

Original Research Article

Application of Landscape Ecology to Develop a Conceptual Model for Planning Urban Rivers

(Case Study: Darakeh River)

Delaram Sabokro*

Ph.D. Student in Landscape Architecture, School of Architecture, College of Fine Arts, University of Tehran, Iran.

Parichehr Saboonchi

Ph.D. in Landscape Architecture, School of Architecture, College of Fine Arts, University of Tehran, Iran.

Morteza Hemmati

Ph.D. in Landscape Architecture, School of Architecture, College of Fine Arts, University of Tehran, Iran.

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Abstract | The excessive use of the ecological capacity of the seven rivers of Tehran, as the most important natural components of the city, has undermined their status in city calculations. This has caused different challenges of various dimensions, such as reduced social interactions, increased insecurity, environmental pollution, etc., which indicate the ineffectiveness of one-dimensional management strategies. On the other hand, a review of past experiences suggests a large gap between theoretical approaches and operational solutions in the management of rivers, which reduces the effectiveness of the existing techniques. Thus, it is imperative to adopt a holistic approach to natural environmental planning to simultaneously address the preservation and revival of the natural ecosystem theoretically and practically and consider social challenges. Using landscape ecology knowledge, this research conducts a pathological investigation of the river dimensions and compares them with the Darakeh River to provide guidelines to resolve the current situation. It also aims to answer the question: how are management and planning to revive the urban rivers performed using the landscape ecology approach through combining theoretical and practical attitudes? To this end, first, a descriptive-analytical method was used to develop a conceptual model, then the Darakeh River was analyzed using the SWOT method. The conceptual model links theoretical and practical approaches to three semantic, structural, and functional areas to describe secondary principles and policymaking. The findings of this study indicate policies such as conservation and restoration of the river basin, habitat regeneration and development, environmental vitality, the reflection of cultural-historical identity, development establishment, and the main strategies in three areas: functional, physical, and semantic, which have been introduced to revive the natural environment of the River Darake based on the conceptual model of research and can be used as a model for the restoration of other urban rivers. The conceptual model of the research has been introduced and can be used as a model for the revitalization of other urban rivers.

Keywords | *Ecology, Landscape, Urban river planning, Horizontal and vertical perspectives, Theoretical and practical approaches.*

Introduction | Rivers are inseparably linked with urban identity in the form of small spaces. The settlement of cities around these life-giving elements brings about a sense of belonging, identification, and history for the citizens. Today, however, one-dimensional interventions have transformed

these natural channels into wastage channels isolated from the urban texture, with the river identity in the people's collective memory downgraded from a vital potential to weak infrastructure. The seven valleys of Tehran, as the lungs of the city, have formed the natural identity of Tehran, though suffering from numerous environmental

* Corresponding author: 09126159920, Delaram.sabokro@ut.ac.ir

damages, including pollution, soil erosion, loss of herbal and animal species, etc., as a result of inappropriate use. Failure to consider the ecological capacity of these valleys and the absence of relevant proper planning has increasingly caused their destruction, engendering in the demise of urban natural places. Thus, it is increasingly important to understand the landscape-making components of these valleys to help revive and restore these natural structures. The said components should be included in a conceptual model to provide an inclusive and holistic plan to meet the existing challenges. However, studies have demonstrated that theoretical perspectives and practical guidelines lack the necessary consistency to leave maximum effects as conceptual differences have led to plunging the optimal functionality of such practices. This research aims to organize the damaged Darakeh riverbed to answer the question: How are management and planning to revive the urban rivers performed using the landscape ecology approach through combining theoretical and practical attitudes? Therefore, this paper first analyzes the models at hand by examining the theoretical foundations of landscape ecology and its existing methods and then organizes the case sample of Rudkenar, which promotes the existing conceptual models.

Research Method

This research aims to provide an environmentally appropriate condition by improving riverbed values and manifestations in connection with the common ecological-human functions to achieve a sustainable landscape. In this regard, it uses a descriptive-analytical approach. In the first step, the descriptive method was used to analyze the landscape

ecology approach principles and theoretical and practical insights using the horizontal and vertical perspectives proposed by Leitao and Ahern (2002). In the second step, a combined conceptual model was presented to describe the quality of urban river planning. This hybrid model used an analytical-inferential method to propose an intermediary of horizontal and vertical approaches within a set of strategies extracted from case studies based on the landscape ecology approach. In the third step, the studied area was analyzed by a survey and via descriptive, analytical, and inferential methods, and a SWOT technique was used to examine and analyze the Darakeh River based on the said conceptual model. In the end, strategies to utilize opportunities and address the limitations and threats were provided. Initial data for the theoretical section are gathered through papers, books, reports, and interviews published on scientific websites, while data on the Darakeh River was collected from field studies, observations, and interviews with experts and stakeholders (Fig. 1).

Literature Review

Lawrence, Ashley, Yonemitsu & Ellis (1995) adopted a naturalist approach to the revival and restoration of rivers. They used ecosystem and landscape ecology knowledge to plan and manage urban rivers' green paths, expediting the preservation and increase of the link between natural regions. Findley and Taylor (2006) investigated the three economic, social, and environmental components that could be used to revive the urban rivers system. Included in major research in recent decades was one performed by Everard & Moggridge (2012) who used an ecosystem

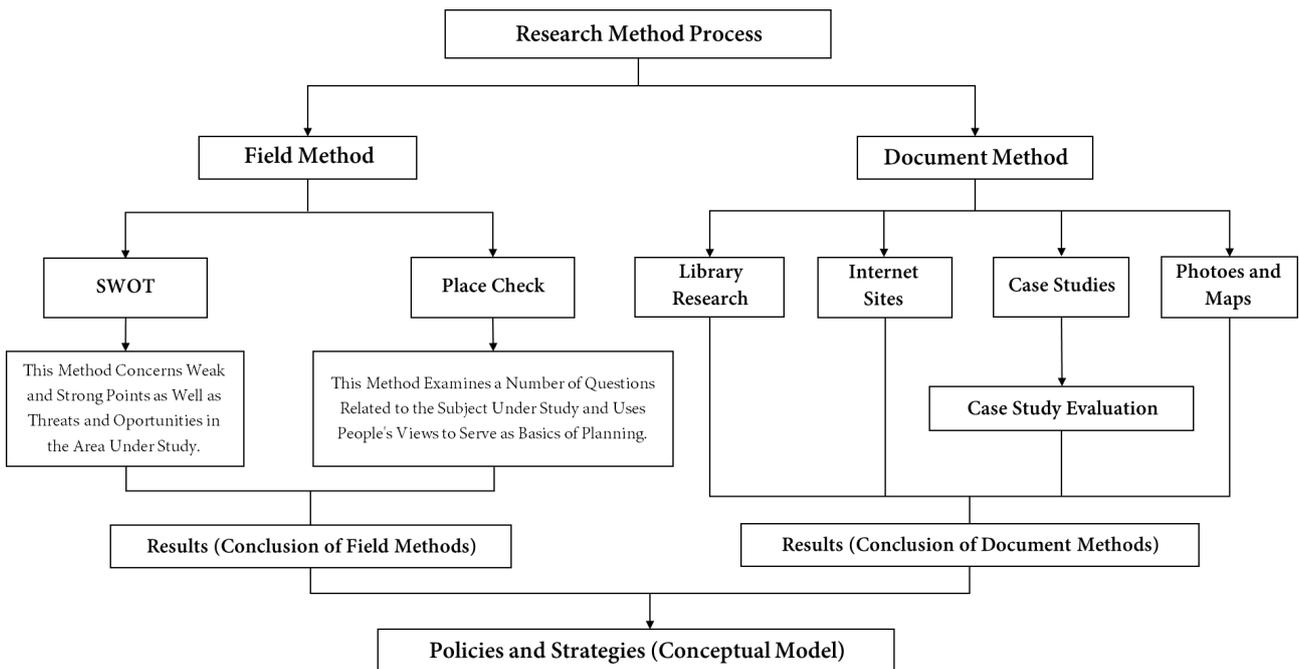


Fig. 1: Research method process. Source: Authors.

approach to prevent the continuous erosion of vital resources such as riverbeds, seeking to restore and preserve the rivers by increasing ecosystem services, biodiversity, improving facilities, and creating some values. Regarding structural and morphological dimensions, Cengiz (2013) emphasizes the floodplains and watershed basins, using an environmental perspective to help revive the rivers. Smith, Clifford & Mant (2014) also stressed the functional dimension of restoring and improving social and environmental services. Poorjafar, Taqvae, Azad Fallah & Sadeqi (2014) examined the structural and functional dimensions to create a desirable equilibrium between the presence of man and the ecological capacity of the riverbank and to revive aesthetical values of the environment, stressing the preservation and implementation of the natural systems, training, and organization of watershed basins and preservation of the climate flow corridors and control of the environmental destruction and pollution. Espinosa, De Meulder & Ollero (2016) studied the river revival from an environmental perspective and through the natural spatial process, emphasizing fluctuating seasonal flows and watershed basin scales. Mirgholami, Medghalichi, Shakibamanesh & Ghobadi (2016) also studied water-related issues using two biophilic designs and water-sensitive approaches to integrate city and nature. Bahrami, Alehashemi & Motedayen (2019) investigated the functional domain by considering the role of resilience in organizing rivers against floods. Mosler (2020) used formation tracking to investigate the deformation of urban character and identify the factors affecting the river changes over time in three functional structural and semantic areas. A review of developments suggests that most structural and physical dimensions of planning urban rivers were focused on attention by theorists. However, integrated perspectives, including structural and functional perspectives, were combined in new semantic, structural, and functional approaches. The important point is the connection of these approaches with landscape ecology as the main concern of river management and planning.

Theoretical Foundations

• Landscape ecology

In the past two decades, the German geography researcher, Alexander von Humboldt, defined landscape as a general mosaic of a region (Von Humboldt, 1871). However, in the mid-60s, as Ecology found its way into "Landscape Ecology", the landscape ecology concept was introduced (McDonnell et al., 1997). Carl Troll (1963), the German geographer and botanist introduced landscape ecology and described it as the study of main and complicated causal relations between life communities and the surrounding environment in a certain part of the landscape (Troll, 1968, 1-21; Troll, 1971, 43-46). Then, Numata (1992) and Forman (1995),

Foreman and Gordon (1986), Makhzoumi (2000) and Naveh (2001) developed theories on this connection. Landscape ecology was initially recognized as an aspect of geographical studies and involved a general nature whose different components affected each other. The landscape was examined as a general character of the site based on its component content (Zonneveld, 1989, 67-86). With this attitude, Naveh studied the spatial, functional, cultural, and environmental nature of landscape (Naveh, 1991, 65-73). Following this, Wu and Hobbs (2007) investigated the relationship between spatial patterns and ecological trends at hierarchical levels of biological organizations and different temporal and spatial scales. Naveh and Liberman acknowledged that landscape ecology studies the relationships between humans and landscape as a new branch of modern ecology. Landscape served as an interacting and concrete cultural-natural system, while landscape ecology studied the profile, planning, management, and preservation (Naveh & Lieberman, 1984; Masnavi, Motedayen, Saboonchi & Hemmati, 2021). The landscape ecology approach consists of two theoretical and practical perspectives. Theoretically speaking, the conceptual framework of this approach indicates the consistency of the role of the human agent and socio-economic and political processes with ecological processes in forming a landscape (Makhzoumi, 2000). Landscape ecology draws upon spatial heterogeneities to achieve landscape sustainability (Wu, 2013) and develop knowledge from the relationship between landscape and process patterns on a large set of scales (Nassauer & Opdam, 2008). However, functionally speaking, landscape ecology aims to provide guidelines to preserve and revive all values of nature where man and the environment are analyzed coherently (Bemanian & Ahmadi, 2015; Ahmadi, Bemanian & Ansari, 2018). Preservation measures emphasize adaptable planning and management and the creation of ecosystems similar to the natural ecosystem to help develop the natural quality of the riverbed (Ahmadi et al., 2018). In sum, the horizontal perspective of the landscape ecology approach deals with removing sustainable planning challenges from a theoretical aspect. In contrast, the vertical and practical aspect tends to technical solutions as it proposes a specific executive phase towards project planning and management. This approach extends concepts in a syllogism way (Leitao & Ahern, 2002)¹. Given the conceptual model proposed, one would infer that to complete a design process and arrive at executive stages from fully theoretical statements, there is a need for concepts that would contain neither a completely general horizontal perspective nor a specific vertical perspective. Hence, presumptions are required to arrive at the implementation stage or vertical perceptible.

• Horizontal perspective: Conceptual framework of landscape ecology

The horizontal perspective analyzes the potential utility of ecological knowledge, including humans, ecology, space, and time, and is mostly a general framework and a conceptual approach (Leitao & Ahern, 2002). The horizontal perspective of the theoretical concepts of the landscape ecology approach helps open a new window to design, which provides a complete understanding of the landscape and feasibility of a dynamic and sustainable development (Hajghani & Ahmadi, 2015). The constituting elements of landscape include “artificial environment”, “natural environment”, and a “human activity environment” which improves the quality of the landscape architectural structure and the reciprocal relations of the components in shaping and studying internal relations underlying landscape and its totality (Taghvaie, 2013). Put it differently, landscape ecology design can be thought of as a layered and inclusive perception that not only includes the objective dimensions (e.g., earth form, vegetation, and buildings) but also includes unobservable (ecological and environmental processes constituting landscape) and perceptive (cultural perceptions and aesthetic preferences) elements (Makhzoumi, 2015). The landscape ecology paradigm studies the non-concrete emotional experiences (Tuan, 1974) in the form of mental consistency as a part of the landscape experience (Saboonchi, Abarghouyi Fard & Motedayen, 2018). It emphasizes the moral and inclusive principles generally aiming to integrate landscape, sustainable design, and improvement of the sense of place and community (Makhzoumi & Pungetti, 1999). Landscape ecology concepts can help design and manage landscape as follows: 1. Complexity and reciprocating relations: a network of interactions formed for landscape sustainability at spatial scales. 2. Ecosystem self-organization: the ability to preserve structures when encountering disturbances that indicate health and soundness of the ecosystem (Woodley, Kay & Francis, 1993). 3. Biodiversity and genetic diversity among species of a habitat: this concept depends on the spatial size and distribution of habitats. 4. Hierarchy system of the ecosystems: refers to a fundamental concept in landscape ecology which studies the landscape patterns at different spatial scales (Farina, 1998). 5. Historical and developmental perspective: changing of landscapes is different at different periods. To meet these principles, it is positive for the people to engage in policymaking and publicly adopt the planning to improve their sense of place (Decker & Chase, 1997). This approach stresses the desirable equilibrium between human activity developments and the ecological capacity of landscapes

(Hajghani & Ahmadi, 2015). In sum, this perspective provides a conceptual model to analyze the components in three categories of the natural environment, artificial environment and human activity environment through initial principles such as complexity, self-organization, diversity, hierarchy, profile, development and participation, holistic (Makhzoumi, 2015, 5; Mansouri, 2015, 101) and multi-scale approaches (Farina, 2006, 36; Lovett, Turner, Jones & Weathers, 2005, 284; Selman, 2006, 27; Crow, 2004, 362).

• Vertical perspective: landscape planning process

The vertical perspective refers to the planning process of each phase, which is common in each area. This standpoint uses a technical approach to introduce planning in five steps: 1. Survey and exact observation of the region. 2. Assessment of resources and public participation at the landscape scale. 3. Ecological understanding to identify place conflicts and spatial design concepts. 4. Design and action. 5. Management and control to preserve the region (Leitao & Ahren, 2002). The vertical perspective considers the spatial dimension of the ecological process a major landscape ecology characteristic, thus creating a common linguistic network for stronger interactions between ecologists and planners (Wu & Hobbs, 2007, 271-278). Unlike traditional environmental approaches, the second characteristic focuses on human ecology and orientation towards planning and management. Human activities are explicitly considered part of the system rather than a distinct component (Habibi, 2015, 49). Meanwhile, the third characteristic is a systematic and conclusive approach to landscape ecology which analyzes the human-made set (Leitao & Ahern, 2002). In sum, in the conceptual landscape ecology model, the horizontal perspective uses a holistic approach to analyze such criteria as space, time, human, and ecology within the planning process. However, practical techniques and functional concepts are studied from the vertical perspective. The landscape ecology-based ecology approach is a major challenge to achieving executive strategies and implementing theoretical concepts. Hence, in addition to the initial principles discussed in the landscape ecology approach, one would define the secondary principles in the form of a host of policies at the planning and management levels. These strategies serve as an intermediary between horizontal and vertical perspectives, which are critical for the feasibility of conceptual frameworks and elaboration of these processes. Although this issue is implemented when a plan is operationalized, the quality of this issue and definitions of the indices in the conceptual model involve ambiguities. Here in this study, a set of strategies employed in case studies are examined by the landscape ecology approach to extract principles used in the planning and policymaking process (Fig. 2).

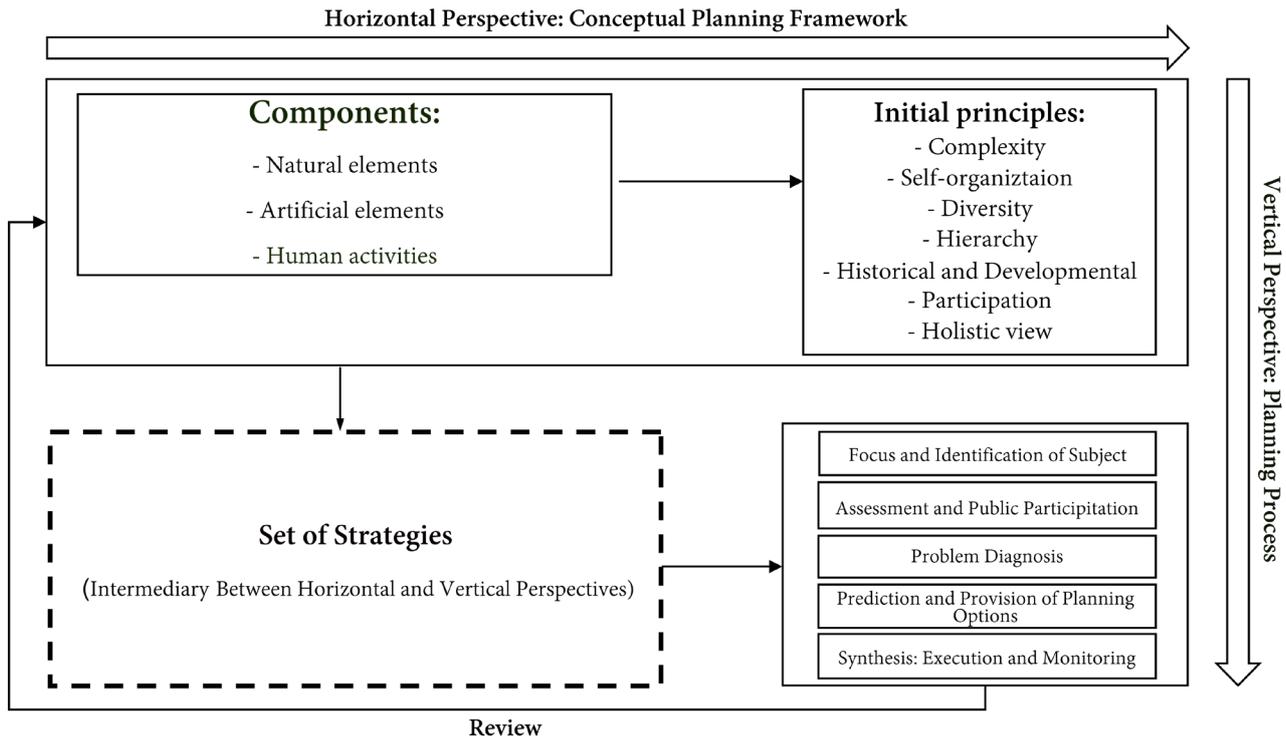


Fig. 2. Conceptual model of landscape using landscape ecology approach to integrate horizontal and vertical perspectives. Source: Authors.

Analysis of Case Studies Using Landscape Ecology Approach

To link theoretical and practical viewpoints, one can use the analysis of case studies that involve both theoretical and practical aspects. Here, landscape cases designed at the riverbank are analyzed using three indicators of landscape architecture (natural environment, artificial environment, and human activity environment). These cases are selected to elaborate on their similar features to opt for the nature-based design approach linking the urban landscape and commonalities in the horizontal perspective. All six projects have different ecological, social, and cultural conditions. In each project, the designers consider the landscape ecological concepts to specify initial objectives which, to be met, some strategies are required to be regarded as a boundary between horizontal and vertical perspectives. Some of the strategies discussed in these projects are specifically dependent on the design context, while others take into account main ecology approach concepts that can be generalized to landscape planning in the area of urban rivers (Table 1).

A review of case studies and strategies used to implement the projects fell under secondary principles under structural, functional, and semantic categories. Such indicators as aesthetics, conformity with riverbed, spatially regulating coherence, enclosure, and access fell under structural dimensions. Such indicators as symbols and signs, reproduction of cultural identity, improvement of the urban core, and readability fall under the semantic category. Meanwhile, educational, economic, social and

ecological criteria fall under functional dimensions, each subindex. These indicators define a middle level which serves as an intermediary between macro-level projects (landscape ecology principles) and micro levels (set of practical measures to respond to the project goal) to practically translate the conceptual frameworks in the form of measures and guidelines for implementation (Fig. 3).

Understanding the Riverbed (Tehran's Darakeh River)

In Tehran, at the foothills of Mt. Alborz, valley-rivers are extending from the north and pass through Tehran to flow into its southern desert parts. The most notable rivers in the city include Lark, Darabad, Jamshidiyeh, Golabdarreh, Darband, Velanjak, Darakeh, Farahzad, and Kan. The Darakeh-Evin valley is one of the most important ecological elements at the urban scale. This valley not only serves as a movement corridor and improves bio-diversity, but also serves as a respiratory reservoir of the city to supply clean air. This site has attracted many tourists who spend their time there. The area under study leads to the residential town of Atisaz from the north, to Chamran Highway from the east, to residential areas of Sa'adatabad from the west to barren lands and gardens from the south. However, this linkage is mainly structural and lacks functional and social interactions. In the meantime, subjective and social structures have engendered deep links between this region and the Dahvanak area, which are caused by the structural consistency of the two areas before the construction of Chamran Highway and their physical linkage (Fig. 4).

Table 1. Analysis of case studies using objectives, policies and measures taken in each project. Source: Authors.

Project	Objectives	Policies	Measures
Mill River Park (Stamford)	<ul style="list-style-type: none"> - Revival of the ecosystem and reduction of environmental risks - Social sustainability and justice - Educational objectives - Revival of historical identity - Economic development of the region 	<ul style="list-style-type: none"> - Integrated revival of natural systems and elimination of environmental pollution - Ecology - Establishment of a responsive, living (active and passive), peaceful and stimulating landscape for recreational and social needs - Long-term planning for economic landscape 	<ul style="list-style-type: none"> - Creation of natural habitats to grow plants and feed animals - Display and training of various packages of native plants and animals - Creation of popular green and lively space - Design of flexible spaces for various events - Inviting design to guide the user to the riverbank - Preservation of historic stone walls and demonstration of the history of the region - Use of flood-resistant materials
River Waller (Texas)	<ul style="list-style-type: none"> - Revival of historical identity - Reduction of environmental risks - Structural and aesthetic objectives - Security - Education objectives and awareness-raising 	<ul style="list-style-type: none"> - Flood dumping and surface water management - Water quality improvement - Sustainability of living organisms - Increase in social interactions 	<ul style="list-style-type: none"> - Construction of tunnels for continuous water flow - Bio-engineering and growth of native plants to revive the riverbank - Improvement of green space levels - Establishment of shelters for animal survival - Creation of standpoints - Creation of multi-functional space to increase social interactions - Design of an island park for ecological, and educational programs
Changni River (Seoul)	<ul style="list-style-type: none"> - Elimination of gray infrastructure (highway) from the city - Restoration of green infrastructure - Respect for the natural and historical values of the region 	<ul style="list-style-type: none"> - Reduction of air and water pollution - Proliferation of animal species - Creation of a collective and vital atmosphere - Feasibility of people's safe relationship with water 	<ul style="list-style-type: none"> - Creation of green spaces for airflow - Use of river flow in sewage accumulation areas - Increase the capacity of urban public transportation and alternative sidewalks following the elimination of highways - Design of stone gardens - Creative design of plazas for urban gathering
Trinity River (Dallas)	<ul style="list-style-type: none"> - Creation of stability - Urban green infrastructure - Reduction of environmental damage - Link between North and South Dallas - Revival of historical identity - Economic development of the region 	<ul style="list-style-type: none"> - Restoration of ecosystem services - Reduction of flood risks - Production of clean energies - Improvement of the urban core - Recovery of historical and symbolic identity 	<ul style="list-style-type: none"> - Construction of new natural wetland parks - Design of flood-controlling embankments - Water Recycling and treatment and use of energy production from renewable sources - Construction of public open spaces such as amphitheatres - Construction of a sports area for different users - Transformation of historical bridges into pedestrian sidewalks - Creation of symbolic elements such as bridges, gates, etc.
Vakilabad valley (Mashhad)	<ul style="list-style-type: none"> - Revival of environmental values - Preservation of the historical heritage and natural mass of Mashhad - Structural and aesthetic objectives - Pursuing educational-leisure goals - Economic return 	<ul style="list-style-type: none"> - Pollution purification, riverbed restoration, and improvement of the environmental quality of the valley - Preservation and retrofitting of existing gardens - Creation of collective and lively spaces - Increase of environmental security 	<ul style="list-style-type: none"> - Preservation of green spaces and prevention of old trees destruction - Use of natural materials to reconstruct the valley - Restoration of historical Golestan dam and aqueduct on the site - Design of botanical gardens - Establishment of cultural and educational activities for the general public - Creation of areas for the distribution of handicraft products
Farahzad Valley (Tehran)	<ul style="list-style-type: none"> - Revival of natural attractions and cultural-historical values - Reduction of environmental risks - Prevention of the city from infiltrating into the nature - Adjacent texture systematization 	<ul style="list-style-type: none"> - Improvement of the river ecology health - Reduction of rivers and valleys pollution - Readability of Ruddareh design - Increase of social security within the valley 	<ul style="list-style-type: none"> - Development of green spaces and pristine natural spaces - Restoration of the old path to Imamzadeh Davood - Design of multi-purpose service spaces along the riverbank - Establishment of the pedestrian link along with the project by creating pedestrian overpasses

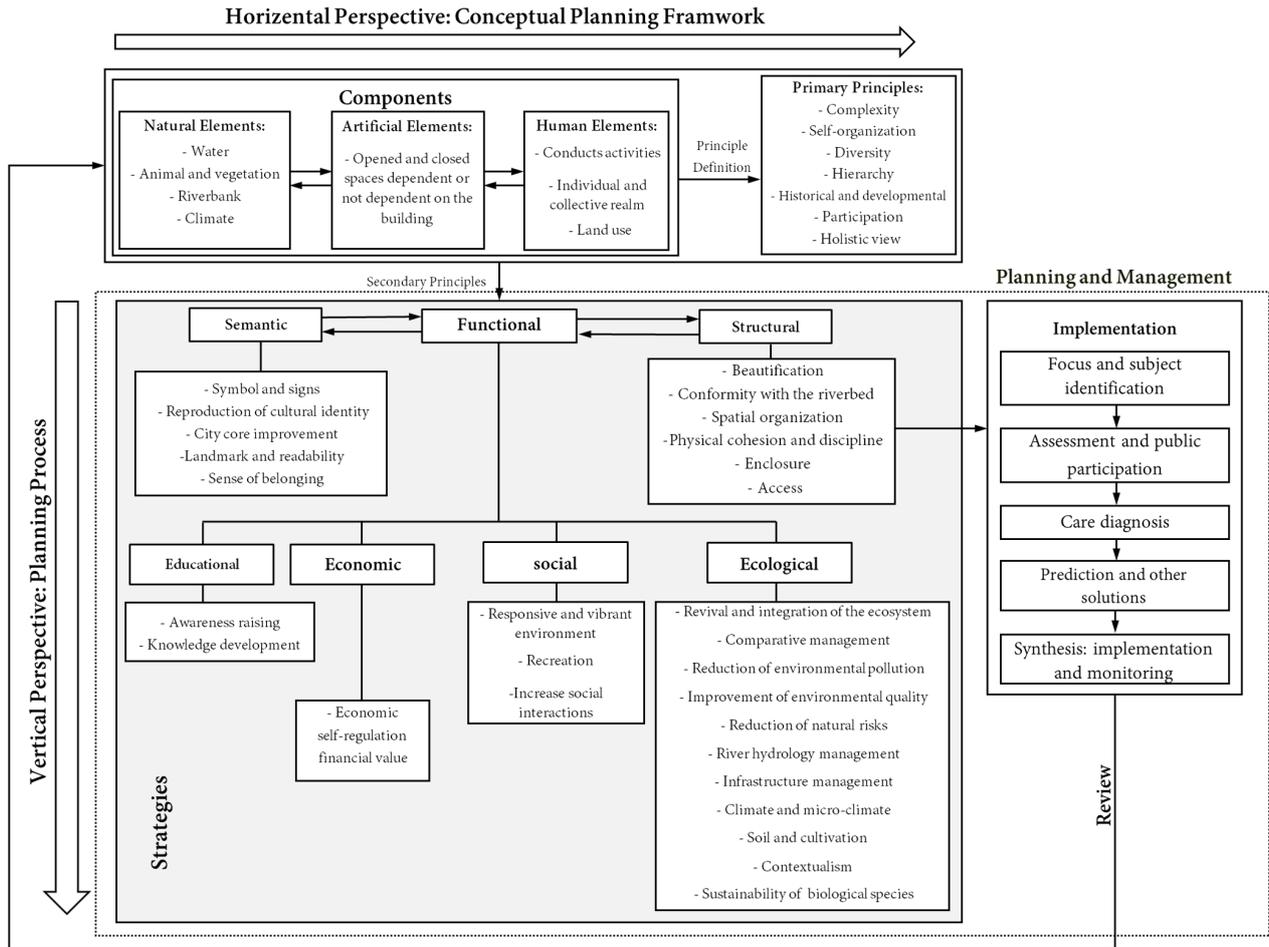


Fig. 3. Conceptual model of landscape planning from theoretical frameworks to practical processes. Source: Authors.

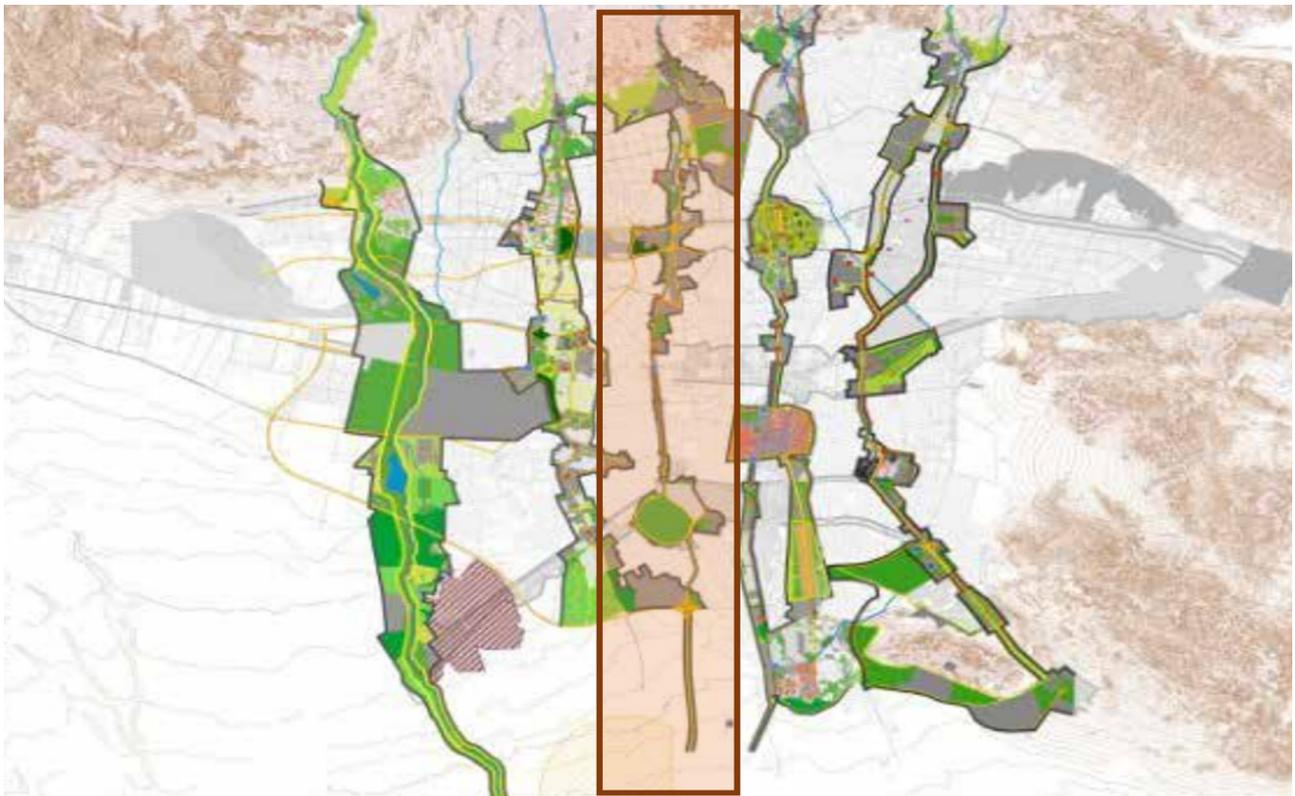


Fig. 4. River-valley area of Darakeh in Tehran. Source: Supreme Council of Architecture and Urban Planning of Iran, 2007.

This section uses the SWOT technique to understand the weak and strong points and opportunities and threats to classify the data better. The approaches extracted from this table, together with data from the questionnaire and theoretical basics, will be used to provide strategies and guidelines (Table 2).

Discussion

Today, the development of urban spaces without knowing environmental capacities and utilization of natural environmental characters of cities could engender serious problems. To create a balance between manufacturing space in the city and nature, one should look to revive the link between man and nature by restoring the natural environment in the city, fostering the facilities and opportunities, removing threats, and turning them into strong points in the form of strategic plans. The current research initially investigated the cases studies and theoretical basics in this area to discuss three semantic, structural, and functional dimensions. Then, with knowledge of the design and use of field and survey methods, some concepts were extracted, which were analyzed through the Delphi technique.

This study constructed a questionnaire based on the conceptual model to categorize natural elements, artificial elements, and human activities using such principles as complexity, self-organization, diversity, hierarchy, profile, development, participation, and holistic view. The most important strategies were produced in these three domains. To put it differently, the structural approach concerned with the axes, diverse visual morphology, and visual disturbance from urban gray arteries; the functional domain dealt with feeding of the groundwater aquifers, vegetation, river canalization, pristine natural environment, and flood absorption risks as well a river hydrologic regime; however, the semantic domain investigated such issues as the revival of the summer village texture of the region and relationship between human senses and running water. Analyses yielded practical measures to organize the Darakeh River in line with the strategies proposed. For example, to preserve and restore the riverbed, one would use water management techniques, create limits and terracing along the riverbank, etc. Also, vegetation management techniques can be used to expand habitats, as the creation of collective spaces

Table 2. SWOT table of the study area. Source: Authors.

Criteria	Strong points	Weak points	Opportunities	Threats
Natural environment	<ul style="list-style-type: none"> - Natural sound and view of the river - Appropriate soil type - Structure of a summer village - Natural pristine environment for recreation - Various visual sequences - Natural vegetation - Signs of the natural index of Tehran (such as the Alborz Mountain range in the north of the site) 	<ul style="list-style-type: none"> - Undermining the animal life - Pestering smell of wastage - Interrupted habitat patches - Rare and weed species - Loss of natural riverbed - Unofficial constructions - Mountain landscape covered (Atisaz Complex) 	<ul style="list-style-type: none"> - Providing site topography to create places overlooking the city. - Cool airflow from the valley to other low-rise areas. - Use of aesthetics-related green spaces/ generation of air pollution/ enclosed vegetation and texture diversity 	<ul style="list-style-type: none"> - Flood absorption risks in upstream areas. - Changing of hydrological properties of the river and the possibility of its drying. - Contamination of the food cycle because of agricultural products of the southern plains. - Contaminated groundwater - Sedimentation caused by water erosion
Human activities	<ul style="list-style-type: none"> - Establishing a walkable link between the valley and adjacent residential structures 	<ul style="list-style-type: none"> - Loss of human relation with running water (because of canalization and lowering of the riverbed) 	<ul style="list-style-type: none"> - Appealing to the public arena at an urban scale because of available access - Leisure [land] use in northern Tehran valleys 	<ul style="list-style-type: none"> - Reduced security due to social presence
Artificial environment	<ul style="list-style-type: none"> - Communication with the surrounding areas through four riding access lines, i.e., Chamran Highway, Darya Boulevard, Farhang Street, and Souri Street. - Non-dominance of the surrounding builder over the structure of this dominating site 	<ul style="list-style-type: none"> - High-rise loading in sloped chords of the valley prevent, obstruct or change the wind direction and air passage channels - Unofficial settlement of Islamabad. - Numerous vertical columns in the area of Niayesh Highway have prevented the air from flowing into the valley 	<ul style="list-style-type: none"> - Locating sidewalks to use appealing natural landscapes and linear urban landscapes. - Presence of recycled lands in the adjacency of the area where parking lots are established. 	<ul style="list-style-type: none"> - Interrupted airflow in green channels due to transverse interruptions of gray channels - Uncontrolled expansion and encroachment of structures on the river. - Incompatible uses on the site (Evin Prison, Milad Hospital). - Extension of the river in the indoor sewage canal. - Urban development penetrating natural lands and river areas.

can help establish social security in the environment. Structurally speaking, measures including using natural vegetation in designing the main path as the backbone of the set and linking vegetation patches as green corridors will be effective. In the semantic domain, however, one would propose designing spaces to link senses with water and establish cultural spaces based on the riverbed and identity to improve path readability and preservation of the corridor (Table 3).

Conclusion

Intra-city rivers can be potentially useful or become channels to transfer environmental pollution if neglected from one region to another. Darakeh River, a basic ecological component of Tehran's nature, was recently exposed to social and environmental damage. This research aimed to strengthen the natural values of the said river using a landscape ecology conceptual model, thus seeking to develop a model to investigate the horizontal and vertical perspectives, as the

Table 3. Evaluation of the structure of the project area using the conceptual model of urban river landscape planning. Source: Authors.

Dimensions	Policy making	Strategy
Functional	Preservation and revival of riverbed texture	<ul style="list-style-type: none"> - Delimitation of the water edge to preserve the ecological function - Removal of floodgates in authorized areas, terracing of the edges, and changing of it to a soft landscape - Allowing the river to occupy a larger area of the floodplain when rainfall rises and flood risks subside - Use of urban watershed management techniques such as ecological ponds in floodplains to break down pollutants using natural processes - Removal of dry waste from water using manual or filtration methods - Prevention of domestic sewage from entering the river by linking it to the municipal sewage network
	Revival and expansion of habitats	<ul style="list-style-type: none"> - Removal of rare and weed species and preservation of local valley plants
	Environment vitality	<ul style="list-style-type: none"> - Designing outdoor areas for children to play in nature - Designing collective spaces for the gathering of the young people - Providing lighting for security
Structural	Sustained development	<ul style="list-style-type: none"> - Establishment of any construction outside the ecological riverbed - Establishment of residential uses of surrounding textures in line with the riverbed capacity (urban development model)
	Use of materials and vegetation	Use of natural coatings (wood and stone) for the riverbed or artificial open-slit drystone coatings
	Configuration of the axes	<ul style="list-style-type: none"> - Design of a main riparian route as the backbone of the complex - Design of sidewalks and bicycle routes to preserve the mobility dynamics - Locating sidewalks based on valuable visual corridors
	Location and functioning	<ul style="list-style-type: none"> - To preserve the ecological functionality of the river, driving areas are loaded, and parking spaces outside the ecological area are foreseen. - Use the edges overlooking the river valley to locate the entrances
	Structural coherence	- Linking small and large vegetation patches using green corridors to foster habitat link
	Conformity with riverbed	- Definition of the main green water route axis in line with the north-south slope
Semantic	Engagement of the perceptual senses with water	<ul style="list-style-type: none"> - Design of spaces to touch the running river water when there is no toxic pollution - Design of a riparian sidewalk route to use the natural sound and landscape of the river
	Reflection of historical, cultural identity	- Establishment of cultural spaces in the zone made overlapping of the centralized recreation model and the riverbed limit
	Symbol and semiotics	- Construction of recreational and service areas in the centralized recreation zone, taking into account the preservation of viewing corridors and improvement of the route readability throughout the project area.

former had a holistic view. At the same time, the latter is concerned with the issue technically. However, a gap between these two perspectives could derail the achievement of an inclusive model. This research used case studies in three structural, functional and semantic domains and then formulated main strategies to deal with the problems. To put it differently, the structural approach concerned with the axes, diverse visual morphology, and visual disturbance from urban

gray arteries; the functional domain dealt with the feeding of the groundwater aquifers, vegetation, river canalization, pristine natural environment, and flood absorption risks as well a river hydrologic regime; however, the semantic domain investigated such issues as the revival of the summer village texture of the region and relationship between human senses and running water. Analyses yielded practical measures to organize the Darakeh River in line with the strategies proposed.

Endnote

1. Similarly, Naveh and Lieberman integrated geographers' spatial and horizontal perspectives and the functional and vertical

perspectives of ecologists to propose the landscape ecology (Naveh & Lieberman, 1990).

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