Sustainable Management Strategies for the Orchards in the Tehran City ETJ with Emphasis on AWOT Analysis

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Case study

Received: 2026-09-05
Revised: 2026-10-09
Accepted: 2026-11-07

Abstract

Gardens within Tehran's urban periphery are components of urban green infrastructure, contributing to ecosystem services and environmental quality. However, urban expansion, land-use change, land fragmentation, water scarcity, and weak management mechanisms threaten their sustainability. This study aims to identify and prioritize factors affecting the sustainable management of these gardens and formulate strategies. The applied, descriptive-analytical research uses a mixed qualitative and quantitative approach. Factors were identified through documentary research, field investigations, and expert judgment, then classified into four SWOT categories: strengths, weaknesses, opportunities, and threats. SWOT was integrated with the Analytic Hierarchy Process (AHP) through the AWOT model to determine factor weights and formulate strategies. Twelve strategies were prioritized using the Quantitative Strategic Planning Matrix (QSPM). Ranking robustness was assessed through sensitivity analysis, changes in factor weights and attractiveness scores, and Monte Carlo simulation. The findings indicate that weak local monitoring and protection mechanisms, alongside urban expansion pressures, are key factors affecting garden management. Preventive control of land-use change ranked first (3.8798), followed by ecological conservation of strategic gardens (3.1925) and rehabilitation and sustainable utilization of water resources (3.0780). The first-ranked strategy retained its leading position in 92.5% of Monte Carlo simulations and appeared among the top three in 99.8% of iterations. The results highlight the need for an integrated management framework linking land-use change control, ecological conservation, sustainable water-resource management, and institutional coordination. Such a framework should also support landowners and meaningful participation to strengthen conservation and compatible use of gardens within Tehran's urban periphery.

Keywords: Peri-Urban Orchards, Strategic Development, Tehran Urban Fringe, Spatial Governance, Land-Use Change, QSPM.

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1. Introduction

Urbanization and the physical expansion of cities have made the relationship between urban development and the environmental capacity of surrounding areas one of the major challenges facing urban planning and management. When urban development proceeds without due consideration of the ecological capacity of the land, it can lead to land-use changes, the reduction of vegetation cover, ecosystem fragmentation, and increased pressure on water and soil resources. These challenges become more complex in metropolitan areas such as Tehran due to the intensity of physical expansion and the high economic value of land. In Tehran, the issue of protecting peri-urban gardens is not merely limited to the declining area of horticultural land; rather, it is simultaneously associated with several interconnected challenges, including land-use conversion, land parcel fragmentation, economic pressures resulting from rising land values, limited water resources, the spatial fragmentation of gardens, and the multiplicity of institutions responsible for their management. From this perspective, the gardens located within Tehran's metropolitan fringe constitute part of a broader spatial, social, and economic system. Their protection therefore requires simultaneous consideration of both the internal factors associated with the gardens and their host areas, as well as the external and broader-scale factors influencing them. In this context, agricultural lands, gardens, and green spaces surrounding cities provide a wide range of ecosystem services beyond their productive functions. These services include climate regulation, biodiversity conservation, the mitigation of environmental hazards, food provision, and improvements in quality of life. Accordingly, these areas constitute an integral component of urban green infrastructure and play a significant role in strengthening urban resilience(Mulya et al., 2023; Pereira et al., 2024). The importance of these areas has become increasingly significant amid the intensification of climate change, rising temperatures, and growing pressure on natural resources. The United Nations' World Cities Report emphasizes the need to strengthen green infrastructure, nature-based solutions, and climate-responsive planning approaches to enhance urban resilience (UN-Habitat, 2024). Within this framework, gardens and agricultural lands surrounding metropolitan areas can help mitigate some of the environmental pressures associated with urban development by maintaining ecological connectivity, regulating ambient temperatures, enhancing water infiltration, reducing soil erosion, supporting biodiversity, and providing economic and recreational opportunities. Nevertheless, urban expansion and the conversion of agricultural and horticultural lands into built-up areas remain among the most significant threats to the continuity of these functions (Mulya et al., 2023).

Tehran, as the largest metropolitan area in Iran, represents a prominent example of the conflict between urban development and the conservation of natural resources in its surrounding areas. Rising land values, pressures associated with physical urban expansion, changes in the land and housing markets, and weaknesses in certain land-use management mechanisms have contributed to land-use conversion and the decline of green spaces and garden areas. Borhani et al. (2021) demonstrated that economic and political factors, land and housing market dynamics, and development interventions play significant roles in unsustainable land-use changes in Tehran. Therefore, the issue of protecting gardens within Tehran's metropolitan fringe is not merely an environmental concern; rather, it is closely interconnected with economic, social, institutional, and spatial dimensions (Borhani et al., 2021). Meanwhile, climatic evidence highlights the importance of conserving and enhancing vegetation cover in Tehran. Using remote sensing data, Zargari et al. (2024) identified an increasing trend in land surface urban heat island intensity in Tehran over the past three decades and associated the expansion of this phenomenon with vegetation loss and the increase in built-up areas (Zargari et al., 2024). Another study examining heatwave conditions emphasized the relationship

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between land-use characteristics, vegetation cover, and the intensity of Tehran's urban heat island (Roshan et al., 2024). Furthermore, satellite imagery from 2015 to 2023 indicates that the structure and connectivity of green and cool spaces in Tehran have undergone considerable changes. Concurrent with the expansion of hot areas in the southern and southwestern parts of the city, the connectivity of some green patches in northern Tehran has declined. Adopting a network-based perspective that extends beyond the isolated conservation of individual green spaces highlights the need for green-space planning approaches that consider not only their total area but also their spatial location, connectivity, and functional role within the metropolitan ecological structure.

Within this context, the gardens located within Tehran's metropolitan fringe hold a particularly significant position in the surrounding metropolitan environmental structure due to their ecological, economic, historical, and cultural values. Nevertheless, land-use conversion and construction activities, fragmentation of land ownership, increasing economic value of land, water scarcity and the instability of water resources, declining economic incentives for landowners, the impacts of climate change, and inadequate coordination among responsible institutions have created substantial challenges for the conservation and sustainable utilization of these gardens. The multiplicity of stakeholders and decision-making institutions has further increased the complexity of the issue. Consequently, conflicts among environmental conservation objectives, the economic interests of landowners, and the requirements of urban development highlight the growing need for an integrated and participatory approach. Despite existing studies on land-use changes, vegetation conditions, and the climatic consequences of urban development in Tehran, translating these findings into a coherent set of managerial and operational strategies for the conservation of peri-urban gardens remains an area requiring further attention. In fact, the central issue is not merely identifying the factors threatening these gardens, but also determining which factors are more significant under the prevailing economic, social, institutional, and environmental conditions, and which strategies can facilitate the conservation and sustainable utilization of these areas. Addressing this issue requires an approach capable of identifying internal and external factors while also enabling their weighting and prioritization.

In this regard, SWOT analysis provides an appropriate framework for identifying the strengths, weaknesses, opportunities, and threats affecting a management system. However, the predominantly qualitative nature of this method presents certain limitations in determining the relative importance of factors and prioritizing them. Although numerous studies have examined land-use changes, urban development, peri-urban agriculture, and the ecological values of green spaces surrounding Tehran, a considerable proportion of the existing literature has either focused on specific dimensions of the issue, such as land-use conversion, development pressures, or environmental values, or failed to provide an integrated framework for translating identified factors into prioritized strategies. Accordingly, the research gap addressed in this study concerns the lack of a comprehensive framework for identifying context-specific factors influencing the sustainability of peri-urban gardens, determining their relative importance, and translating these factors into a set of strategies that can be systematically prioritized. To address this research gap, the present study integrates SWOT analysis with the Analytic Hierarchy Process (AHP) within the AWOT framework. First, it identifies the internal and external factors affecting the sustainable management of gardens within Tehran's metropolitan fringe and subsequently determines their relative importance. Next, four categories of strategies are formulated based on the relationships between internal and external factors. Finally, the strategies are evaluated and ranked according to their relative attractiveness and priority using the Quantitative Strategic Planning Matrix (QSPM). Accordingly, the practical contribution of

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this research lies not in the independent application of SWOT or AHP, but rather in integrating context-specific factor identification, quantitative weighting of expert judgments, strategy formulation based on the relationships between internal and external factors, and quantitative strategy prioritization within a framework for the sustainable management of gardens in Tehran's metropolitan fringe. Therefore, this study aims to identify and prioritize the factors influencing the management of gardens within Tehran's metropolitan fringe, formulate sustainable management strategies, and determine priority strategies through the application of the AWOT model and QSPM.

2. Literature Review and Theoretical Foundations

In Iranian culture and architecture, the garden has historically represented more than a green space; it has constituted an integral component of the social, economic, cultural, and environmental structure of human settlements. The Persian garden, through the integration of water, vegetation, architecture, and climatic conditions, represents an example of human adaptation to the natural environment and the sustainable use of natural resources (Sultan-Zadeh, 2004; Parhami, 2010). In addition to providing agricultural products and generating economic value, these spaces have served important social, cultural, and aesthetic functions. Today, gardens and green lands surrounding cities can also be regarded as part of the natural and cultural capital of urban areas. Alongside their productive value, they provide a wide range of ecosystem services, including temperature regulation, biodiversity conservation, water regulation, soil erosion reduction, and the provision of recreational and cultural opportunities. Recent studies have likewise emphasized the multifunctional role of urban and peri-urban agriculture and green spaces in promoting sustainability, resilience, and urban quality of life (Mulya et al., 2023; Pereira et al., 2024). The urban fringe, as a transitional zone between the built-up urban fabric and surrounding areas, represents one of the most significant areas of interaction between urban development and the conservation of natural resources. In addition to their agricultural and natural potential, these areas are exposed to pressures arising from physical urban expansion, increasing land values, land-use conversion, and infrastructure development. From this perspective, peri-urban gardens should not be considered merely as agricultural lands; rather, they should be understood as integral components of the green infrastructure and ecological networks of metropolitan regions. In contemporary approaches to urban planning, green infrastructure is defined as an interconnected system of natural and semi-natural spaces that simultaneously provides environmental, social, and economic benefits and can contribute to enhancing urban resilience to climate change and development pressures (Benedict & McMahon, 2006; Pereira et al., 2024).

Accordingly, the conservation of peri-urban gardens does not simply mean preventing construction and land-use conversion. Rather, it is a multidimensional process that requires the simultaneous consideration of ecological, economic, social, spatial, and institutional dimensions. From an ecological perspective, the conservation of water and soil resources, vegetation cover, biodiversity, and the spatial connectivity of gardens is essential. Economically, creating incentives to sustain horticultural activities and promoting the sustainable use of tourism and local economic opportunities are necessary. From social and institutional perspectives, the participation of landowners and local communities, coordination among responsible organizations, and strengthening monitoring systems and integrated management are of particular importance. Within this framework, the sustainable management of gardens is closely aligned with concepts such as ecosystem services, green infrastructure, nature-based solutions, and urban resilience. From a theoretical perspective, Howard's Garden City concept emphasizes the role of green belts surrounding cities in controlling uncontrolled

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urban expansion and establishing a balance between urban development and open spaces. Furthermore, landscape ecology and urban ecology approaches consider gardens as components of a spatial structure consisting of patches, corridors, and the landscape matrix. Therefore, in addition to the total area of gardens, their connectivity and relationships with other natural elements are important for maintaining ecological functions (Forman, 2014). On the other hand, the concept of ecological carrying capacity emphasizes the need to balance human pressures with the environment's capacity to provide and regenerate resources (Rees & Wackernagel, 1996). The green infrastructure approach also considers gardens and other natural and semi-natural spaces as components of a multifunctional ecological network that can contribute to controlling urban development, providing ecosystem services, and enhancing resilience (Benedict & McMahon, 2006). Recent studies have demonstrated that urban and peri-urban agriculture and green spaces play an important role not only in food production but also in providing ecosystem services and enhancing the environmental sustainability of cities. Huan et al. (2024), in a systematic review of 70 studies, emphasized the multifunctional nature of urban agriculture and its role in delivering ecosystem services. At the same time, they identified the lack of practical guidelines for translating scientific knowledge into operational solutions as one of the existing research gaps (Huan et al., 2024).

Regarding peri-urban areas, a study demonstrated that ecosystem services provided by these areas are directly associated with the health, well-being, and livelihoods of urban and peri-urban communities. It further indicated that integrating these services into urban policymaking and planning can help generate synergies between conservation and development objectives. This study highlights the need to simultaneously consider environmental, social, and economic dimensions in the management of peri-urban lands (Marshall et al., 2024). From a climate change perspective, Al-Qubati et al. (2024), through a review of 96 studies on urban and peri-urban agriculture, examined the relationships between these lands, greenhouse gas emissions, and carbon sequestration capacity. Their findings indicated that peri-urban agriculture can contribute to mitigating climate impacts and providing certain ecosystem services. However, the simultaneous assessment of resource consumption, carbon emissions, and carbon sequestration capacity is essential for accurately evaluating the sustainability of these spaces (Al-Qubati et al., 2024). Similarly, another study (2024), examining peri-urban agricultural development scenarios in the Barcelona metropolitan region, demonstrated that the expansion of these areas could simultaneously increase food production and reduce local temperatures. However, such expansion could also increase water demand and, under certain conditions, lead to a decline in carbon stocks. These findings highlight the importance of considering trade-offs and synergies among ecosystem services in the planning and management of peri-urban lands (Segura-Barrero et al., 2024).

2.1. Review of Experiences with Gardens Located within Urban Peripheries

Peri-urban gardens and agricultural lands have been recognized in many metropolitan areas as components of green infrastructure and as natural capital within urban regions. Experiences from different countries indicate that the sustainable protection of these areas cannot be achieved solely through legal restrictions. Rather, it requires a combination of urban growth control, land-use protection, economic incentives, stakeholder participation, continuous monitoring, and environmentally compatible land management. The most relevant experiences are outlined below:

- **United Kingdom (London):** London's Green Belt policy was established to prevent uncontrolled urban expansion around the city. It includes strict regulations to protect agricultural lands and gardens, satellite-based monitoring, and substantial penalties for violations. According to the reported figures, this policy has succeeded in preserving 3,200

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hectares of historic gardens, preventing the development of 450,000 housing units, and reducing the urban heat island effect in the surrounding areas by up to 35%. The participation of 66 local authorities and 120 non-governmental organizations, alongside initiatives such as next-generation gardening, ecotourism, and environmental education, has contributed to the policy's success (Ministry of Housing, 2023; Natural England, 2023).

- **Canada (Toronto)**: Toronto's Greenbelt Program protects an area of 7,280 square kilometers comprising peri-urban gardens and agricultural lands. Its key measures include prohibiting land-use conversion, implementing protective zoning, establishing an independent monitoring body, and conducting continuous satellite-based monitoring. Over an 18-year period, the program has reportedly preserved 91% of gardens and agricultural lands, created 150,000 green jobs, and attracted 3.2 million tourists annually. Tax incentives and the participation of 29 municipalities and 45 specialized working groups are among the factors contributing to its success (Greenbelt Foundation, 2023).
- **United States (California):** The Williamson Act encourages landowners to conserve agricultural lands and gardens through voluntary ten-year contracts and tax incentives. The Act has reportedly protected 16.5 million hectares of land, reduced the rate of land-use conversion by up to 60%, and preserved more than 85% of historic gardens. Use-based property valuation and penalties for unauthorized land-use conversion constitute the program's principal mechanisms for achieving these outcomes (California Department of Conservation, 2023).
- **France (Paris):** Through the implementation of ecotourism programs in historic gardens and surrounding forests, Paris has sought to simultaneously promote environmental conservation, generate sustainable income, and enhance public environmental awareness. Key measures include low-impact tourism, ecological restoration, and the sale of locally produced organic products. These policies have contributed to increased biodiversity, the return of animal species, and environmental education among citizens (European Environment Agency, 2018).
- **Australia:** Cities such as Melbourne and Sydney have implemented a combination of strict zoning regulations, financial incentives, community participation, and environmental measures. Instruments such as Urban Growth Boundaries and community-based agriculture programs have helped control urban expansion and maintain gardens as an integral component of the urban environment (Landcare Australia, 2023; Victoria State Government, 2022).
- **United States (Atlanta):** The Atlanta BeltLine project has expanded green space by more than 1,200 hectares through the development of a green loop and the conversion of former railway corridors into parks and pedestrian pathways. Financial incentives for farmers and smart-growth regulations have also provided economic motivation and legal protection for green spaces (Urban Agriculture Network, 2023).
- **United States (Oregon):** The adoption of Senate Bill 100 (SB 100) established strict urban growth boundaries, innovative financial incentives, and participatory governance mechanisms. Portland has reportedly lost only 1% of its agricultural land, while 4,200 urban farms have been established. The use of Purchase of Development Rights (PDR) programs and periodic reviews of urban growth boundaries has contributed to the continuity and effectiveness of this approach (Oregon Agricultural Trust, 2023).

Given the role of gardens within urban peripheries in maintaining ecological cycles, mitigating the urban heat island effect, and providing spaces for recreation and urban agriculture, various theories and approaches emphasize the need for their protection and sustainable management. The fundamental principles of these approaches involve a combination of legal and conservation policies, community participation, the use of native species, and the application of modern technologies for monitoring, supervision, and evaluation. These principles are

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reflected in approaches such as urban green networks and biophilic planning. Global experiences further demonstrate that the success of programs for protecting peri-urban gardens and green spaces depends on several factors, including the stability and continuity of legal policies; periodic review of plans; the use of economic incentives, such as tax exemptions, financial support, and the purchase of development rights; and the active participation of municipalities and civil society organizations. Examples such as London's Green Belt, Toronto's Greenbelt Program, the Williamson Act in California, and green-space conservation projects in Atlanta demonstrate the importance of simultaneously addressing the economic, social, and environmental dimensions of peri-urban green-space conservation.

Drawing on the theoretical discussions and the experiences reviewed, this study examines the sustainability of gardens within the urban periphery of Tehran across five principal dimensions: ecological, economic, spatial, social, and institutional. These dimensions constitute the conceptual framework of the study and were used to identify and classify SWOT factors, providing a basis for examining the capacities, constraints, opportunities, and threats affecting the management and conservation of these gardens. Within this framework, the ecological and spatial dimensions emphasize the role of gardens in maintaining green networks, ecosystem services, and landscape connectivity; the economic dimension focuses on income-generating potential and environmentally compatible uses; the social dimension addresses community participation and the role of local communities; and the institutional dimension concerns policymaking, legislation, inter-organizational coordination, and management mechanisms. Accordingly, the conservation of gardens within urban peripheries, as a multidimensional component of green infrastructure, requires an integrated approach based on participatory governance and the incorporation of ecological, economic, social, and spatial objectives. Based on the theoretical foundations and the dimensions identified, the conceptual framework of the study is presented in Figure 1.

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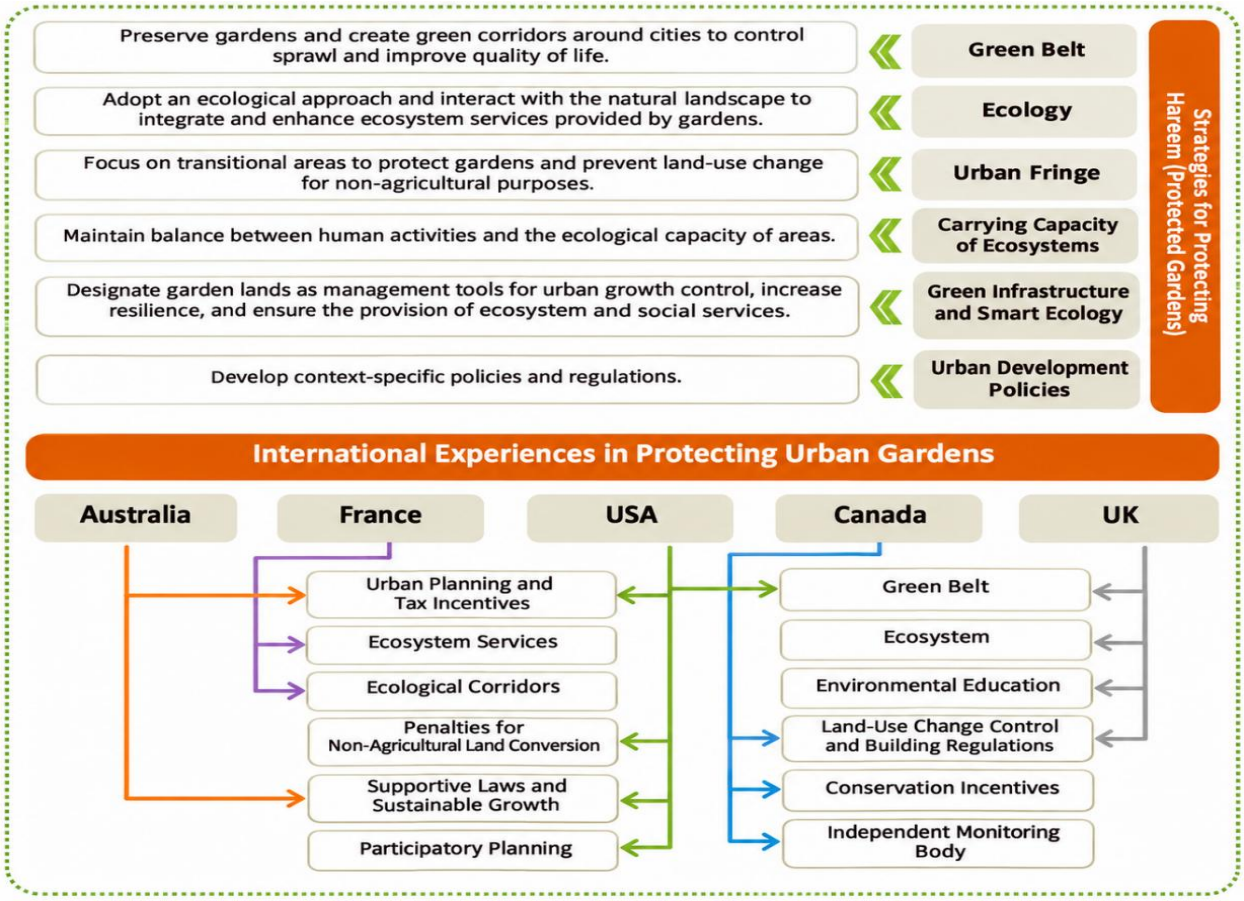
3. Methodology

In terms of its purpose, this study is applied research, while methodologically it adopts a descriptive–analytical approach with a mixed qualitative and quantitative design. The study

Figure 1. Conceptual Framework of the Study



aims to identify and prioritize the factors influencing the sustainable management of gardens within the urban periphery of Tehran, and to formulate and prioritize appropriate strategies for the conservation and sustainable use of these areas. To achieve this objective, the AWOT model, which integrates SWOT strategic analysis with the Analytic Hierarchy Process (AHP), was employed. In addition, the Quantitative Strategic Planning Matrix (QSPM) was used to determine the final priorities of the formulated strategies. Accordingly, the research process was conducted across three main stages: identification and classification of factors; weighting of factors and strategy formulation; and final prioritization of strategies.

In the first stage, an initial framework of factors affecting the sustainable management of gardens was developed through a review of academic literature, official documents and reports, and laws and regulations related to urban peripheries, gardens, and the conservation of green lands. To further develop, refine, and contextualize these factors, the views of six experts and specialists with relevant expertise were incorporated. These experts were purposively selected based on the relevance of their professional expertise to the management and conservation of gardens within the urban periphery of Tehran. They were drawn from the fields of urban planning, urban-periphery management, natural resources, environmental studies, and garden management. The selection criteria included relevant specialized knowledge, professional experience in the research area, and familiarity with the spatial and management-related challenges of Tehran's urban periphery, as well as the conservation and use of garden lands.

The identification and finalization of the factors were carried out in several steps. First, a preliminary list of factors was compiled based on documentary studies and academic sources. The factors were then assessed in terms of their relevance to the research problem, conceptual overlap, and suitability for classification within the SWOT framework. The six experts' opinions were subsequently used to refine, revise, and contextualize the list. During this process, factors that were similar or conceptually overlapping were merged, while those lacking a direct connection to the research objectives and study scope were excluded. Finally, the selected factors were classified into four categories: strengths, weaknesses, opportunities, and threats. Strengths and weaknesses represented internal factors associated with the condition of the gardens, their existing capacities, and their management constraints. Opportunities and threats, in contrast, referred to external conditions and factors affecting the conservation, continuity, and management of the gardens. This distinction was made to maintain a clear conceptual boundary between internal and external factors and to prevent the conflation of internal capacities and constraints with external environmental and institutional conditions. Thus, the final list of SWOT factors resulted from the integration of documentary research findings and expert judgment.

Following the finalization of the SWOT factors, the same six experts completed the Analytic Hierarchy Process (AHP) pairwise comparison questionnaires. At this stage, the relative importance of the factors within each of the four SWOT categories strengths, weaknesses, opportunities, and threats—was assessed using Saaty's nine-point scale. To aggregate the individual judgments of the experts and construct a group pairwise comparison matrix, the geometric mean of corresponding judgments was calculated. The relative weights of the factors were then derived from the aggregated matrices, and the Consistency Ratio (CR) was calculated to assess the consistency of the judgments. A consistency ratio of less than 0.10 was considered an acceptable threshold. Subsequently, the resulting weights were incorporated into the SWOT analysis to support the formulation and evaluation of strategies for the sustainable management of gardens within the urban periphery of Tehran. In the next stage, strategies were formulated by combining the identified internal and external factors and incorporating their calculated weights. These strategies were organized into four strategic categories. They were designed to capitalize on strengths and opportunities (SO strategies), use internal strengths to address external threats (ST strategies), overcome weaknesses by taking advantage of available opportune ities (WO strategies), and simultaneously minimize weaknesses and mitigate threats (WT strategies).

In the final stage, the Quantitative Strategic Planning Matrix (QSPM) was employed to prioritize the formulated strategies. Given the limited availability of the experts involved in the first stage, four additional specialists participated in this stage, including two university faculty members and two specialists in urban-periphery management from the Center for Studies. In the QSPM method, the internal and external factor weights obtained through the AHP stage are used to evaluate the relative attractiveness of the strategies. For this purpose, the attractiveness of each strategy is assessed in relation to the relevant factors, and its Attractiveness Score (AS) is multiplied by the corresponding factor weight. The sum of the resulting values constitutes the Total Attractiveness Score (TAS) for each strategy and provides the basis for comparing and determining their relative priorities. Accordingly, strategies with higher total attractiveness scores are assigned higher relative priority. The results of this stage are presented in the Findings section and in the corresponding QSPM table.

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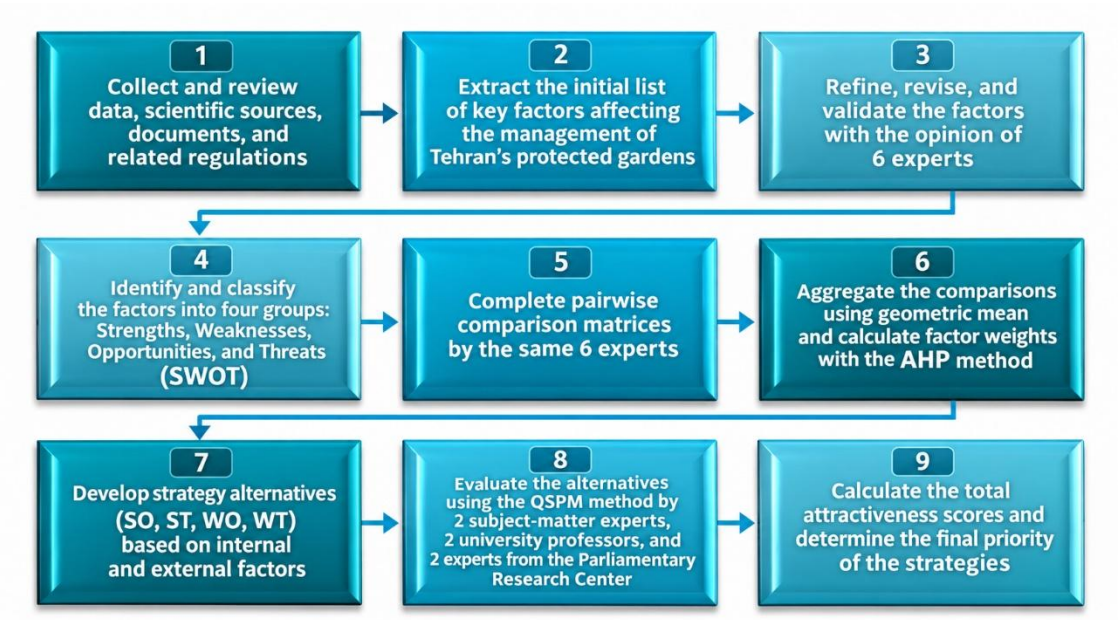
Figure 2. Research Process Model



3.1. Study Area

The urban periphery of Tehran, with its gardens, agricultural lands, open spaces, river valleys, and other surrounding natural resources, constitutes an important area for the conservation of ecological assets and the management of spatial development in the Tehran metropolitan area. In addition to its protective role in controlling the city's physical expansion, this area is significant for conserving water and soil resources, sustaining horticultural and agricultural activities, and supporting the environmental balance of the Tehran urban region. The Strategic Plan for the Periphery of the Capital, approved by the Supreme Council of Urban Planning and Architecture of Iran in 2016, emphasizes the need to protect the natural and agricultural areas surrounding Tehran and control incompatible land-use changes (Tehran Municipality, 2016). According to this report, the capital's urban periphery covers approximately 5,916 km², whereas the legally defined area of Tehran is approximately 730 km². This difference indicates that the urban periphery and the legally defined city limits are two distinct spatial territories in terms of both extent and planning function. The urban periphery encompasses an extensive area of natural lands, gardens, agricultural lands, and surrounding settlements. Its management is particularly complex because of the diversity of spatial zones and the multiplicity of responsible institutions (Foroughi, 2025). Therefore, when examining Tehran's gardens, it is essential to distinguish the urban periphery from both the city's legally defined boundaries and the administrative boundaries of Tehran Province. The present study primarily focuses on identifying and prioritizing strategies for the sustainable management of gardens located within Tehran's urban periphery. Accordingly, the urban periphery of Tehran is considered the study's spatial reference area, while gardens and garden areas constitute the primary subject of analysis. In identifying the factors affecting garden management, areas such as Kan, Farahzad, and Soohanak, as well as other locations relevant to the identified factors, are considered. These locations represent spatial examples of the issues and capacities associated with gardens; references to them should therefore be interpreted within the scope of the documentary evidence, field observations, and data collected in this study.

In terms of spatial transformation, the urban periphery of Tehran has undergone changes in both its extent and management structure over the past several decades. According to information reported in the sources used in this study, its area increased from approximately 2,100 km² in

the initial plans of the 1970s to around 6,000 km² in more recent plans. These changes, together with the city's physical expansion and administrative-territorial transformations, have increased the complexity of managing and conserving the natural and garden lands surrounding Tehran. Nevertheless, an increase in the extent of the urban periphery does not necessarily imply more effective protection of gardens, as land-use conversion, unauthorized construction, economic pressure on land, and water-resource constraints remain major management challenges in this area. In terms of spatial distribution, gardens located in parts of northern and northwestern Tehran, including Kan and Farahzad, as well as areas such as Soohanak and Ozgol, have been identified in the studies reviewed as important concentrations of garden land. In the current version of the study, the reported figures for these areas including approximately 1,000 hectares of gardens in Kan, 300 hectares in Farahzad, and a combined total of approximately 400 hectares in Soohanak and Ozgol can be used as evidence of garden distribution only if their geographical boundaries, reference periods, and statistical sources are verified. These figures should not be extrapolated to represent the total area of gardens within Tehran's urban periphery without confirming their geographical correspondence with the study area. Similarly, statistics on changes in the area of gardens across Tehran Province must be distinguished from data specifically concerning gardens within Tehran's urban periphery. If the reported decline in garden area from approximately 14,000 hectares in the early 1980s to around 1,800 hectares in the early 2020s refers to the entire province of Tehran (Sheikhi & Shabestari, 2019), this information can only be used to explain the broader context of the decline in garden lands; it cannot, on its own, indicate the extent of garden loss within Tehran's urban periphery. Accordingly, any conclusions regarding changes in garden areas within the study territory must be based on data for which the geographical boundaries, reference periods, and definitions of gardens are clearly specified and comparable. The general location of Tehran's urban periphery and the spatial structure of its surrounding areas are presented in Figure 3.

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Figure 3. Approved Zoning Plan for the Capital's Urban Periphery

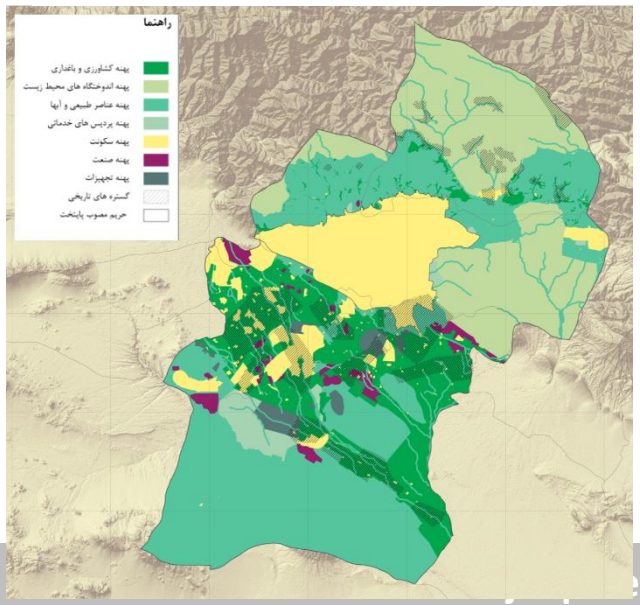
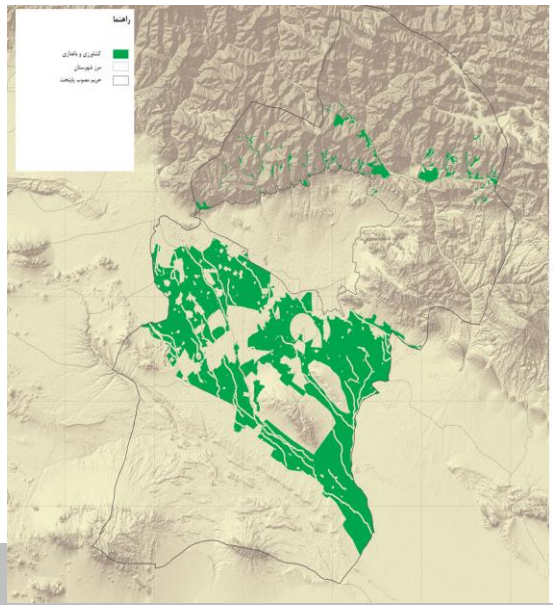


Figure 4. Agricultural and Horticultural Zoning Plan



Source: Strategic Plan for the Capital's Urban Periphery (2016)

4. Findings

The gardens located within the urban periphery of Tehran, particularly in its northern, northwestern, and eastern areas, are among the most significant natural, ecological, and cultural assets of the Tehran urban region. The presence of traditional gardens with a long historical legacy in areas such as Kan, Farahzad, Solqan, and Soohanak; traditional and natural water resources, including qanats and springs; and the spatial connections between gardens, foothills, river valleys, and other natural features provide considerable potential for maintaining ecological connectivity and enhancing environmental resilience. Furthermore, species diversity, landscape values, and the historical role of gardens in shaping the identity of certain settlements and neighborhoods surrounding Tehran further underscore the importance of conserving these areas. Conversely, gardens within the urban periphery face a range of internal constraints that make their continued operation and conservation increasingly challenging. Fragmented land ownership and land subdivision, inadequate land-registration coverage in certain areas, the deterioration and declining efficiency of traditional water supply and distribution networks, insufficient protective and service infrastructure, and the absence or inadequacy of specific documents and regulations for protecting certain garden areas are among the main weaknesses identified. Combined with water-resource constraints and declining economic incentives for landowners, these factors increase the vulnerability of gardens to land-use conversion.

Externally, the gardens within Tehran's urban periphery face multiple opportunities and threats. The rehabilitation of qanats and the use of alternative water resources and treated wastewater; the integration of gardens into networks of open spaces and green infrastructure; the development of agricultural and educational parks; agri-tourism and nature-based tourism; the creation of green jobs; and the use of government incentive mechanisms represent some of the key opportunities for garden conservation and sustainable use. Conversely, the expansion of construction around gardens, villa development and unauthorized land-use conversion, the development of unregulated service and tourism facilities, the construction of unauthorized roads, the expansion of incompatible infrastructure, waste dumping, and inappropriate use of water resources constitute major identified threats. The persistence of drought and intensifying water scarcity may further exacerbate the impacts of these threats. Accordingly, the factors influencing the management of gardens within Tehran's urban periphery were identified and classified into four categories: strengths (S), weaknesses (W), opportunities (O), and threats (T). These factors were derived from documentary studies, a review of relevant literature and documents, and field observations and investigations. The resulting list was then presented to six experts for review. The final list of identified factors is presented in Table 1.

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Table 1. Internal and External Factors Affecting the Management of Gardens within Tehran's Urban Periphery

Strengths	-S1: High concentration of traditional gardens with a long historical legacy in areas such as Kan, Farahzad, and Soohanak. -S2: Availability of natural and traditional water resources, including qanats, springs, and rivers, in certain garden areas such as Kan, Tarasht, and Emamzadeh Davood. -S3: Strong spatial connectivity between some gardens and natural features, including mountains, river valleys, and surrounding highlands. -S4: Existence of formal and well-established ownership structures in some gardens in northwestern and northeastern Tehran. -S5: Plant species diversity and ecological potential in gardens adjacent to the mountainous areas and natural landscapes of northern and northeastern Tehran. -S6: Historical role of gardens in shaping the local and cultural identity of neighborhoods such as Jamaran and Niavaran.
Weaknesses	-W1: Absence of unified ownership deeds or inadequate ownership and land-registration coverage for some gardens and garden lands. -W2: Weak local mechanisms for monitoring, protecting, and maintaining gardens in certain garden areas and host settlements. -W3: Fragmentation and declining spatial coherence of gardens due to multiple ownership, inheritance-based subdivision, and fragmentation of garden plots. -W4: Deteriorated or inadequate irrigation networks and water supply and distribution infrastructure in certain garden areas, as well as the dependence of some gardens on deteriorated qanats or unsustainable water sources. -W5: Inadequate service and protective infrastructure for gardens, including security personnel, fencing, signage, and maintenance facilities. -W6: Absence of a unified organizational or management structure representing owners and operators across garden areas and host villages.
Opportunities	-O1: Availability of government programs and technical support (such as national qanat rehabilitation and water-resource management programs) at the provincial and national levels. -O2: Potential for developing green infrastructure and networks of open spaces at the urban and regional scales. -O3: Opportunities to develop and organize natural access routes and tourism corridors to establish connections among urban, rural, and garden settlements. -O4: Availability of government and civil-society support programs to encourage local community participation in the conservation of agricultural lands and gardens. -O5: Potential to establish economic clusters and develop green jobs, agriculture, and tourism-related activities in rural and peri-urban areas surrounding Tehran. -O6: Availability of supportive policies, economic incentives, and government and urban management programs for the conservation, rehabilitation, and sustainable use of gardens and natural resources.

Threats	-T1: Continued physical expansion and urban development across the Tehran metropolitan area, increasing pressure on peri-urban gardens and agricultural lands. -T2: Rising land values and pressures arising from construction activities and land speculation, which may contribute to land-use conversion and fragmentation of garden lands. -T3: Expansion of transportation infrastructure, roads, and other construction projects at the regional and provincial scales, with the potential to increase pressure on the spatial connectivity of gardens. -T4: Continued conversion of garden and agricultural lands due to development, settlement, tourism, and service-related pressures within and around Tehran's urban periphery. -T5: Intensification of water scarcity, depletion of sustainable water resources, and the persistence of drought and climate change at the regional and provincial scales. -T6: Multiplicity of higher-level decision-making institutions (including governorates, municipalities, and executive agencies) and lack of coordination among regulations governing land-use conversion across the urban periphery and provincial scales.

4.1. Weighting and Prioritization of Factors Using AHP

Following the identification of the four SWOT factor categories, the Analytic Hierarchy Process (AHP) was employed to determine their relative importance. At this stage, pairwise comparison questionnaires were distributed to six experts and specialists with relevant expertise in urban planning, environmental studies, and garden management. The experts assessed the relative importance of the factors within each of the four SWOT categories using Saaty's nine-point scale. After collection, the experts' judgments were organized into pairwise comparison matrices, and the relative weight of each factor was calculated. Subsequently, the Consistency Ratio (CR) of the matrices was calculated to assess the consistency of the judgments. According to the AHP methodology, a consistency ratio of CR < 0.1 indicates an acceptable level of consistency (Saaty, 1980). Once consistency had been confirmed, the final weights of the factors were derived for use in the subsequent AWOT strategy formulation stage.

Table 2. Pairwise Comparison Matrix of Strengths

	S1	S2	S3	S4	S5	S6	Weight	Score
S1	1	$\frac{1}{4}$	$\frac{1}{3}$	$\frac{1}{3}$	$\frac{1}{4}$	$\frac{1}{5}$	0.0495	6
S2	4	1	2	3	2	5	0.3314	1
S3	3	$\frac{1}{2}$	1	$\frac{1}{2}$	$\frac{1}{2}$	3	0.1375	4
S4	3	$\frac{1}{3}$	2	1	$\frac{1}{2}$	4	0.1713	3
S5	4	$\frac{1}{2}$	2	2	1	3	0.2210	2
S6	5	$\frac{1}{5}$	$\frac{1}{3}$	$\frac{1}{4}$	$\frac{1}{3}$	1	0.0892	5

CR <0.1

Table 3. Pairwise Comparison Matrix of Weaknesses

	W1	W2	W3	W4	W5	W6	Weight	Score
W1	1	$\frac{1}{3}$	$\frac{1}{2}$	2	2	2	0.1433	3
W2	3	1	2	4	4	3	0.3515	1
W3	2	$\frac{1}{2}$	1	3	2	3	0.2205	2
W4	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{3}$	1	$\frac{1}{2}$	1	0.0726	6
W5	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{2}$	2	1	2	0.1125	4
W6	$\frac{1}{2}$	$\frac{1}{3}$	$\frac{1}{3}$	1	$\frac{1}{2}$	1	0.0995	5

CR <0.1

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Table 4. Pairwise Comparison Matrix of Opportunities

	O1	O2	O3	O4	O5	O6	Weight	Score
O1	1	2	3	3	2	4	0.3276	1
O2	$\frac{1}{2}$	1	2	2	1	3	0.1914	3
O3	$\frac{1}{3}$	$\frac{1}{2}$	1	2	$\frac{1}{2}$	2	0.1205	4
O4	$\frac{1}{3}$	$\frac{1}{2}$	$\frac{1}{2}$	1	$\frac{1}{3}$	2	0.0914	5
O5	$\frac{1}{2}$	1	2	3	1	3	0.2059	2
O6	$\frac{1}{4}$	$\frac{1}{3}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{3}$	1	0.0631	6

CR <0.1

Table 5. Pairwise Comparison Matrix of Threats

	T1	T2	T3	T4	T5	T6	Weight	Score
T1	1	2	4	$\frac{1}{3}$	6	$\frac{1}{5}$	0.1373	3
T2	$\frac{1}{2}$	1	3	$\frac{1}{4}$	5	$\frac{1}{6}$	0.0967	4
T3	$\frac{1}{4}$	$\frac{1}{3}$	1	$\frac{1}{5}$	3	$\frac{1}{7}$	0.0528	5
T4	3	4	5	1	7	$\frac{1}{2}$	0.2610	2
T5	$\frac{1}{6}$	$\frac{1}{5}$	$\frac{1}{3}$	$\frac{1}{7}$	1	$\frac{1}{8}$	0.0294	6
T6	5	6	7	2	8	1	0.4227	1

CR <0.1

Based on the results of the AHP analysis, the three factors with the highest weights in each of the four categories strengths, weaknesses, opportunities, and threats were selected as key factors for formulating strategies for the sustainable management of gardens within Tehran's urban periphery. These factors were then integrated into the SWOT decision-making matrix to develop and prioritize strategies across four categories: aggressive (SO), competitive (ST), conservative (WO), and defensive (WT). The aim of this stage was to translate the results of factor identification and weighting into a set of actionable strategies and policies that can be applied to the management and conservation of gardens within Tehran's urban periphery.

Aggressive strategies (SO) were formulated to leverage the internal capacities and strengths of gardens within Tehran's urban periphery to capitalize on opportunities in the external environment. Based on the factor prioritization results, the availability of natural water resources and traditional water-supply networks, the relative stability of ownership structures, and the biodiversity of gardens were identified as the most important internal strengths. Meanwhile, opportunities for qanat rehabilitation and the use of alternative water resources, strengthening the integration of gardens into the urban open-space network, and developing economic activities and green jobs represent the most significant opportunities for these areas. Accordingly, three main strategic directions are proposed: rehabilitating garden water-supply systems, strengthening the spatial and ecological connectivity of gardens, and leveraging natural assets to promote a green economy and tourism. The corresponding implementation policies are presented in the following table.

Table 6. Conservation and Management Policies Associated with the Aggressive (SO) Strategy

Strategy	Policy
Strategy S2O1: **Rehabilitation and Sustainable Utilization of Natural and Traditional Water Resources in Gardens**	- Rehabilitation of qanats and restoration of traditional water supply and conveyance networks in garden areas. - Development of water-demand management practices and improvement of irrigation efficiency in accordance with the ecological capacity of gardens. - Integrated protection of surface and groundwater resource zones and prevention of harmful interventions in natural watercourses. - Development of supplementary water sources and water reuse, in compliance with environmental requirements and water-quality standards. - Prioritization of water supply to gardens located in areas of high ecological and productive value

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Strategy S5O2: Strengthening the Spatial and Ecological Connectivity of the Garden Network within Tehran's Urban Periphery	- Identification and consolidation of green corridors and ecological connections among gardens, highlands, and natural areas. - Prevention of the fragmentation and discontinuity of gardens during the development of transportation networks and infrastructure. - Conservation of native plant cover and species diversity as core components of green infrastructure. - Integration of high-value garden areas into the green network planning framework of the Tehran urban region.
Strategy S5O5: Diversifying the Garden Economy and Developing Green Activities	- Development of value chains for horticultural products and enhancement of the added value of locally produced goods. - Promotion of agritourism, garden tourism, and ecotourism based on the ecological and cultural assets of garden areas. - Support for green jobs and economic activities compatible with the area's ecological and environmental capacity. - Establishment of local and regional market networks for the distribution of horticultural products and related goods. - Provision of financial incentives and investment support for activities that ensure the continued use of land for gardening and horticulture.

Conservative strategies (WO) seek to address internal weaknesses by capitalizing on opportunities in the external environment. These strategies adopt an approach that leverages the potential of the surrounding environment to compensate for existing structural deficiencies and shortcomings. Within the framework of managing gardens in Tehran's urban periphery, this approach draws on key opportunities to address identified weaknesses, including establishing an integrated system for garden monitoring, information management, and oversight; organizing ownership structures; strengthening participatory garden management; and upgrading protective infrastructure and water-use efficiency in accordance with the specific conditions of individual garden areas. The ultimate objective is to enhance the resilience and sustainability of these valuable natural and cultural landscapes in the face of urban pressures and climate change.

Table 7. Conservation and Management Policies Associated with the Conservative (WO) Strategy

Strategy	Policy
Strategy W1O1: Organizing Ownership Structures and Securing the Legal Status of Gardens	- Identification and legal and cadastral regularization of gardens lacking title deeds or having ambiguous ownership status. - Completion of cadastral maps and establishment of a comprehensive database of garden ownership. - Simplification of registration and legal procedures for owners committed to maintaining garden land use. - Linking incentives for garden conservation and rehabilitation to the legal clarification of ownership status. - Establishment of transparent mechanisms for recording ownership and utilization histories, as well as changes in garden land use..
Strategy W2O2:	- Establishment and capacity-building of local organizations comprising garden owners, operators, and host communities.

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Institutionalizing Local Participation in Garden Management and Conservation	- Involvement of local stakeholders in garden planning, monitoring, and maintenance. - Delegation of the management of selected maintenance and conservation activities to qualified local organizations. - Development of incentive mechanisms to encourage public participation in reporting violations and protecting gardens. - Strengthening the social capital and environmental awareness of local communities regarding the value of gardens.
Strategy W3O5: **Integrating the Management and Utilization of Small and Fragmented Gardens**	- Establishment of production and joint-management cooperatives among owners of small garden plots. - Support for integrated management and utilization models without relinquishing or altering property rights. - Integration of services related to production, irrigation, maintenance, processing, and marketing of horticultural products. - Development of economic clusters based on the productive and tourism potential of each garden area. - Allocation of financial facilities and investment incentives to collaborative projects involving owners of adjacent plots.

Competitive strategies (ST) aim to leverage the internal strengths and capacities of gardens within Tehran's urban periphery to mitigate external threats, including urban development pressures, land-use conversion, declining water resources, and the gradual degradation of gardens. Accordingly, the existing ecological, economic, social, and managerial capacities of these gardens serve as the foundation for formulating strategies and policies to counteract these threats.

Table 8. Conservation and Management Policies Associated with the Competitive (ST) Strategy

Strategy	Policy
Strategy S4T4: **Legal Consolidation and Spatial Protection of Gardens Against Development Pressures**	- Consolidation of garden boundaries and land-use designations in property records, urban development plans, and higher-level planning documents. - Enforcement of regulations governing land-use conversion and the subdivision of gardens in areas subject to development pressure. - Designation of protective buffer zones around gardens adjacent to residential, service, and tourism areas. - Development of legal and economic incentives for owners committed to maintaining garden land use. - Strengthening of enforcement mechanisms and deterrents against garden destruction and unauthorized land-use conversion.
Strategy S5T1: **Ecological Conservation of Strategic Gardens and Peri-Urban Areas**	- Assessment and zoning of gardens based on their ecological significance, biodiversity, and contribution to landscape connectivity. - Designation of ecological conservation zones adjacent to highlands and environmentally sensitive natural areas. - Control of incompatible land uses in areas of high ecological value. - Restoration of native vegetation and enhancement of biodiversity in vulnerable gardens.

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	- Prioritization of strategic garden conservation within the spatial development framework of the Tehran urban region.
Strategy S2S4T6: Establishing Integrated Governance for the Management of Gardens within Tehran's Urban Periphery	- Establishment of cross-sectoral coordination mechanisms among institutions responsible for garden management, conservation, registration, and utilization. - Integration of spatial, cadastral, and management databases for gardens. - Harmonization of legal regulations and procedures concerning the conservation and land-use conversion of garden lands. - Establishment of a joint decision-making system for reviewing plans and requests for interventions in gardens. - Development of mechanisms for resolving institutional conflicts and clearly defining the responsibilities of relevant agencies.

Defensive strategies (WT) primarily aim to reduce the vulnerability of gardens by addressing managerial, institutional, and infrastructural weaknesses while simultaneously controlling external threats. These strategies are protective and preventive in nature, emphasizing the prevention of further degradation, abandonment, land-use conversion, and loss of the ecological capacity of gardens.

Table 9. Conservation and Management Policies Associated with the Defensive (WT) Strategy

Strategy	Policy
Strategy W2T1: Establishing a Preventive System for Controlling Garden Destruction and Land-Use Conversion	- Establishment of an integrated system for identifying and monitoring land-use changes in garden areas. - Identification of gardens at risk of destruction and prioritization of conservation measures. - Strengthening oversight of construction activities and land subdivision within garden areas. - Establishment of rapid-response mechanisms for detecting and addressing violations and unauthorized land-use conversions. - Strengthening coordination among responsible agencies in monitoring and controlling land-use changes.
Strategy W3T2: Reducing Vulnerability Arising from Garden Fragmentation and Abandonment	- Organization of ownership structures and establishment of integrated management mechanisms for small and fragmented gardens. - Provision of economic incentives to prevent garden abandonment and gradual sale of garden plots. - Support for the establishment of cooperatives comprising garden owners and operators. - Facilitation of collaborative management and utilization of small and fragmented plots. - Development of legal and economic mechanisms to maintain the spatial continuity of garden lands.
Strategy W5T3:	- Prioritization of the rehabilitation and upgrading of irrigation infrastructure in vulnerable gardens.

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Reducing the Infrastructural and Water-Related Vulnerability of Gardens	- Reduction of dependence on high-risk water sources through diversification of sustainable water supplies. - Rehabilitation of existing qanats and water conveyance and distribution networks. - Development of water-efficient irrigation systems and improvement of irrigation efficiency. - Establishment of emergency water-supply plans for gardens during periods of drought. - Provision of financial and technical support to owners for the maintenance and rehabilitation of water infrastructure and gardening facilities.

5. Results and Discussion

5.1. Final Prioritization of Strategies Using QSPM

Following the formulation of the four strategic categories derived from the SWOT analysis, the Quantitative Strategic Planning Matrix (QSPM) was employed to determine the final priorities and identify the most suitable strategies for the sustainable management of gardens within Tehran's urban periphery. At this stage, the key internal and external factors identified through the SWOT framework, together with their relative weights derived from the Analytic Hierarchy Process (AHP), provided the basis for evaluating the formulated strategies.

For each strategy, its relative attractiveness in relation to the key factors was assessed using Attractiveness Scores (AS). The Total Attractiveness Score (TAS) for each factor was then calculated by multiplying its weight by its corresponding Attractiveness Score. The scores across all factors were subsequently summed for each strategy. Finally, the strategies were ranked according to their overall Total Attractiveness Scores, with those receiving higher scores identified as the research's priority strategies. The results of this stage provided the basis for selecting and presenting the proposed strategies for the sustainable management of gardens within Tehran's urban periphery.

Table 10. Attractiveness Scores (AS)

NO.	SWOT	Weighted Score	S2O1	S5O2	S5O5	W1O1	W2O2	W3O5	S4T4	S5T1	S4T6	W2T1	W3T4	W1T6
1	S2	0.3314	4											
2	S5	0.2210	2	4	4					4				
3	S4	0.1713				3			4		4		2	3
4	W2	0.3515					4				3	4		
5	W3	0.2205						4					4	
6	W1	0.1433				4		3	3					4
7	O1	0.3276	4			2								
8	O2	0.2059		4			2			3				
9	O5	0.1914			4			4						
10	T1	0.4227		3						4		4		
11	T4	0.2610			3				4			3	4	
12	T6	0.1373					3				4			4

Table 11. Total Attractiveness Scores (TAS) and Ranking

Score	Strategy		Category	TAS
1	W2T1	Preventive Control of Land-Use Change	WT	3.8798
2	S5T1	Ecological Conservation	ST	3.1925

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3	S2O1	Water Resource Rehabilitation	SO	3.0780
4	S5O2	Ecological Connectivity	SO	2.9757
5	S5O5	Economic Diversification	SO	2.4326
6	S4T6	Integrated Governance	ST	2.2889
7	W3T4	Fragmentation and Land-Use Change	WT	2.2686
8	W2O2	Local Participation	WO	2.2297
9	S4T4	Spatial and Legal Protection	ST	2.1591
10	W3O5	Integrated Utilization	WO	2.0775
11	W1O1	Ownership Organization	WO	1.7423
12	W1T6	Ownership Clarification for Institutional Coordination	WT	1.6363

To determine the final priorities of the strategies, the Quantitative Strategic Planning Matrix (QSPM) was applied to all twelve strategies. In Table 10, Attractiveness Scores (AS) were assigned on a scale of 1 to 4, exclusively to factors influencing the strategy under consideration: a score of 4 was assigned to a direct influence (i.e., a factor explicitly included in the strategy code), 3 to a strong indirect influence, and 2 to a weak indirect influence. Three factors were scored for each strategy to ensure that the number of factors did not affect the results. The Total Attractiveness Score (TAS) for each strategy was calculated by summing the products of each factor's AHP weight and its corresponding Attractiveness Score.

As shown in Table 11, the preventive control of land-use change strategy (W2T1) ranked first, with a score of 3.8798. This result is consistent with the AHP weights, as T1, with a weight of 0.4227, was identified as the most significant threat, while W2 (weak local monitoring and protection mechanisms), with a weight of 0.3515, was identified as the most significant weakness. This strategy directly addresses both factors. The ecological conservation strategy (S5T1) ranked second, with a score of 3.1925, while the rehabilitation and sustainable utilization of water resources strategy (S2O1) ranked third, with a score of 3.0780. Notably, both top-ranked strategies address the most significant threat (T1), indicating that controlling land-use change is the central priority for managing gardens within Tehran's urban periphery. The third-place ranking of S2O1 also highlights water supply as a prerequisite for the continued use of land for gardening. The ecological connectivity strategy (S5O2), with a score of 2.9757; the economic diversification strategy (S5O5), with a score of 2.4326; and the establishment of integrated governance for garden management strategy (S4T6), with a score of 2.2889, ranked fourth, fifth, and sixth, respectively. At the strategic-group level, the average scores were 2.8288 for aggressive (SO) strategies, 2.5949 for defensive (WT) strategies, 2.5468 for competitive (ST) strategies, and 2.0165 for conservative (WO) strategies. The SO group ranked clearly highest, with all three of its strategies appearing among the top six. This indicates that existing capacities, particularly water resources and the ecological value of gardens, provide the primary foundation for implementing management strategies. The WT group ranked second, although its scores showed considerable variation: W2T1 ranked first overall, whereas W1T6 ranked last. The small difference between the average scores of the WT and ST groups suggests that the sustainable management of gardens within Tehran's urban periphery requires a combination of leveraging existing capacities and mitigating external threats. The WO group had the lowest average score, indicating that strategies focused solely on addressing weaknesses by capitalizing on opportunities are insufficient, on their own, to counter the threat posed by land-use conversion pressures.

The W1T6 strategy (clarifying ownership status to facilitate institutional coordination), with a score of 1.6363, and the W1O1 strategy (organizing ownership structures and securing the legal status of gardens), with a score of 1.7423, ranked twelfth and eleventh, respectively. Their low

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rankings reflect the relatively low weights assigned to their associated factors: W1 was the least-weighted weakness, and T6 was the least-weighted threat. However, this does not imply that these strategies are unimportant. Clarifying the cadastral and ownership status of gardens provides the necessary foundation for implementing many of the other strategies and should therefore be pursued as a foundational measure alongside the priority strategies. Accordingly, strategies ranked first to third (W2T1, S5T1, and S2O1) are proposed as the primary priorities, while those ranked fourth to sixth (S5O2, S5O5, and S4T6) should be implemented in the subsequent phase as complementary strategies.

5.2. Sensitivity Analysis of the Results

To assess the robustness of the QSPM ranking, sensitivity analysis was conducted using two approaches. The first aimed to determine the extent to which the final ranking depended on two sources of uncertainty: AHP weights and Attractiveness Scores (AS). The weight of each factor was individually decreased and increased by 30%, resulting in 24 scenarios, and the strategy rankings were recalculated. Across all 24 scenarios involving individual weight changes (±30%), the preventive control of land-use change strategy (W2T1) retained its first-place ranking. The score difference between this strategy and the second-ranked strategy (S5T1) was 0.6873, representing a substantial margin relative to the overall score range. The third-place position shifted from S2O1 to S5O2 in only five scenarios: when the weight of S2 or O1 decreased by 30%, or when the weight of S5, O2, or T1 increased by 30%. This shift reflects the proximity of the scores of these two strategies (3.0780 and 2.9757). The greatest ranking change for an individual strategy was four positions, occurring when the weight of O5 increased by 30%; in most scenarios, ranking shifts did not exceed two positions.

The second approach examined simultaneous changes in the factors through a Monte Carlo simulation involving 20,000 iterations, in which the weights of all factors were randomly varied simultaneously within a range of ±30%. In this simulation, W2T1 ranked first in 92.5% of the iterations and appeared among the top three strategies in 99.8% of the iterations. S5T1 appeared among the top three in 96.8% of the iterations. To examine the effect of Attractiveness Scores, the indirect scores (3 and 2) were modified under three scenarios: assigning a value of 2.5 to both, assigning a value of 1 to both, and increasing the score of 3 to 4. In all three scenarios, W2T1 retained its first-place ranking, while Spearman's rank correlation coefficient between each revised ranking and the baseline ranking ranged from 0.881 to 0.967. Overall, W2T1 and S5T1 emerge as robust priorities, whereas the third-place position is sensitive to changes in factor weights and may alternate between S2O1 and S5O2. The intermediate rankings should therefore not be treated as definitive grounds for decision-making.

5.3. Discussion, Comparison of Findings with Previous Studies, and Implications for Management

The findings of this study indicate that the sustainable management of gardens within Tehran's urban periphery is a multidimensional issue that cannot be addressed solely through the imposition of legal restrictions or the physical protection of garden lands. The results of integrating SWOT and AHP demonstrate that, alongside the ecological and natural capacities of gardens, weaknesses in local monitoring and protection mechanisms and pressures arising from urban expansion are among the key factors affecting the condition of these areas. Furthermore, the QSPM results show that the preventive control of land-use change strategy (W2T1) ranks first, followed by the ecological conservation of strategic gardens (S5T1) and the rehabilitation and sustainable utilization of water resources (S2O1). These findings indicate that, from the experts' perspective, the management of gardens within Tehran's urban periphery should prioritize controlling the drivers of degradation, protecting ecological values, and ensuring the continuity of resources essential to horticultural activities.

The first-place ranking of the preventive control of land-use change strategy is consistent with the findings of Borhani et al. (2021), who examined the role of economic and political factors,

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the land and housing market, and development interventions in land-use changes in Tehran. This consistency suggests that, when land is subject to economic and development pressures, protecting gardens cannot be limited to establishing conservation regulations; rather, it requires effective monitoring mechanisms, the timely detection of land-use changes, and coordination among the responsible institutions. From this perspective, the managerial implication of the present finding is that reactive measures taken after destruction or land-use conversion should be replaced by a preventive system in which gardens at risk are identified, land-use changes are continuously monitored, and the responsibilities of relevant agencies in addressing violations are clearly defined. At the same time, implementing these policies should be accompanied by support for landowners and the provision of incentives to sustain horticultural activities, thereby preventing conflicts between legal protection and the potential for economically sustainable utilization.

The second-place ranking of the ecological conservation of strategic gardens strategy further highlights the importance of recognizing the role of gardens beyond their cultivated area or the economic value of their products. In their study of changes in Tehran's land surface urban heat island, Zargari et al. (2024) emphasized the relationship between the expansion of built-up areas, the reduction of vegetation cover, and the city's thermal dynamics. Similarly, Roshan et al. (2024) examined the relationship between land-use characteristics, vegetation cover, and the intensity of Tehran's urban heat island. Considered alongside the findings of the present study, these studies reinforce the need to conserve gardens in recognition of their role in the environmental structure of the urban region. However, findings from urban heat island studies alone do not establish the direct effect of individual gardens within Tehran's urban periphery on reducing the city's temperature. Rather, they demonstrate the broader importance of vegetation cover and the need to consider its spatial distribution in environmental planning. Accordingly, the managerial implication of this finding is to identify and zone gardens based on their ecological value, connectivity with natural areas, vegetation conditions, and vulnerability to development pressures. Such an approach can provide a basis for establishing conservation priorities and preventing the introduction of incompatible land uses in environmentally sensitive areas.

The third-place ranking of the rehabilitation and sustainable utilization of water resources strategy highlights the importance of water-resource constraints for maintaining garden land use. This finding is consistent with studies emphasizing the multifunctional nature of peri-urban agriculture and the need to assess its benefits and environmental constraints simultaneously (Mulya et al., 2023; Pereira et al., 2024). Furthermore, reviews of urban and peri-urban agriculture indicate that sustainability assessments of these lands should also account for resource consumption and the environmental consequences of their utilization (Al-Qubati et al., 2024). Accordingly, the rehabilitation of qanats and traditional water conveyance networks, improvements in irrigation efficiency, and assessment of the feasibility of using supplementary water sources are among the measures that could be considered within a sustainable garden management framework. However, the use of treated wastewater or other alternative water sources must be contingent on assessments of water quality, its suitability for the crops being cultivated, and compliance with public health and environmental requirements. Therefore, supplying water to gardens should not lead to increased withdrawals from unsustainable sources or the transfer of water stress to other sectors. Another important finding concerns the position of the strategy for strengthening the spatial and ecological connectivity of gardens, which ranked fourth. This finding is consistent with the principles of green infrastructure and landscape ecology, both of which emphasize the importance of spatial connections among natural and semi-natural patches, alongside the conservation of their area (Benedict & McMahon, 2006; Forman, 2014). Accordingly, garden conservation should not focus exclusively on individual plots; rather, their connections with river valleys, highlands, open

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spaces, and other natural features should also be incorporated into spatial planning. From an implementation perspective, this requires identifying ecological linkages, preventing fragmentation caused by infrastructure development, and incorporating high-value garden areas into the planning and management documents governing the green network of the Tehran urban region. At the same time, the precise delineation and prioritization of ecological corridors require reliable spatial data and specialized assessments; the formulation of a strategy alone cannot replace these evaluations.

The findings also indicate that economic diversification and the establishment of integrated governance, despite their managerial significance, ranked fifth and sixth, respectively. These rankings should not be interpreted as indicating that such measures are unnecessary, since the sustainable conservation of gardens depends not only on controlling threats but also on maintaining landowners' economic incentives and ensuring coordination among the responsible institutions. Studies on ecosystem services in peri-urban areas have likewise emphasized the need to integrate environmental, social, and economic considerations into policymaking and planning (Marshall et al., 2024). In addition, assessments of peri-urban agriculture scenarios indicate that the development of these activities may generate synergies or trade-offs among different ecosystem services, including food production, temperature regulation, and water consumption (Segura-Barrero et al., 2024). Therefore, the development of agritourism, local markets, and green jobs should be organized in accordance with the ecological capacity of each area, landowners' needs, and water-resource constraints, without encouraging new construction or increasing pressures on gardens. Furthermore, establishing inter-institutional coordination mechanisms, facilitating the exchange of spatial and cadastral information, and clearly defining implementation responsibilities can provide a basis for more coordinated implementation of conservation policies. From a management decision-making perspective, the QSPM results also highlight the need to distinguish between strategic priority and foundational necessity. For example, strategies for organizing ownership structures and clarifying cadastral status received lower rankings. Nevertheless, establishing the legal status of land can be a prerequisite for the effective implementation of certain conservation measures, enforcement of regulations, and provision of support to landowners. Accordingly, the lower ranking of these strategies does not necessarily mean that they can be entirely postponed; rather, it indicates that their relative attractiveness was lower than that of other strategies in the assessment. In practice, foundational legal and institutional measures should proceed in accordance with the requirements of implementing the priority strategies. On this basis, preventive control of land-use change can be considered the central focus of short-term intervention; ecological conservation and sustainable water management can serve as complementary priorities; and ownership organization, local participation, and institutional coordination can be treated as supporting conditions for implementation.

6. Conclusion

The sensitivity analysis results reported in this study also underscore the need for caution when interpreting the rankings. Based on the results presented in the previous section, the preventive control of land-use change strategy retained its first-place position across all the scenarios examined, whereas the third-place position showed greater sensitivity, alternating between the rehabilitation of water resources strategy and the strengthening of ecological connectivity strategy. If the calculations and supporting documentation for this analysis are verified, it can be concluded that the priority assigned to controlling land-use change is relatively robust, while the ranking of some intermediate strategies depends on factor weights and Attractiveness Scores. Therefore, the QSPM ranking should be interpreted as a decision-support tool rather than a substitute for spatial, economic, legal, and implementation assessments. Overall, comparison of the findings of this study with previous research indicates that the sustainable management of

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gardens within Tehran's urban periphery requires an integrated approach linking land-use conservation, protection of ecological values, water-resource management, the continuity of horticultural economic activities, and institutional coordination. The practical contribution of this study lies in providing a framework for translating identified factors into comparable and prioritized strategies. Nevertheless, these priorities are based on expert judgments and the factors and weights incorporated into the model. To translate them into an operational program, they must be supplemented by detailed spatial assessments, cost and financial resource evaluations, designation of responsible institutions, implementation schedules, and clearly defined monitoring indicators. Furthermore, the limited number of experts and the dependence of the results on expert judgments indicate that the proposed priorities should be examined in subsequent stages through broader participation by landowners, operators, local communities, and executive agencies. Accordingly, it is recommended that the findings of this study serve as a basis for developing a phased program for the conservation and management of gardens within Tehran's urban periphery. Such a program should pursue land-use change control, ecological conservation, and sustainable water supply alongside institutional reform and support for economically viable and environmentally compatible utilization.

7. Author Contributions

Both authors contributed equally to all stages of the research and manuscript preparation, with each author accounting for 50% of the total contribution.

8. Conflict of Interest

The authors declare that they have no conflict of interest regarding the publication of this article.

9. Acknowledgements

This study was financially supported by the Tehran Urban Planning and Research Center and was derived from the Knowledge City Report entitled "Policies for the Conservation and Management of Gardens within Urban Peripheries," authored by Pegah Moradi under the supervision of Ahmad Khalili. The study was updated through a revision of its theoretical foundations and published in autumn 2025 as Report No. 1091. The authors would like to express their gratitude to the Center for its support.

The authors also acknowledge the use of ChatGPT (GPT-6, OpenAI; accessed on November 10, 2026) as an AI-assisted tool for translating this article.

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