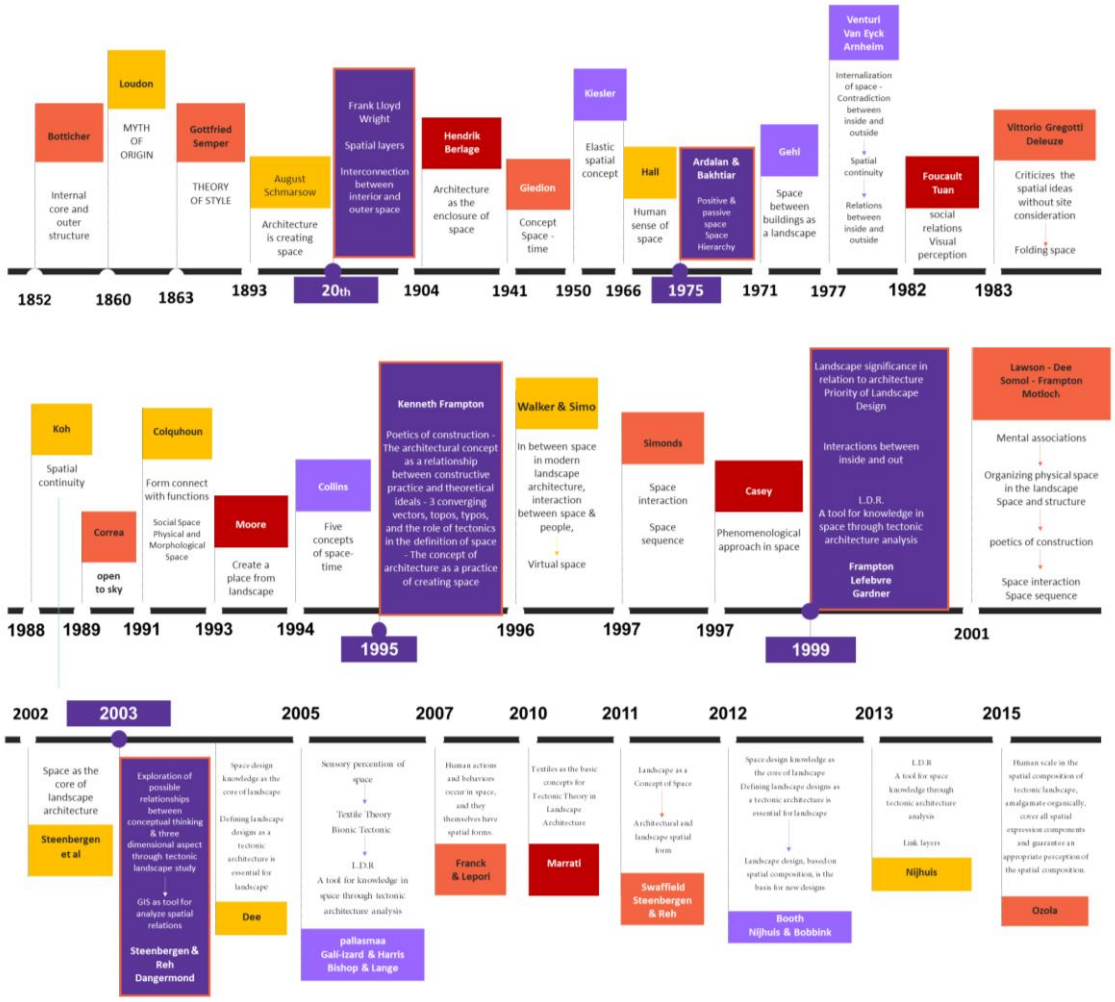
Figure 3. **Authors' Diagram Developed from Table 1**



Source: Authors, 2019.

1. Materials and methods

In order to bridge the gap between tectonic and landscape architecture, a descriptive-relational study based on the reviewed literature was used to highlight important theories (as shown in Table 1). The academic literature on tectonics has been reviewed in order to (1) identify the most influential studies, (2) trace the theoretical origins and the field development, (3) compare the definitions of tectonics in a variety of studies, (4) develop a refined literature-based definition of tectonic approach and address the conceptual tension, and (5) identify the knowledge gaps.

In the first place, to find quantitative reviews concerning the tectonic approach to the landscape architecture, varied various databases were selected. Furthermore, two search methods were run, i.e., manual search and automatic searchand automatic searches. These methods of search are mutually complementary (Zhang, Bebar and Tell, 2011). We searched the electronic data sources using the search terms mentioned in Figure 4.

2.1 Search Terms

The search terms, which are fully illustrated in Figure 4, were used to match paper titles, keywords, and abstracts during the automatic search in of the electronic data sources. The exceptional cases are the WOS database, in which the search terms are only coordinated with paper titles because

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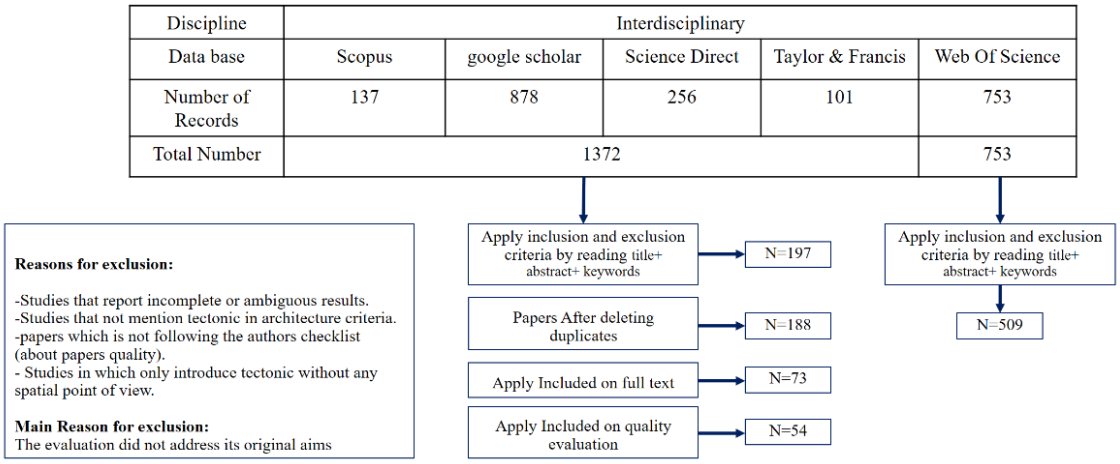
these databases restore an excessively large number of papers, including abstracts and keywords. We utilized the accompanying techniques to create the most applicable automatic search terms. The search terms consisted of the terms "architecture' AND 'tectonic' AND 'landscape'. We also used the following search terms: (architecture OR architectural OR landscape) AND (tectonic OR architectonic).

Figure 4. **Stages of the Search Process and Number of Studies Selected in Each Stage**



Source: Authors, 2019.

2.2 *Summary of 54 Articles' Review*

Combining both the methodological search and deletion of duplicates, 54 papers cited in Table 2 had been checked. Gibbs (2018) mentioned that the studies were conducted based on a qualitative paradigm through an analytical process.

The articles were analyzed from the viewpoint of the focus areas and research methods. Moreover, the themes and keywords covered by tectonics were explored based on the content analysis with coding.

Table 2. **Summary of 54 Articles' Review and Evaluation of Current Self-report Measures**

NO.	Scholars	Focus areas	Research methods
1	Fowler, 013	Soundscape studies Relationship between aural design and architecture	Design method Analytical research Auditory design methodologies
2	Andersson and Kirkegaar, 2006	Digital tectonics Performative architecture	Case study analyses Theoretical analysis
3	Voet, 2012	Dom van der Laan's poetics Moder-Marias Convent	Descriptive and analytical research based on case studies
4	Gough, 2013	Autonomy in architecture	Literature Review
5	Kim and Park, 2017	Ancient building technologies Tectonic tradition Cultural fusion	Descriptive and analytical research based on case studies
6	Ozola, 2015	Spatial structure Rural inhabited areas Cultural heritage natural value	Analysis of the planning of the case study
7	Meagher, 2015	Changeable responsive architecture Building elements Environment	Case study analyses
8	Holst, 2017	Epistemological ontological	Literature Bibliometric methods
9	Katona, 2010	Reconsidering ritual characteristic	Case study analyses

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10	Frampton, 2002	Architectural space Durability and fleetingness of architecture	Case study analyses
11	James and Nagasaka, 2010	Multimedia Spatial significance Interactive tectonic	Case study analyses
12	Badillo, 2014	The interface between phonological and morphological structures Structural linguistics	Descriptive and analytical research
13	Corbella and Magalha, 2008	How architecture and urbanism interact with climate Open spaces Integrating urbanism and climate	Descriptive and analytical research Expansion
14	Catling, 2015	Bottom-up growth of cities Tactical Urbanisms Megacity	Case study analyses
15	Farjami, 2015	Empty space Iranian Architecture	Phenomenological recursive abstraction method Case study
16	Liu and Lim, 2006	New tectonics Digital theory Design theory	Case study analyses
17	Oxman, 2012	Digital design Material Formulated taxonomy	Case study analyses Pilot study
18	Nijhuis and Bobbink 2012	The research strategy for design Experimental design study	Design-related research Case study analyses
19	Schmidt and Kirkegaard, 2006	Technology in connection to architecture Human experience	Descriptive research based on case studies
20	Lim and Liu, 2005	New digital space New tectonic factors Computer-aid design process	Case study analyses
21	Ham, 2003	Tectonic education Comparisons between virtual and actual construction	Case study analyses
22	Shannon and Manawadu, 2007	Landscape Urbanism Sri Lanka Water Management	Descriptive and analytical research Case studies
23	Hindle, 2012	Vegetation Bearing Structure Vertical gardening	Case study analyses
24	Smith, 2011	Fiber art Gerhardt Knodel, Warren Seelig, Kay Sekimachi	Case study analyses
25	Jo and Lee, 2007	Architectural process Narrative of architectural production in forms	Case study analyses
26	Marszałek et al., 2014	Sandstones Monuments Architectural details	Case study analyses Analysis samples Survey
27	Rice, 2012	Regional Rhetoric	Descriptive study
28	Almerbati et al., 2016	3D Printing Parametric architecture Digital tectonic Culture Re-envisioning of the Construction	Bibliometric methods

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29	Treib, 2009	Behavior in urban spaces Finnish architecture Life in the Senate Square	Descriptive and analytical research Case studies
30	Schwartz, 2015	Study of precedents Understanding the design of architecture	Grounding Theory
31	Diamond, 2011	Contemporary parks Cubist space Design theory	Descriptive and analytical research Case studies
32	Despang and Mumm, 2007	Urban infrastructure Societal and economic challenges	Case study analyses
33	Kite, 1999	Tectonic and spatial aspects of Stokes's thought Aesthetic context	Literature review Case study analyses Theoretical analysis
34	Hartoonian, 2001	Tectonic and tactile aspects of construction	Case study analyses
35	Kim, 2015	Mies van der Rohe Space Tectonic quality	Case study Theoretical analysis Descriptive research
36	James and Nagasaka, 2011	Multimedia Spatial significance Correlating architectural space People experience Interactive space	Case study analyses System theory approach
37	Koca and Barlas, 2014	Space and social life continuum Karabaglar	Descriptive and analytical research Case Study
38	Hedfors, 2014	Characterization of substantive theory in landscape architecture Tropism and tectonic	Descriptive and analytical research Case Study
39	Rosenberg, 2012	The social vision of the kibbutz Landscape and modernism	Descriptive and analytical research Developmental research based on case studies
40	Lægring, 2017	Bjarke Ingels Post-criticality Visual culture Robert Venturi Denise Scott Brown	Literature Review Descriptive and analytical research Case Study
41	García et al., 2006	Texture Visual integration Building design Rural landscape Photographic Interaction	Quantitative method Computer analysis of landscape images GIS
42	Tang et al., 2019	Building façade Conservation planning Regeneration of the facade Traditional architecture	Generative design method Cognition investigation and morphology analysis
43	Troiani and Ewing, 2014	Disciplinary and hybridized practice Material and design practice	Design practice research
44	Walliss et al., 2014	Digital technologies Techniques and processes for conceiving and constructing	Computational methodology Simulation
45	Van Gerrewey, 2015	Dutch spatial development Regional planning OMA	Case Study
46	Gabrijelcic, 2016	Sustainable development Low energy house	Descriptive and analytical research Case studies

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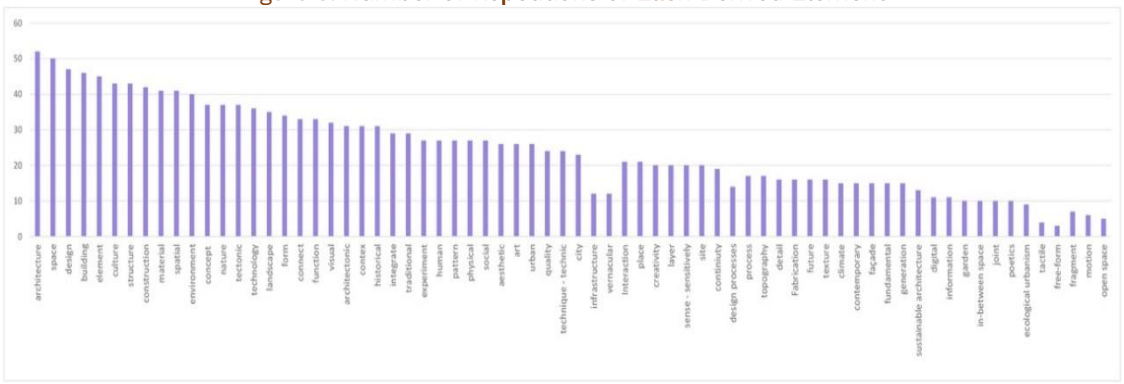
47	Sheridan and McMenamin, 2012	Spatial strategies Built structures Rural context Vernacular structures	Case Study
49	Kakalis, 2016	Music and architecture Silence	Descriptive and analytical research Case Study
50	Leila and Naima, 2016	Aesthetic, tectonic, abstract, and figurative processes Architectural conception	Developmental research based on case studies
51	Di Maio et al., 2012	Archaeological research Architectonic structures	Non-destructive methodology Ground geophysical methods direct current geoelectric method (DCG)
52	Ren, 2017	Rural reconstruction Chinese architecture	Descriptive and analytical research Case Study
53	Mikkelsen and Lange, 2017	Conception of place Relocation and transformation in urban design	Case Study
54	Mitrache, 2012	Reconfiguration of the relationship between artistic expression and built objects Impact of technology on re-shaping	Descriptive and analytical research based on the case study in a complementary way

Source: Data adapted from authors, 2019.

The textual data analysis process was designed to identify themes after encoding the articles (Table 2). Accordingly, the keywords with the highest number of repetitions are shown in Figure 5.

Figure 5. **Number of Repetitions of Each Derived Element**



Source: Authors, 2019.

2.3 *WOS Analysis and the Existing Definitions of Tectonics*

Compared to the WOS analysis and the existing definitions of tectonics, the analysis of this study has unveiled distinct topics and themes. The research was carried out on October 7, 2018. First, citation databases of Taylor & Francis, Scopus, Elsevier, and Web of Science were used to determine tectonic literature for 58 years, from 1960 (when John Claudius Loudon (1825) expounded on MYTH OF ORIGIN, with an alternative firmly grounded in landscape-specific constructive practice) to consummation in 2018. These databases generally do not include books and have an Anglo-American bias by concentrating mainly on publications in English (Newell and Cousins, 2014).

Table 1 resulted in additional resources, such as dissertations and book chapters for further studies on the definition of tectonics. Since the analysis was conducted, additional definitions may have been published due to the quick improvement of the tectonic field. The search terms 'tectonic' or 'architectonic' yielded 15 results in Scopus, 17 in Taylor & Francis, 509 in WOS, and 30 in other databases. After the collection, 571 unique publications from various resources (i.e., articles, papers, and reviews) were included in the tectonic data set.

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Some co-citation analysis was conducted for quantitative evaluation of the academic literature. Co-citation analysis was used to identify influential publications and researchers in the given field of research and to provide insight into the field's intellectual origins (Meerow, Newell and Stults, 2016) by measuring how often two or more studies are cited together in the literature.

The bibliometric software Bibexcel (Persson, Danell and Schneider, 2009) was used to assess these co-citations. The degree of centrality was reflected by node size in the network, i.e., the larger its means, the more edges interface to a node and serves as an indicator of the influence of a study.

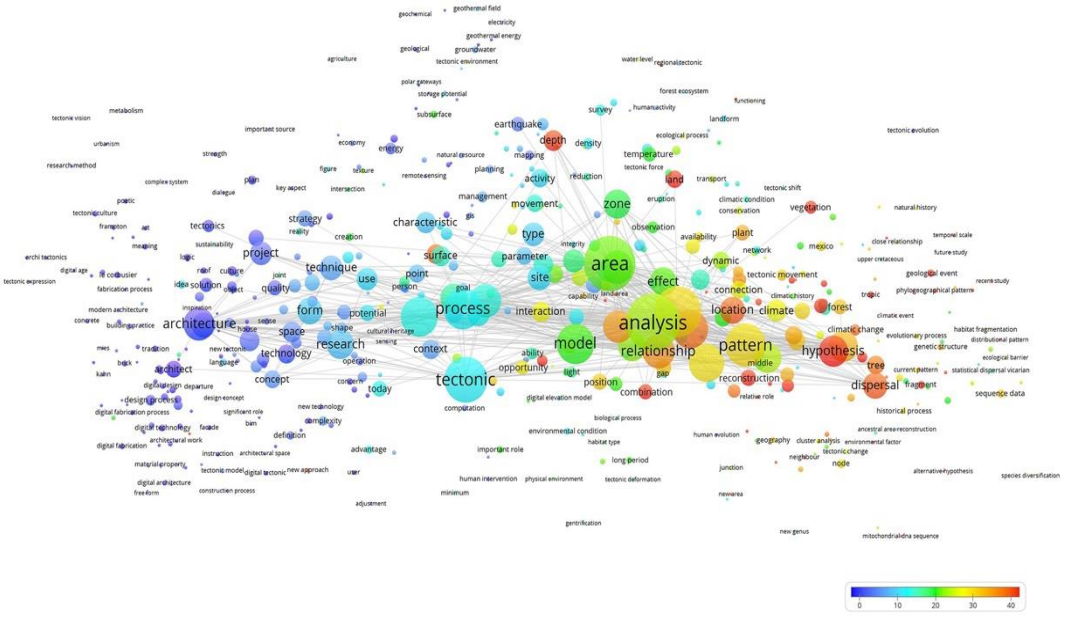
2. Discussion

In spite of subsequent categorizations, the study aimed at demonstrating a simplification of complex ideas and studies, and the goal was to provide a general concept of how definitions were speculated on these tensions. In conclusion, the knowledge gaps in the definition of landscape tectonics were identified more extensively using the reviewed tectonic and landscape architecture literature. 509 studies were reviewed to find out whether they had defined tectonics.

Moreover, they were scrutinized to determine whether they contained architecture, environmental studies, green sustainable science studies, or ecology categories.

Influential publications of tectonic literature were presented in Figure 6, illustrating the network of co-citations for the assembled tectonic WOS data set. The nodes or circles demonstrate the explicit references cited, while the edges (interfacing lines) imply that two references are related. The size of the nodes reflects the number of connections that a reference has within the network (degree of centrality).

Figure 6. **Term Citation Impact 'Heat Map' for Tectonic, 1960-2018**



Source: Authors, 2019.

As shown in figure 6, color communities represent more closely related publications, and the Force Atlas algorithm is employed for the scheme, which shows a closer relationship with more clustering.

An increasingly particular methodology for utilizing the maps would distinguish hot topics from the warmest of the periods.

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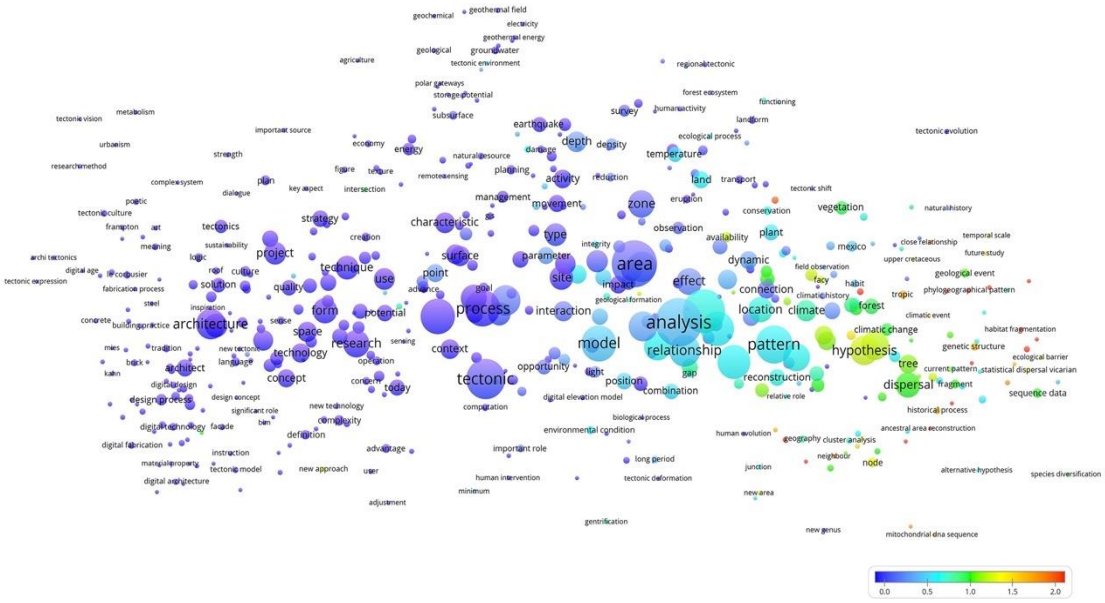
Moreover, Figure 7 demonstrates the visual investigation of the maps and their arrangements. One initial observation is that the hottest terms tend to be small and specific in 'land and fragment'. The 'heat' or citation impact ranging from blue (cool) to red (hot) corresponds to the normalized scores from 0 to 2; afterward, the score of 1 is subtracted from the range to show the average (green).

Figure 7. **Term Citation Impact 'Heat Map' for Tectonics, 1960-2018**



Source: Authors, 2019.

Having driven from Figure 7, although the most common keywords in the term citation impact 'heat map' are depth, reconstruction, hypothesis, vegetation, combination, and geological events, the ones that are the most related to the others are tectonics, process, structure, area, analysis, pattern, model, and architecture.

Additionally, Table 4 displays the selected examples and characteristics of 'Hot Topics' derived from the Heat Map Citation Effect Analysis.

Table 3. **The Most Repeated Keywords in WOS Selected Papers**

Year	Hot keywords
2014	Tectonic fabrication computation GIS
2013	City building methodology energy economy climate condition point
2012	Architecture technology
2011	Process model project form space design process integration
2010	Analyse area time layer correlation surface context nature
2009	Pattern depth climate diversity earthquake tectonic

Source: Data adapted from authors, 2019.

Listed in Table 3, emerging topics are 'environmental change', 'spatial pattern', 'climatic change', 'contemporary process', and 'community structure', while on the other side of the figure, 'city', 'tectonic', 'fabrication', 'dialogue' and 'GIS' are the most published keywords in 2013–2014 LAND map (Figure 7 and Figure 8); furthermore, Global-scale is the emerging topic on both charts. Nonetheless, in Figure 8, instead of being represented by clusters, the terms are represented by colored circles to reflect the average citation impact for each term.

As shown in Figure 9, one could find out that the emerging topics would also be 'hot topics' in terms of citation rates.

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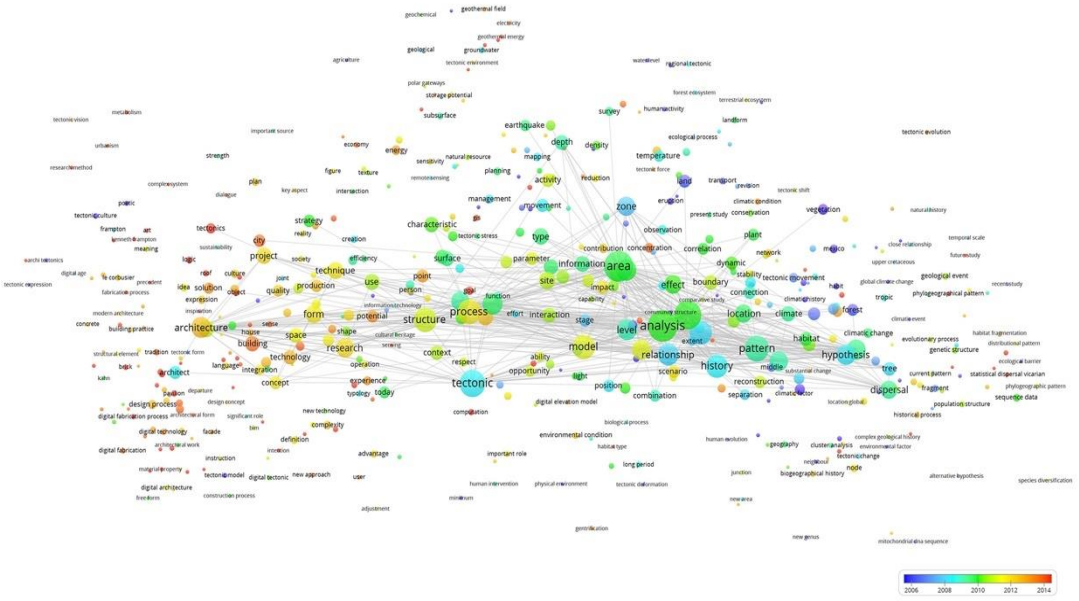
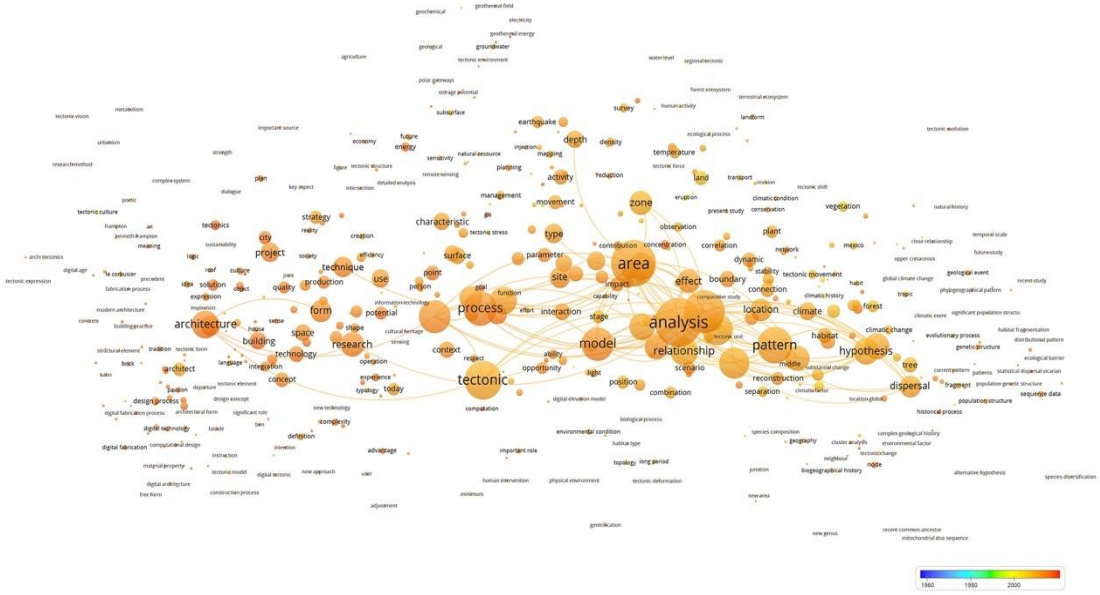
Figure 8. **Term Published Year 'Heat Map' for Tectonic, 2006-2014**



Source: Authors, 2019.

Figure 9. **Term Published Year 'Heat Map' for Tectonic, 2006-2014**



Source: Authors, 2019.

In Table 4, the selected examples and characteristics of the term 'Hot Topics', which were driven from the 'Heat Map' citation effect analysis, are thoroughly stated.

A comparison of Figures 4 and Figure 8 shows that more than 95% of the published articles were published after the year 2000, and the most heated ones are around 'area', 'tectonic', 'process', 'analysis', structure', 'pattern', 'architecture', and 'context'. Figure 5 is about the coding of 54 articles and refers to the most repeated words such as tectonic, architecture, space, spatial, building, environment, construction, material, technology, and form.

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Whereas Figure 6, which is analyzed by a VOS viewer and based on the articles extracted from the WOS databases, includes other terms: land, configuration, depth, reconstruction, hypothesis, vegetation, combination, and geological events.

Table 4. **Selected Examples and Characteristics of the Terms Hot Topics from the Heat Map Citation Effect Analysis**

Term	Period	Occurrences	Relevance	Size	Cluster
Architecture	2012-2014	92	1.7504	Big	Architecture, environmental studies, urban studies
Building	2012-2014	49	1.4937	Medium	Environmental studies, architecture
City	2012-2014	30	0.9933	Medium	Architecture, environmental studies, urban studies, green sustainable science technology
Climate change	2012-2014	24	0.2802	Very small	Urban studies, ecology
Complexity	2012-2014	15	0.6461	Small	Environmental studies, urban studies
Digital fabrication	2012-2014	7	2.7746	Small	Urban studies
Form finding	2012-2014	3	2.4069	Very small	Architecture
GIS	2012-2014	8	0.75	Small	Architecture, urban studies, environmental studies
Material	2012-2014	9	2.4953	Very small	Architecture, urban studies
Sustainability	2012-2014	4	1.9661	Small	Urban studies
Technology	2012-2014	43	1.3832	Medium	Architecture, urban studies, green sustainable science technology
Urban planning	2012-2014	4	1.4246	Small	Architecture, environmental studies, urban studies
Urban space	2012-2014	5	1.3122	Small	Environmental studies, urban studies
Connectivity	2009-2011	10	0.2492	Small	Ecology
Context	2009-2011	44	0.4553	Medium	Architecture, urban studies
Environment	2009-2011	90	0.2104	Big	Architecture, urban studies, ecology, environmental studies
Integration	2009-2011	22	1.5201	Medium	Urban studies
Landscape	2009-2011	34	0.2396	Medium	Green sustainable science technology
Site	2009-2011	64	0.2055	Medium	Urban studies, ecology, green sustainable science technology
Space	2009-2011	47	0.8328	Medium	Architecture, urban studies
Tectonic	2009-2011	113	0.4536	Big	Architecture, ecology, urban studies, environmental studies, green sustainable science technology
Architectonic	2006-2008	4	26.3349	Small	Architecture
Ecology	2006-2008	22	0.1506	Very small	Urban studies
Environmental factor	2006-2008	3	0.2932	Small	Urban studies, architecture
Fragment	2006-2008	12	0.9423	Small	Ecology
Human activity	2006-2008	5	0.6437	Small	Architecture

Source: Data adapted from authors, 2019.

Since the landscape is a multi-layered entity, tectonics parameters should be identifiable in its structure. According to Bobbinik, tectonic architecture is evident in 3 layers: urban, natural, cultural (Bobbink 2009) 'joint', 'detail', 'material' and 'object' are tectonic-related parameters that are identifiable in nature and urban layers. Interaction is a parameter that relates these three layers and is not separately definable in a landscape context.

However, the 'structure' and 'construction' parameters in the urban layer have a closer definition to their tectonic origin.

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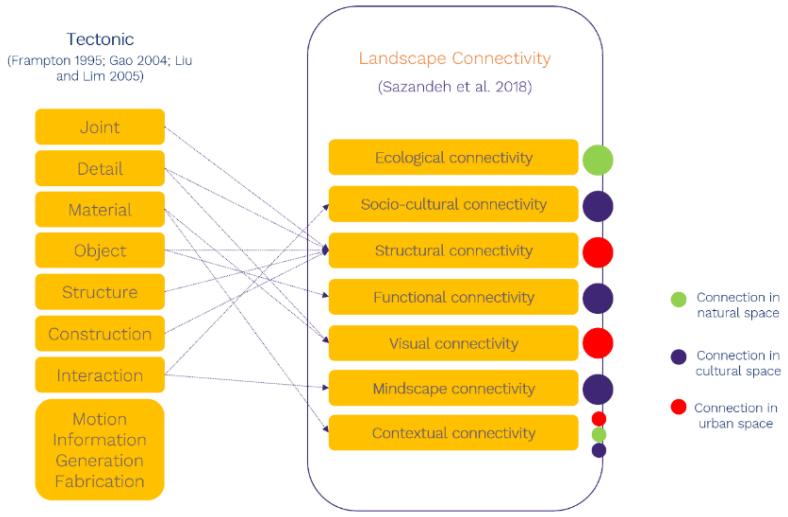
Figure 10. **Landscape connectivity and Tectonic parameters**



Source: Authors, 2019.

The parameters of digital tectonic are related to the construction in the city and mostly in the urban layer. If we consider that 'joint' is equal to connection, this can be translated to landscape connectivity in the landscape field, which can be categorized under Ecological connectivity, Socio-cultural connectivity, Structural connectivity, Functional connectivity, Visual connectivity, Mindscape connectivity, Contextual connectivity, Contextual connectivity groups. However, 'joint' in tectonic is only an indication of physical form. Figure 10 shows this relation.

Comparing the definitions of Frankl, Steenbergen, and Reh, and Marot in the table, we can match each tectonic layer to landscape layers. Therefore, and due to Botcher's claim that tectonics needs a new definition in each field, we need to synthesize the tectonic parameters in the landscape. If we use Steenburgen's method in landscape layer analysis, we have the parameters 'object', 'structure', 'construction', 'joint', 'detail', material, and interaction in the basic form layer equivalence in the landscape.

Table 5. **Comparing the definitions of Frankl, Steenbergen & Wouter, and Marot**

Landscape architectural layers		**Tectonic layers**
Based on Marot (1999)	Based on Steenbergen and Wouter Reh (2003)	Based on Frankl 1968)(
Anamnesis (Traces of history). (Hunt, 2000)	Basic form	Basic form
Process focuses	Spatial form	Corporeal form
Spatial sequencing	Metaphorical form	Visible form
Context	Programmatic form	Purposive intention (Steenbergen et al., 2003)

Source: Authors, 2019.

Since Steenburgen has mentioned the circulation pat, framing, and picturesque, we can locate 'motion' and 'interaction' parameters in the spatial form layer -which was our focus due to the significance of space in this field. The layer of metaphorical form in the landscape has some theoretical shortcomings in tectonic and lacks some parameters. For example, the parameters 'object', 'interaction', and 'material' can be used. In digital tectonic, parameters like 'motion' allow the analysis of the layers of spatial and programmatic forms. These parameters can be redefined in the landscape but need to consider different layers to include different aspects.

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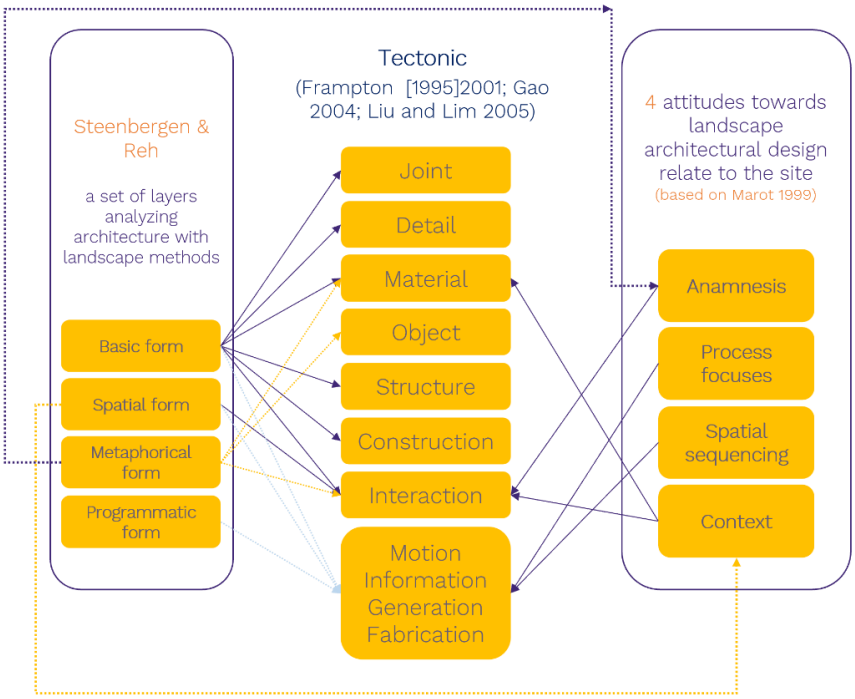
Figure 11. **Landscape layers and Tectonic parameters**



Source: Authors, 2019.

3. Conclusion

Based on the background and aim of this research, findings indicated a definite relationship between landscape architecture, tectonic, and space. Although Botticher has established the basis for the theory of tectonics since 1852, the most relevant articles in this field were published after 2006, according to the related history (Figure 2 and Table 1).

While 'land', 'fragment', and 'vegetation' have been highly referenced over the times, their relationship with 'tectonics' has not been seen. Based on Figure 3, 'spatial continuity' is an important issue to be pointed out, but this relation is not included in WOS articles.

Based on the WOS database, keywords such as 'configuration', 'distribution pattern', 'land', 'fragment', 'configuration', and 'significant change' are mostly cited since encoding and analyzing the 54 selected articles pointing out the words 'architecture', 'building', 'space', 'material', 'environment', 'design', 'nature', 'spatial', 'landscape', and 'tectonic' were the most cited and correlated with the other keywords.

In 2003, Steenbergen, Reh, and Dangermond highlighted the importance of the 'GIS' in discovering the possible relationships between conceptual thinking and the three-dimensional aspect with of the study of the tectonic landscape; however, it was since 2014, that the 'GIS' has been taken into account in the articles. In 2000, Gardner introduced 'landscape design research' as a tool for obtaining space knowledge through the tectonic architecture analysis; nevertheless, these related issues have been taken into consideration in WOS articles since 2013. Moreover, in terms of 'fabrication', to which Frampton also referred, the importance was noted as one of the hot topics in WOS articles since 2012, and based on Table 3, it has been noted after 2005 as one of the most cited keywords.

A review of 115 theorists and architects during the period of 1790-to 2017 shows that they often referred to the issue of space as a necessary topic in tectonic architecture, whereas they had not attended to it in the published articles.

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From the advent of the first tectonic theory, the issue of space has been considered (Figure 3), but until 2009, it had not been seriously considered in the articles.

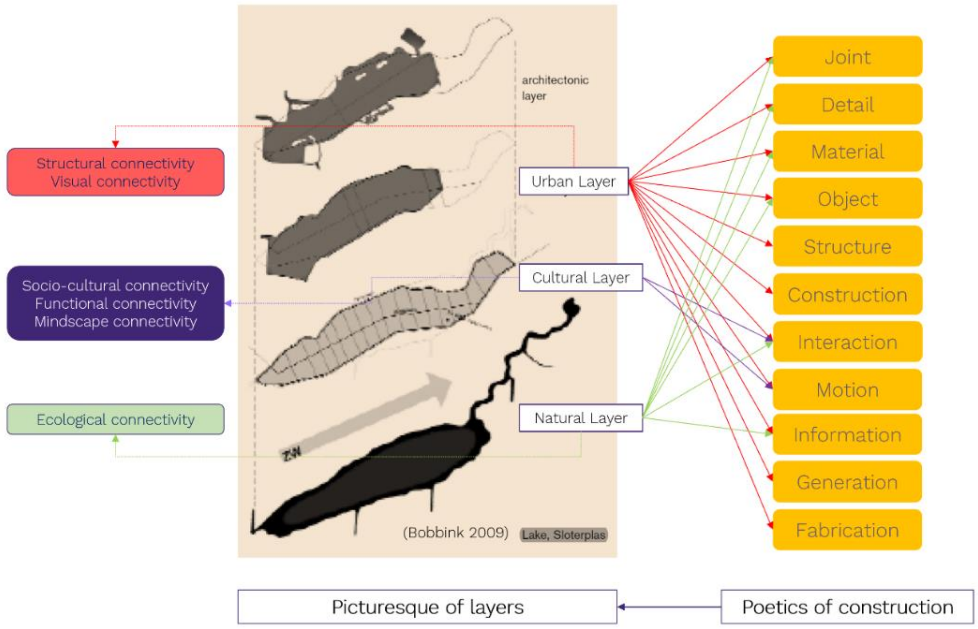
Such keywords as tectonic, area, analysis, process, pattern, structure, and architecture are the most relevant in the current field of study and are considered as more comprehensive keywords. Although distribution pattern, fragment, neighbor, species composition, depth, configuration, form-finding, and spatial space have high references, they have not been used in various fields. Hence, it is understood that they have been used in specific research fields.

So far, numerous studies have been conducted on tectonics and other fields; however, they seem to be not sufficient enough in the fragment, climate condition, habitat fragmentation, fragment and pattern, environmental condition, user, continuity, connectivity, form-finding, human activity, restoration, dialogue, integration, and junction.

For instance, there is no significant interaction between tectonics and the words 'environmental change', 'habitat', and 'fragmentation'. The results of iInvestigating many keywords and the areas related to tectonics, which were mentioned in this study's figures and tables, could ultimately result in finding new aspects and developments in future research in this field.

Due to the layered nature of the landscape, acknowledged by Ian Mc-Harg and Frampton's definition of poetics construction, this study chooses the phrase 'picturesque of layers' to for tectonic in landscape and calls for more research in on tectonic parameters in landscape layers, as is shown in Figure 12.

Figure 12. **Definition of tectonic landscape**



Source: Authors, 2019.

Authorship

The first author has participated In the conceptualization, methodology, data analysis, writing - original draft, writing - review & editing. And the second author has participated in conceptualization, supervision, methodology, writing - review & editing, and the third author In supervision, and methodology.

Conflict of interests: The authors declare that there is no conflict of interest.

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