THE TYPOLOGY OF CONNECTIVITY IN LANDSCAPE ARCHITECTURE: A REVIEW OF STUDIES ON LANDSCAPE CONNECTIVITY (LC)

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Abstract
Connectivity is an important landscape characteristic that is essential for health, welfare and aesthetic values in human societies as well as for the protection of native ecosystems. Diversity in objectives, approaches, definitions and methods in studies on connectivity and its widespread use in the field of landscape ecology are reasons why Landscape Connectivity (LC) in landscape architecture has been deemed as the counterpart of Ecological Connectivity leading to neglect of other aspects of this comprehensive concept. This study, reviews and classifies studies carried out in the field of landscape with a focus on connectivity in order to achieve a comprehensive definition of LC and its various components in landscape architecture literature. The research method used in this study was quantitative-qualitative. In the first phase, the literature was collected using library research and internet search via a descriptive-analytical approach. Then, an inductive constructionist strategy using Delphi technique was used to classify and categorize relevant studies, and logical argumentation was used to develop the concept of LC in landscape architecture literature. Finally, the objectivist Descriptive/Synthetic Modelling strategy was used to provide a conceptual model of urban landscape connectivity (ULC). The key finding of this study is the researcher-made conceptual model of ULC, its corresponding components and parameters with the viewpoint of landscape architecture.

Keywords: Connectivity, Elements of Landscape Connectivity, Landscape Connectivity, Urban Landscape Connectivity

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INTRODUCTION

Landscape is dynamic in nature and consists of homogeneous internal structure and processes (Forman & Godron, 1986). However, with the growing rate of urbanization and human intervention in landscape, its structure including its components and spatial layout has changed leading to the phenomenon of landscape fragmentation (Carvalho et al, 2009).

Air and water pollution, reduced soil quality, low humidity, development of heat islands in cities, increased temperature, the loss of valuable ecosystems, destruction of habitats, extinction of species, loss of biodiversity, introduction of non-native species, psychological and social adverse impact on the health of citizens, reduced permeability, and visual pollution are examples of the consequences of landscape fragmentation (Alberti, 2005; Forman, 2008; Hough, 2004; Warren, 1998; Wheater, 1999, Tian et al, 2011).

Since 1970, landscape ecologists began their studies on landscape fragmentation resulting in an extensive theoretical and empirical literature in this area. However, the concept of connectivity as opposed to isolation at urban and smaller scales has remained under-researched in the landscape architecture literature. Destructive effects of landscape fragmentation at urban scale including fragmentation of urban green spaces, intermittent visual interruptions, intermittent walking paths, etc. not only harms the health of urban ecosystems, but also reduces the quality of life and working environments, and physical, mental and social health of residents in these areas. This can lead to obstacles for sustainable environmental and social development, especially in dense cities (Jaeger et al, 2008).

This study aims to explain the concept of connectivity in landscape architecture via an extensive study of previous research in this area. So, from among various sources studied in this study, 19 studies with a more significant role in the development of the concept of LC and its components were selected for detailed review. These included four books, two doctoral dissertations and 13 articles which had been published in the period from 1993 to 2016. Classification of these studies helped in laying the groundwork for the development of a conceptual model of ULC by the researchers.

THEORETICAL FOUNDATION

Definitions

Since the concept of landscape connectivity is suggested in opposition to isolation or fragmentation, first, the concept of landscape fragmentation is explained below.

Landscape Fragmentation

Landscape fragmentation is a human process that -on a large scale- includes the breaking up of a continuous habitat, land use type, or ecosystem. At urban scale, it results in an environment with a heterogeneous and isolated composition (Carvalho et al, 2009). The process of landscape fragmentation directly affects the development of ecosystems and may lead to extinction, displacement, or increase in plant and animal species (Li et al, 2009). Fragmentation of urban green space has led to a decline in urban ecosystems health and the quality of living environments (Tian, et al, 2011).

In landscape ecology, certain parameters are used in order to quantify the level of fragmentation. In relevant studies the parameters of AREA-MN, SHAPE-MN, PD, and ENND-MN are used as basic standards and metrics (Keyghobadi et al, 2005; Munroe et al, 2007; Carvalho et al, 2009). In addition, according to Jaeger (2000), three standards of DIVISION, SPLIT, and MESH are preferred to the usual metrics in the process of assessing fragmentation. That is because of their lack of sensitivity to the removal or addition of small residual patches. Connectivity, represented by connectance index (CONNECT) is usually used as a strategy to thwart the fragmentation problem (Noss, 1991; Tischendorf and Fahrig, 2000; Tian et al, 2011).

Most landscape fragmentation studies have been done for natural and rural landscapes in connection with the dynamics of certain animals or habitats of birds (Davidson, 1998; Li et al, 2009). Few studies have focused on fragmentation of vegetation in urban landscapes and the potential impact of fragmentation on urban life particularly in compact cities such as Hong Kong. Nevertheless, the process of landscape fragmentation is extensive and can encompass a wide range of complex processes. Aggravation of the process in urban green spaces not only interferes with ecological functions of the system, but also leads to deterioration of the quality of life for residents, because the green space is getting smaller and this is accompanied by simplification of the vegetation structure that can no longer meet the needs of neighborhood residents in terms of mental, social and physical health (Tian et al, 2011).

Landscape Connectivity

The Webster dictionary defines connectivity as the quality, state, or capability of being connective or connected; while continuity refers to uninterrupted connection, succession, union or uninterrupted duration of continuation, especially without essential change (Webster dictionary online, 2017). Key questions in application of either of these terms to landscape are what to connect, why to connect, and which way to connect (park, 2011). Table 1 show the Synonyms of the word connectivity.

Table 1: Synonyms of the word connectivity
(Oxford dictionary online, 2017; Webster dictionary online, 2017; http://translate.google.com, 2017)

Term	Synonym
connectivity	connectedness, relatedness, accordance, affinity, association
continuity	cohesion, constancy, continuum, continuation, durability, persistence, stability
continuousness	cohesion, constancy, continuum, durability, persistence, ceaselessness
connectedness	Connectivity, relatedness, accordance
association	communication, relationship, connection, correlation, relevance, linkup
duration	continuation, continuance, continuity, endurance, persistence
sequence	continuity, concatenation, continuance, continuousness, progression, consecution
linkage	connection, correlation, interconnection, interdependence, relationship, association

The essential role of ULC in countering the damaging effects of urbanization on nature has led to a considerable increase in studies in this area. Therefore, various definitions have been suggested for connectivity in different sciences making it a somehow complicated and confusing concept. The main reason for this complexity is the differences in objectives and insights of different branches of these sciences that have led to a different understanding of connectivity and adoption of different approaches to it (Fischer & Lindenmayer, 2007; Crooks & Sanjayan, 2006) Figure 1 shows the trend of increase in landscape connectivity studies since 1991.

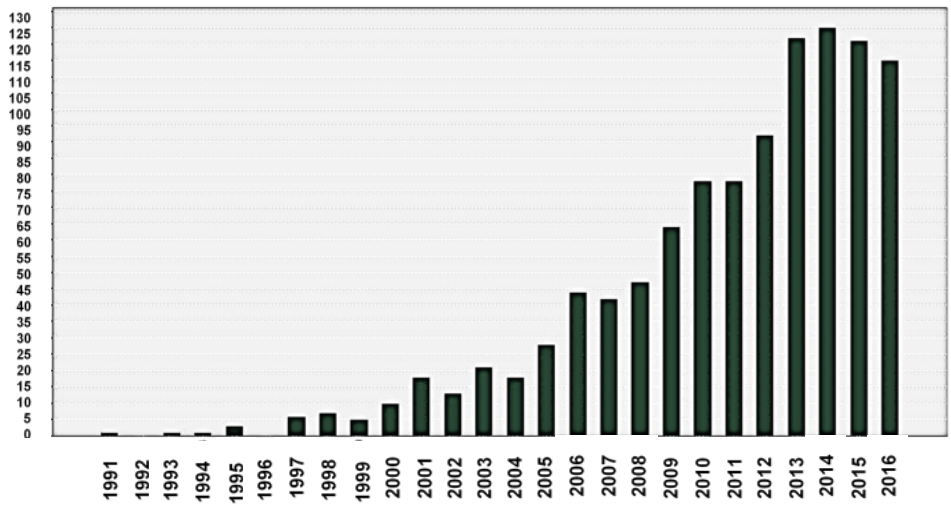

Figure 1: Increase in the number of connectivity studies between 1991 and 2016. These studies were selected based on the presence of "landscape connectivity in the titles and keywords sections (ISI web of science, 2017).

Since the concept of connectivity has received much attention in various branches of environmental science including landscape ecology, population ecology, wildlife conservation, geography, agriculture, etc., most studies on connectivity have been carried out by experts in these areas. The concept of LC has been primarily investigated in large-scale megalopolises as a counterpart to Ecological Connectivity in order to protect plant and animal biodiversity. Therefore, the definitions offered for the concept have focused on its ecological and environmental aspects, whereas it deserves a very wider definition beyond the ecological look as discussed below.

Ecologists deem the term connectivity as an important indicator of ecosystem health and an essential factor in landscape management for biological diversity. Urban planners and civil society activists use connectivity trying to integrate urban life with the related riversides. Even environmental philosophers use the term connectivity to describe a method by which the position of individual organisms and species -particularly human- in the environment is perceived. Urban planners and politicians use the same term to promote the human access to the riverfronts. The use of conceptual and visual connectivity increases the hope for utilization of human creative energy in order to maintain the integrity of the system. These different meanings are overlapping in some cases, but contradictory in others (May, 2006). The greenways movement has also supported connected ecological networks (Fabos, 1995). Table 2 shows the most important definitions that ecologists have presented for LC.

Table 2: Definitions presented for connectivity in the field of ecology (Source: author)

Theorist	LC definition
Taylor et al, 1993	LC is the degree of connectivity in the landscape where the movement among resource patches for species of animal or plants from one point to another is possible.
Forman, 1995	LC is the degree of spatial coherence among landscape elements including patches, corridors and matrices.
Bennett, 1998	Connectivity is an important feature of landscape that is measurable, parametric and functional.
Chon, 2004	Connectivity is an important characteristic of landscape that is essential for health, welfare and aesthetic values in human societies and for the protection of native ecosystems.
May, 2006	Conceptual connectivity is a key concept for landscape and riverfront ecologists and those who want to use it as a tool for natural integration in the ecosystem.
Crooks and Sanjayan, 2006	LC is a critical feature of the landscape that results from the interaction between movement behavior of environmental elements and its physical structure. In other words the more the movement, the better the connectivity.
Dutcher et al, 2007	Connectivity with nature means experiencing nature as a part of community and not just as the raw material for society. Community and connectivity involve a sense of belonging, and that sense of belonging includes not only each other but also some sense of place, one that exists at a human time scale.
Park, 2011	LC is a bridging concept to urban morphology and environmental goods and benefits.
Campoli, 2013	Connectivity and green networks are factors that can either decrease or increase walking in the streets or neighborhoods.

Connectivity in Urban Design

In the urban design literature, the terms connection, linkage, and bond are used interchangeably with connectivity. In urban design, connectivity is defined as linking urban environments with a perspective beyond the ecological and structural outlook of environmental designers and on a different scale. In the book Public Places, Urban Spaces: The Dimensions of Urban Design, Carmona considers urban design as a connector at two levels: 1- urban design as a means to link a collection of expertise, and 2- urban design as a means of rehabilitation or promotion of the quality of solidarity and continuity in separate, and often introspective urban constructions (i.e. improvement of the overall quality of the environment and creation of better places) (Carmona, 2009).

In a complex and sensitive discussion, Sternberg argued that the primary function of urban design is to "assert the cohesiveness of the urban experience". His approach is based on organicism school of thought that has affected Patrick Geddes, Lewis Mumford and recently, Christopher Alexander. He noted how modernity has broken up the society, nature and city. According to Sternberg inspiring ideas in urban design share intellectual foundations that acknowledge the “noncommodifiability" of the human experience (that is, the components cannot be separated from the whole). He thought that the leading theorist of urban design “share the view that good design seeks to reintegrate the human experience of urban form in the face of real estate markets that would treat land and buildings as discrete commodities” (Sternburg, 2000: 265).

In this regard, Alexander (1979) argued that what we see every day as "things" around us - buildings, walls, roads, fences- can be better understood as "patterns" that interact (have a relationship) with other patterns. For example, a window builds a relationship between inside and outside, between public and private. When we perceive these patterns as "things" rather than as "relationships" (i.e. they are removed away from their context), they lose the quality dubbed by Alexander as "aliveness". Therefore, as stated by Alexander and others (1977) a pattern is not an isolated entity, but it is located in the surrounding patterns. The function of urban design is to a great extent, to link the patterns provided by others (architects, developers, highway engineers, etc.) (Alexander, 2008).

Mitchell (1999) believes that with the modern world developments in new urban contexts, the working and living places are merged, twenty-four-hour neighbourhoods are acknowledged, remote meeting locations through electronic communications are formed, products are produced in a decentralized and flexible form, and electronic marketing, distribution, transportation, and sales systems are developed. Urban design will mainly include designing multi-functional, commercial and office complexes, resorts and recreational places, offices, shopping centres, and work/live dwellings that are developed as interconnected or distributed. Words such as downtown, and suburbs do not make much sense any more (Mitchell, 1999). Table 3 shows the major theories of urban design in relation to connectivity in urban design.

Table 3: summarizes the major theories of urban design in relation to connectivity in urban design (Source: author)

Theorist	connectivity in urban design
Carmona, 2009	- urban design as a connector - urban design as a means to link a set of disparate expertise - urban design as a means of rehabilitation or promotion of the quality of solidarity and continuity in separate, and often introspective urban constructions (i.e. improvement of the overall quality of the environment and creation of better places) - urban design’s task is to link the patterns provided by others (architects, developers, highway engineers, etc.)
Sternberg, 2000	- the primary function of urban design is to "assert the cohesiveness of the urban experience. - good design seeks to reintegrate the human experience of urban form. - urban design is the process that rehabilitates or gives integrity and continuity to otherwise separate constructions
Alexander, 1979	- a pattern is not an isolated entity, but it is located in the surrounding patterns - When patterns cease to be "relationships", they become "things" as they are removed away from their context.
Mitchell, 1999	- in modern world urban contexts, the working and living places are merged, and twenty four-hour neighborhoods are acknowledged.

RESEARCH METHODS

Since the ultimate goal of this study was to explain the concept of LC and its corresponding components and parameters in landscape architectural, first, using library documents and internet

search via a descriptive-analytical method, macro definitions of landscape fragmentation and connectivity were presented. Then an inductive constructionist strategy was to review and extract different types of LC from 19 studies related to the concept of LC that had a greater role in the formulation of relevant literature. At this stage, the Delphi technique was used to classify types of LC by experts and according to logical argumentation strategy, a comprehensive concept of LC was developed. At the end, the objectivist strategy of descriptive-synthetic modelling was used to provide a conceptual model for ULC (Swaffield & Deming, 2011). Figure 2 shows the research process.

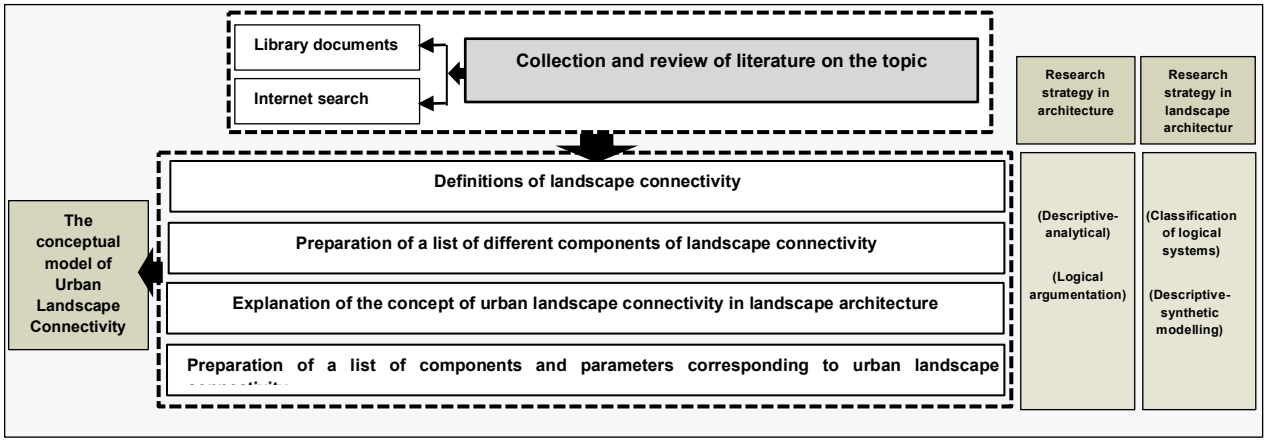

Figure 2: The research process

REVIEW OF LITERATURE

Among the abundant resources associated with the concept of LC, those that had a more significant role in the development of the concept were selected for review purposes. These sources were then reviewed in detail and a precise classification was developed on the basis of place of study, research area, research scale, the main problem of research, research methodology, and various LC components and parameters presented by different authors. Table 4 shows the classification of these resources.

Analysis of Relevant Research

Analysis of studies related to the concept of LC showed that most studies were carried out on landscape ecology, landscape protection, environment, and wildlife biodiversity and few studies have been carried out in the field of LC as related to urban transportation, urban planning, urban design, and sustainable development. The USA had the largest share of research projects related to LC.

The scale in which LC was discussed and evaluated was one of the most important issues in this study. The researchers' investigations in this field indicated that approximately half of the connectivity studies reviewed was at the city and country level. Nearly one-third of the studies were carried out at natural landscape levels such as forests, valleys, plains and rivers. There was one study conducted on Mediterranean rural landscape, two studies at urban and neighborhood landscape level, and one study at street landscape level.

Reviewing the main subject of these studies showed that the rapid growth of urbanization and its impact on accelerating the process of landscape isolation and fragmentation were the main problem investigated. This problem has led to issues such as reduced urban ecosystem health, adverse impact on the psychological and social health of citizens, degradation of living and working spaces for residents, fragmentation of vegetation in urban landscape, the loss of valuable ecosystems, creation of heat islands in cities, reducing biodiversity and the extinction of animals, introduction of non-native species, reduced soil permeability and quality, air pollution, water pollution, visual pollution, and reduced moisture.

Since the studies by Chon and Campoli were carried out at urban landscape scale, they had more affinity to the definition of ULC in landscape architecture. Chon studied urban greenways and Campoli found neighborhood connectivity an important factor in promoting pedestrian life (Chon, 2004; Campoli, 2013).

In terms of research methodology, ecological methods of evaluating LC including ecological matrices, experiments, GIS-based modeling of landscape network based on Least-Cost Modelling, Circuit Theory, and Graph Theory were used in case studies. Some case studies classified previous studies via a descriptive-analytic approach. Campoli used visual assessment methods and took advantage of behavioral maps and images for quantification of variables, while Chon used virtual

computer simulation method for quantifying the natural LC in greenways. Green is used on roads. Dutchr used a Likert-scale questionnaire to quantify the natural connectivity under investigation.

Table 4: Classification of research projects related to LC based on the author's name, date and place of study, research area, research scale, the main research question, research method, and components of LC mentioned

Num.	author, publication year	Location	Research Areas	Study scale	Focus of study	Research Methodology	Landscape Connectivity norms
1	Su et al. (2016)	Guangdong, China	- Ecology, - Environment	City	Rapid urbanization and threatening the ecological security	- Cost-distance analysis method	Ecological Connectivity- Hydrological Connectivity
2	Zimmerer & Bell (2015)	the Andes of western South America	- Ecology, - Geography	Valley-upland landscape	social–ecological connectivity and sociocultural-climate changes	- Descriptive-Analysis research, - Review, - Case study	Social–ecological connectivity
3	Serret et al. (2014)	The Parisian region, France	- Biodiversity	Country	Urban green spaces	- Graph theory	Ecological Connectivity -functional connectivity-Regional connectivity-potential connectivity-green network connectivity
4	Bergsten & Zetterberg (2013)	Stockholm, Sweden	Landscape ecology	City	Fragmentation, Graph theory	- Interviews with thirteen municipal ecologists and environmental planners about Graph theory	Patch-level connectivity
5 book	Campoli (2012)	12 North American neighborhoods	Urban designing	Neighborhood Streetscape	he role of density in promoting walkable neighborhoods, human-scale social and economic factors, public health problems	- Visual methods, such as context maps, figure/ground diagrams of building footprints, maps of density, services, network intersections, and green spaces, and many streetscape photographs.	-
6	Tian et al. (2011)	Hong Kong	Landscape ecology	City	Fragmentation on urban green space (UGS)	- Fragmentation index Landscape metrics based on GIS	-
7 dissertation	Park (2011)	Izmir, Turkey and Phoenix, Arizona, U.S.A.	Landscape ecology	City	Fragmentation and connectivity	- GIS-based connectivity modeling	Ecological Connectivity-Path Connectivity-Corridor Connectivity-Matrix Connectivity-Structural Connectivity-Functional Connectivity-Behavioral Connectivity-Regional Connectivity-Spatial Connectivity
8	Antonson et al. (2010)	south-central Sweden	Landscape ecology Transportation	City	transportation infrastructure planning	- GIS-based automated search tool	Cultural heritage Connectivity (CHC)-Ecological Connectivity-Habitat Connectivity-Social Connectivity
9	Kindlmann & Burel 2008)		Conservation biology	City	Different definition of landscape connectivity, different measures of landscape connectivity.	- Review, - Descriptive-Analysis research	Structural Connectivity-Functional Connectivity Path Connectivity-Buffer Connectivity
10	Dutcher et al. (2007)	riparian landowners in central Pennsylvania	Environment	Area around stream	Connectivity with the whole environment, sense of connectivity with nature.	- The survey instrument, - Likert response categories, - The questionnaire's Connectivity scale.	Environmental Connectivity

Num.	author, publication year	Location	Research Areas	Study scale	Focus of study	Research Methodology	Landscape Connectivity norms
11 book	Crooks & Sanjayan, 2006)	Different countries	Nature Conservancy	River, city, forest, country	Connectivity Conservation	- Descriptive-Analysis research, - Case study	Migratory Connectivity-Hydrologic Connectivity-Functional Connectivity-Structural Connectivity-Hyperconnectivity Potential Connectivity-Actual Connectivity-Direct Connectivity Ecological Connectivity-Directional Connectivity-Habitat Connectivity-Population dynamic connectivity-Historical Connectivity Traditional Connectivity-Regional Connectivity-Natural connectivityTerrestrial Connectivity
12	May (2006)	The Don River (Toronto)	River ecology Hydrology	Urban River	Connectivity in urban rivers	- Descriptive-Analysis research,	Cognitive connectivity-Visual connectivity-Conceptual Connectivity-Habitat Connectivity-Lateral Connectivity-Longitudinal Connectivity-Vertical connectivity-Hydrological Connectivity-Riparian Connectivity-River Connectivity-Land Connectivity-Urban Connectivity-Social Connectivity-Biophysical Connectivity-Human Connectivity-Ecological Connectivity-Cognitive Connectivity-Philosophical connectivity
13	Badland & Schofield (2005)	19 studies in diverse settings in different countries	Urban design Urban environment	Local neighborhood	Transport, urban design, and physical activity	- Review - Descriptive-Analysis research	Street Connectivity
14 dissertation	Chon (2004)	Texas	Urban design, Recreation, Park and Tourism Sciences	Cityscape	Greenways,	- Computer likability, a web-based virtual tour	Visual Connectivity-Ecological Connectivity-Structural Connectivity
15 book	Bennett (2003)	all around the world	Landscape Ecology Forestry	Forest	Linkage, Corridors, conservation	- Descriptive-Analysis research, - Case study	Habitat Connectivity-Potential Connectivity-Structural Connectivity-Forest Connectivity-Natural Connectivity-Functional Connectivity
16	Goodwin (2003)	63 papers investigating connectivity	Ecosystem Studies Biology Ecology	Different scales	Connectivity as a dependent or independent variable, review between 1985-2000	- Review, - Descriptive-Analysis research,	Structural Connectivity-Functional Connectivity
17	Leitao & Ahern (2002)	the Mill River, Watershed, U.S.A.	Landscape architecture, Regional planning, Landscape ecology , sustainable Landscape planning	City	Landscape metrics	- Review - Descriptive-Analysis research, - Case Study	Ecological Connectivity-Structural Connectivity
18 book	Makhzoumi & Pungetti (1999)	The Mediterranean Context	Landscape ecology	Rural society	The dimension of Landscape, Landscape assessment, Ecological landscape design	- Descriptive-Analysis research, - Case study, - GIS	Landscape Continuity-Linear Connectivity-Social Connectivity-Temporal Connectivity
19	Taylor et al. (1993)	-	Landscape ecology	City	The definition of landscape connectivity	- Descriptive-Analysis research	-

In the meantime, each of the authors pointed to different aspects of LC in their studies (a total of 40 aspects). By examining different types of connectivity listed, we could classify them into macro categories based on similarity of content and application. At this stage, the Delphi technique was used. The researchers sent the list of 40 connectivity types to 6 landscape professors and experts so that they could provide assistance in classifying and naming categories. The use of multiple iterations to collect data is a unique method, which allows for achieving a more precise and refined knowledge (Hsu & Sanford, 2007). The Delphi technique was used in two stages: first, in-depth unstructured interviews, and second, semi-structured interviews. Seven categories of Ecological Connectivity, Social connectivity, Structural connectivity, Functional connectivity, Context Connectivity, mindscape connectivity, and Visual connectivity were introduced as components of LC by the experts. Table 5 shows this classification.

Table 5: Components of LC (extracted from related studies)

Ecological Connectivity	Ecological Connectivity – green network connectivity - Path Connectivity - Corridor Connectivity - Matrix Connectivity - Habitat Connectivity - Buffer Connectivity - Environmental Connectivity - Migratory Connectivity - Cognitive connectivity - Population dynamic connectivity - Hydrological Connectivity - Lateral Connectivity - Longitudinal Connectivity -Vertical connectivity – Temporal Connectivity
Socio-Culture connectivity	Social Connectivity - Cultural Connectivity – Human Connectivity - Population Connectivity - Behavioral Connectivity
Structural Connectivity	Structural Connectivity - Spatial Connectivity - Directional Connectivity - Linear Connectivity
Functional connectivity	Functional Connectivity - Physical Connectivity – Street Connectivity
Visual connectivity	Visual Connectivity
Mindscape connectivity	Historical Connectivity - Traditional Connectivity - Conceptual Connectivity - Philosophical connectivity, Temporal Connectivity, Cultural heritage Connectivity (CHC)
Context Connectivity	Natural Connectivity - Terrestrial Connectivity - Regional connectivity - Riparian Connectivity - River Connectivity - Forest Connectivity - Land Connectivity - Urban Connectivity

ULC AND ITS CLASSIFICATION

In order to explain the concept of ULC and its classification in landscape architecture literature, first, the views of landscape architects regarding urban landscape are discussed below.

Urban Landscape

What is important in defining urban landscape is the difference in "scale" from the point of view of landscape architects and urban planners. Although urban planners try to have a macro view of city and its elements, landscape architects act on small and medium-scale levels thanks to more design tools they have at hand (Daneshpur et al. 2013). Landscape ecologists' look at urban landscape is primarily environmental and restorative. Urban landscape from their point of view is the most complex mosaic of land on the planet that includes an enormous diversity of coverage and users. In general, landscape ecologists tend to stress on urban ecology studies aimed at recognizing organisms and their relationship with the non-live part of the ecosystems. This way, the role of natural factors are considered as more important than that of human factors, and the impact of human factors are introduced as external to the system (Parivar et al, 2013).

Perhaps this multiplicity of meanings of urban landscape can be seen as the outcome of two main historical views in landscape that are still influential in the field of landscape either intentionally or unintentionally. The first view is a historical perspective in physical geography that focuses on materiality of the landscape and the physical changes, while the second view is affected by human geography with a focus on people and their activities and organization on the earth. In such a context, landscape research in the last century developed in two categories: macro-studies including natural landscape (in conjunction with the physical geography and influenced by the geographic trends in Great Britain), and cultural landscape studies (close to human geography under the influence of geographic American school of geography and historical geography of Carl O. Sauer at Berkeley) (Makhzoumi and Pungetti, 1999).

However, because landscape (from the point of view of landscape architects) is the product of natural and human forces at the same time, urban landscape can be the result of interactions between two important components, i.e. "human environment" and "natural environment", that require a third component, i.e. the "built environment", due to their position in context. The third component focuses on the hard elements of landscape and includes part of physical interventions in the immediate urban landscape of natural elements in the city, the presence of which in the context of contemporary cities is to some extent inevitable. This third component distinguishes urban landscape from other types of landscape (Asadpur, 2014). Classification of landscape elements into elements of the built environment, the natural environment, and the human activity environment, presents three different environments for the formation of urban landscape (Taghvai, 2012).

The ULC Model

The components of LC were introduced above under Ecological Connectivity, Social Connectivity, Cultural Connectivity, Structural Connectivity, Functional Connectivity, Visual connectivity, Mindscape connectivity, and Context Connectivity. In addition, the concept of urban landscape and its scale and elements from the landscape architects' point of view were investigated and three different environments in which urban landscape is formed were introduced accordingly. In this phase of research, the concepts of LC and urban landscape were integrated to explain the comprehensive concept of ULC and its components in landscape architecture.

Given that the focus of this study was on urban environment, Context Connectivity, which represented the context and environment of formation of connectivity, was excluded from the components of LC, because city is considered as the fixed context in the explanation of the concept of ULC. Therefore, ULC with six connectivity components, i.e., ecological connectivity, socio-cultural connectivity, structural connectivity, functional connectivity, visual connectivity, and mindscape connectivity were defined in three different landscape environments. Human environment, natural environment, and built environment, as three constructive environments of Landscape, were introduced by Taghvaei (Taghvaei, 2012). Figure 3 shows the conceptual model of ULC.

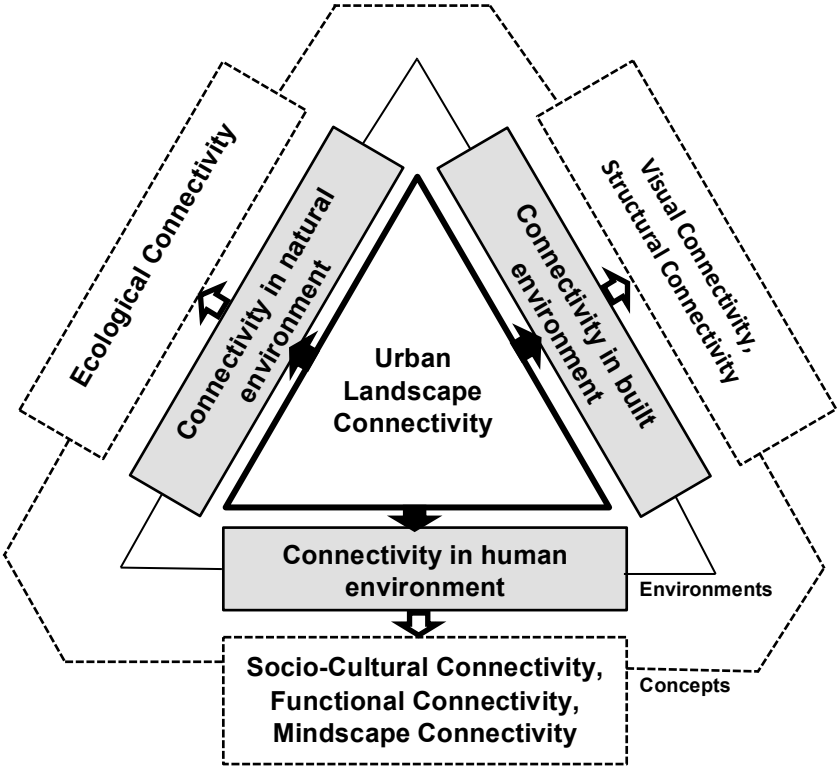

Figure 3: the conceptual model of ULC

According to the conceptual model, ULC refers to a degree of visual, structural, functional, cultural, social,mindscape and ecological communications in the landscape environments, where interactions between human, and natural and built environment are defined and intensified. ULC links elements of the landscape and is introduced as a quality of landscape that connects the three environments, i.e. natural environment, human environment, and built environment, that creates it. In other words, the higher the connections between these triple environments, the higher the LC.

Concepts of ULC and Their Corresponding Parameters

As noted earlier, the landscape studied in landscape architecture is at small and medium scales compared to the large-scale landscape in studies by urban planners and ecologists. Therefore, the researchers in this section presents their key findings in the form of 6 ULC components, their definitions and their corresponding parameters at a smaller scale for the landscape of the city. Table 6 shows these concepts with the name of theorists which influenced this conclusion.

Table 6: Definitions of components of ULC and their corresponding parameters

Macro criteria	component	definition	Parameters	theorist
ULC (Urban Landscape Connectivity)	Socio-cultural Connectivity	relationship between human and the environment, lively environment with the constant presence of people in the city, presence of different groups of people in urban space	- different gender groups - different age groups - people with different incomes, different occupational groups - possibility of movement for the disabled, the blind, and the elderly - native people - intermittent meeting of neighbors and acquaintances - a sense of participation - celebrations and cultural events	Carmona, 2003 Buffalo, 2001, May,2006 Moeini, 2006 Pakzad, 2011 Habibi, 2001
	Visual connectivity	Continuous visual connection; an open space where the field of vision is open and does not face a visual barrier.	- visual continuity (specified destination and path) - Presence of visual cues - Natural attractive landscapes (lakes, etc.) - continuous vegetation - Rhythm (flooring, furniture, lighting, etc.) - Skyline - Presence of consecutive views and important and valuable axes - design compatible with seasonal changes - continuous water movement	Carmona, 2003 Moeini, 2006 Pakzad, 2011 Habibi, 2001
	Structural Connectivity	Presence of fluid urban spaces and integrated routes with proper equipment and configuration of structural elements	- furniture connectivity (chairs, light posts, water taps, restrooms) - Connectivity in structural elements (floors and exterior) - spatial connectivity (public spaces, semi-public spaces, private spaces) - pedestrian network connectivity - presence of a continuous bike path - consistency and connectivity of new and older design; Correct location of urban space uses	Carmona, 2003 Moeini, 2006 Pakzad, 2007 Gharib 2004
	Functional Connectivity	Presence of various activities at different hours of the day,	- Presence of different uses - Connectivity of activity - activities encouraging nightlife - access to parking - access to public transit - connection with the immediate area	Habibi, 2001 Carmona, 2003 Park, 2011 Cook, 2000
	Mindscape connectivity	Presence of historical sequence and compliance with the principles shaping the environment in a certain time period	- remembering memories - preservation of valuable building over time - Presence of important historical-cultural elements and their integration - the use of traditional and evocative elements along the paths	Habibi, 2001 Carmona, 2003
	Ecological Connectivity	Quiet and clean environment that allows for air flow	- absence of visual pollution - absence of noise pollution - Presence of green paths leading to the lake - possibility of movement for animal species	Lynch, 1971 Taylor, 1993, Forman, 1995, Makhzoumi, 199

CONCLUSIONS

Growing urbanization and human interventions in the environment have produced many harmful effects, the most important of which is the phenomenon of landscape fragmentation. The concept of LC has been suggested to counter this phenomenon. An increase in related studies in various fields shows the importance of the issue; however, the definition and use of ULC in landscape architects has not been addressed. This prompted the researchers to review and classify relevant studies and extract definitions and components of LC. The results of this stage alongside the review of the urban landscape, set the ground for the formation of a conceptual model of ULC and clarification of its components and corresponding parameters.

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