Explaining the Key components for realizing continuous productive urban landscapes based on urban agriculture in mid-sized cities with orchard and farmland potential (case study: Tonekabon, Iran)

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Abstract

Food security, environmental resilience, and public health are major urban-planning challenges. The Continuous Productive Urban Landscape (CPUL) links urban form, urban agriculture, and ecological infrastructure, yet its application in mid-sized cities with agricultural potential remains understudied. This study identifies and explains key components for realizing CPUL through urban agriculture, focusing on Tonekabon. This applied qualitative study draws on semi-structured interviews with ten experts, analyzed thematically using Braun and Clarke's approach. GIS analysis supported the identification of agricultural land and assessment of spatial continuity. Unlike the classical European CPUL model, which begins with vacant urban land, the findings emphasize protecting and connecting existing agricultural capacities across four physical-spatial, socio-cultural, environmental-health, and economic-governance. Expert consensus identified the neighborhood as the primary implementation scale. Surplus-water management and flood control were environmental priorities, while the economic viability of retaining agricultural land for smallholders was essential to sustainability. These dimensions form a reinforcing cycle. The study was constrained by incomplete descriptive data, limited land-ownership statistics, and outdated base maps and shapefiles. A conceptual productive green-blue network for Tonekabon is proposed, comprising production cores, a connecting axis, a linkage ring, and socio-economic nodes. It offers a preliminary framework for mid-sized cities with similar conditions.

Keyword: Continuous Productive Urban Landscape (CPUL), Thematic Analysis, Tonekabon, Urban Agriculture

1.Introduction

Cities, as the primary centers of population concentration, face escalating challenges regarding food security, environmental resilience, and public health. Urban dependency on food imports has rendered them vulnerable to supply chain disruptions (Xie et al., 2025). Quantitative evidence

also demonstrates that urban agriculture's potential on a trans-national scale is remarkable; for instance, it has been estimated that low-tech vegetable cultivation in hundreds of European cities can cover a significant portion of urban demand (Svintsov et al., 2026). A similar challenge has been observed in the metropolis of Wuhan, China, where urban sprawl transformed green and productive peri-urban landscapes into enclosed residential complexes, simultaneously creating dual crises of water management and food security for local residents—a problem clearly manifested during the COVID-19 lockdowns (Nuanla-or & Xu, 2024). Meanwhile, the Continuous Productive Urban Landscape (CPUL) has emerged as a novel approach that, beyond food production, fulfills multiple functions including enhancing citizens' physical and mental health, increasing physical activity, fostering social interactions, supporting urban circular economies through green waste recycling, and reinforcing local food supply chains (Hino et al., 2023; Iida et al., 2024). Urban food self-sufficiency depends on production capacity, cultivation structure, and the strategic design of productive spaces (Xie et al., 2025). Within this geographical framework, mid-sized cities with orchard and farmland potential refer to settlements whose physical fabric has an organic bond with productive patches and agricultural heritage, acting as a connective link between surrounding biomes and the urban network (Jiang & Zhang, 2023).

Urban agriculture is recognized as a strategic pathway toward achieving sustainable food security and urban resilience, which requires local governance, public policy, cross-sectoral collaboration, innovation, and appropriate regulatory frameworks (Gunapala et al., 2025). Featuring tea and citrus orchards, fertile riverside lands, and agritourism potential, Tonekabon holds high potential for developing productive urban landscapes; however, the weakness of functional linkage between integrated productive landscapes, urban agriculture, and urban form, along with the neglect of the neighborhood scale and the dominance of a physical-engineering approach over socio-cultural dimensions, has created a distinct research gap. In Tonekabon, despite a rich history of citrus orcharding, tea cultivation, and paddy farming, rapid physical expansion, peri-urban construction, and land fragmentation have caused ecological disconnections between the river network (particularly the Cheshmeh-Kileh River) and production zones. The prevailing approach in urban development plans treats intra-urban and fringe orchards and farmlands merely as potential reserves for physical development, neglecting their structuring role as productive infrastructure. On the other hand, scattered urban agriculture initiatives lacking spatial connectivity, hydrological integration, and ties to public spaces fail to achieve the efficiency and resilience needed against land-use changes. The core gap is that existing CPUL frameworks, which essentially evolved in Western metropolitan contexts featuring public lands or vacant spaces, do not adequately address the unique characteristics of northern Iran's mid-sized cities with smallholder ownership structures and seasonal flood flows. Therefore, this study seeks to answer a key question: What are the key components for realizing an integrated productive urban landscape (CPUL) based on urban agriculture within the ecological, physical, and ownership context of Tonekabon, and how do these components link within a synergistic spatial-institutional model featuring reciprocal feedback mechanisms?

In response to this question, the fundamental objective of this study is to identify and explain the key components for realizing an integrated productive urban landscape in orchard and farmland contexts of mid-sized cities (Case Study: Tonekabon) and to formulate an integrated spatial-institutional model governing them. This aims to clarify the pathway from isolated agricultural patches to a continuous productive urban network by elucidating circular linkages and synergistic feedback loops among physical, ecological, socio-institutional, and economic dimensions.

2.Domestic and International Research Background

In recent years, urban agriculture has gained attention as a key strategy for ensuring sustainable food security and strengthening urban resilience. Gunapala et al. (2025), drawing on a theoretical approach and library studies, demonstrated that urban agriculture can serve as a strategic pathway

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for responding to pressures arising from urbanization, food insecurity, and livelihood vulnerability, emphasizing the role of local governance, public policy, collaboration, innovation, and regulatory frameworks in achieving this objective (Gunapala et al., 2025). In the same vein, Xie et al. (2025), employing spatio-temporal modeling and the assessment of various cultivation scenarios over the 2003–2021 climatic period, estimated local food self-sufficiency in Amsterdam and found that productive green roofs—if strategically designed with attention to crop rotation and climatic conditions—can strengthen local food supply chains and enhance urban resilience; they also stressed the necessity of integrating circular economy thinking and the recycling of water and nutrients (Xie et al., 2025).

In a comparative study, Huan et al. (2026), by analyzing urban agriculture policies in Havana, New York City, and Chongming Island, demonstrated that the landscape-based approach, compared to human-centered and nature-centered approaches, achieves a better balance among ecological function, social inclusion, governance, spatial integration, and temporal resilience (Huan et al., 2026). Schaan et al. (2025), adopting a multi-scale spatial planning approach based on QGIS analysis, proposed a policy-oriented and flexible method for the restoration and prioritization of landscape features in agricultural zones, which can support strategic planning in these areas (Schaan et al., 2025). Marat-Mendes et al. (2020), by examining urban agriculture practices in Lisbon and linking food-system analysis with urban planning tools, showed that the Continuous Productive Urban Landscape enables the analysis of urban agriculture not merely as food production but also from social, ecological, and spatial perspectives, expanding the scope of food-system analysis in metropolitan planning (Marat-Mendes et al., 2020). In another study, Khalilnezhad et al. (2025), focusing on the urban park scale and adopting a degrowth transition approach, examined landscape architecture strategies for developing urban agriculture; they demonstrated how urban park spaces can serve as a platform for ecological regeneration, local production, and physical sustainability (Khalilnezhad et al., 2025).

Nuanla-or and Xu (2024), focusing on the peri-urban areas of Wuhan, China, showed that national urban water management programs (such as the Sponge City program) are mainly confined to intra-urban areas and lack a framework for planning and designing productive agricultural landscapes in peri-urban regions; by introducing the concept of Nature-based Solutions (NbS) as an umbrella concept, their study offered a design-oriented framework for preserving productive landscape communities that simultaneously considers food security, local identity, and social health (Nuanla-or & Xu, 2024). Viljoen and Bohn (2020), in a conceptual and design-oriented discussion drawing on the case studies of Heidelberg and Tokyo's Nerima district, demonstrated that productive peri-urban landscapes can contribute to climate adaptation and impact reduction, biodiversity conservation, and the enhancement of urban quality of life, presenting urban and peri-urban agriculture as a tool for sustainable development (Viljoen & Bohn, 2020). At a more overarching level, Antunes et al. (2026), in a theoretical discussion of the Continuous Productive Urban Landscape (CPUL) framework, articulated it as a planning concept for green infrastructure with a food-production function, emphasizing the physical continuity of peri-urban green spaces, connected networks, and the preservation of food production as far as possible; from their viewpoint, the integration of urban and peri-urban agriculture into green infrastructure is vital for food security, resilience, and social justice (Antunes et al., 2026).

A review of domestic research indicates that attention to productive urban landscapes and urban agriculture is expanding in Iran's scientific literature, although such studies have largely remained at the level of theoretical foundations or case studies of specific fabrics. Sanjari et al. (2022 and 2023), in their studies, articulated the Continuous Productive Urban Landscape framework as a theoretical foundation for urban green infrastructure planning, emphasizing components such as the physical continuity of peri-urban green spaces, interconnected networks, multifunctionality, and the preservation of the food-production function. They introduced the productive urban

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landscape not merely as a tool for food production but as a multifunctional infrastructure serving food security, resilience, social justice, and ecological services, highlighting the link between nature and urban structure through the idea of a nature-based productive city. In the same vein, Khazaee and Babajani (2024), by examining the evolution of urban agriculture in Iran, analyzed the environmental, social, economic, and food-security functions of this approach and demonstrated that urban agriculture can serve as a tool for reducing food insecurity, improving urban environmental quality, and supporting sustainable urban development (Khazaee & Babajani, 2024).

At a more applied level, Hassandaie et al. (2025), adopting a descriptive-analytical and qualitative approach based on library and field studies, formulated urban design guidelines for realizing the Continuous Productive Urban Landscape within the historic fabric of Shiraz. Through a case study of Seyyed Zolfaghar Passage, they identified spaces suitable for urban agriculture using survey methods and, employing GIS-based spatial analysis, transformed design patterns into strategies, policies, and implementation regulations. Their findings indicate that the CPUL framework can function as a planning and design model in historic urban fabrics, playing a role in responding to challenges such as climate change, food insecurity, and environmental pollution by creating productive open spaces; they also emphasized that the successful realization of this approach depends on cross-sectoral collaboration among urban management, local communities, and relevant stakeholders (Hassandaie et al., 2025).

In another quantitative study, Rahimi et al. (2025), by analyzing Landsat satellite images over half a century (1972 to 2022), examined the gradual decline of urban and peri-urban agricultural lands in the city of Marivan in connection with the city's physical growth and demonstrated that, despite this declining trend, climatic potentials, water resource management, the commercialization of agricultural products, and the municipality's preventive policies have managed to preserve a significant portion of these lands as a new model for the development of urban green space (Rahimi et al., 2025).

Table 1. Summary of Domestic and International Research Related to Productive Urban Landscape and Urban Agriculture

No.	Researcher(s) and Year	Research Context and Methodology	Most Important Findings and Contributions
1	Gunapala et al. (2025)	International / Library Review	Defining urban agriculture as a strategic response to food insecurity and livelihood vulnerability.
2	Xie et al. (2025)	Amsterdam / Spatio-temporal Modeling	The role of productive green roofs in food self-sufficiency and resilience through circular economy and water recycling.
3	Khalilnezhad et al. (2025)	Urban Park Scale / Landscape Architecture	Presenting landscape architecture strategies for urban agriculture toward a degrowth transition and ecological regeneration.
4	Huan et al. (2026)	Havana, New York, and Chongming / Comparative Analysis	The effectiveness of the landscape-based approach in balancing ecology, social inclusion, and resilience.
5	Schaan et al. (2025)	Regional Scale / QGIS Analysis	Formulating a policy-oriented framework for restoring landscape features in agricultural zones.
6	Marat-Mendes et al. (2020)	Lisbon / Food System Analysis	Application of CPUL for a multidimensional (social, spatial, ecological) analysis of urban agriculture.
7	Nuanla-or & Xu (2024)	Wuhan, China / NbS-based Design	Presenting a design framework integrating food security, social health, and local identity in peri-urban areas.
8	Viljoen & Bohn (2020)	Heidelberg and Tokyo / Analytical & Design-oriented	Explaining the role of productive peri-urban landscapes in climate adaptation and sustainable urban development.
9	Antunes et al. (2026)	Theoretical Foundations / Conceptual Framework	Defining CPUL as a continuous and multifunctional green infrastructure serving

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No.	Researcher(s) and Year	Research Context and Methodology	Most Important Findings and Contributions
			social justice.
10	Sanjari et al. (2022–2023)	Iran / Descriptive-Analytical	Introducing the nature-based productive city and explaining CPUL for ecological services and food security.
11	Khazaee & Babajani (2024)	Iran / Trend Analysis	Examining the fourfold functions of urban agriculture in achieving sustainable development.
12	Hassandaie et al. (2025)	Historic Fabric of Shiraz / Mixed + GIS	Formulating implementation regulations for realizing CPUL in historic fabrics and emphasizing stakeholder participation.
13	Rahimi et al. (2025)	Marivan / Quantitative & Landsat Analysis (50-year)	Assessing the transformation trend of agricultural lands and the importance of urban conservation policies.

The synthesis of domestic and international studies shows that productive urban landscapes and urban agriculture are recognized as a multifunctional system beyond mere food production, playing a role in promoting food security, ecological services, social interactions, public health, circular economy, and climate resilience. The CPUL framework has also been emphasized as the linking ring between physical connectivity, green infrastructure, food production, and multifunctionality. However, a review of the background reveals that existing research has largely remained either at the level of theoretical foundations and conceptual frameworks (such as Sanjari et al.) or has limited its practical application to metropolises and historic fabrics (such as Hassandaie et al. in Shiraz). Consequently, the gap regarding providing an indigenous and place-based model for mid-sized cities with orchard and agricultural capacity, such as Tonekabon, which can identify and explain the key components of realizing an integrated productive urban landscape in connection with the spatial and physical structure of the city and present a model for it, still remains. The present study has been formed in response to this very gap.

1.2. Theoretical Foundations

Continuous Productive Urban Landscape and Urban Agriculture

The growing expansion of urbanization and the consumption-oriented urban lifestyle have increased food demand and, at the same time, weakened the balance between city and nature by reducing the production of organic food; conditions that reveal the necessity of planning for urban food systems and rethinking the link between the physical structure of the city and food production. In response to this challenge, the concept of the Continuous Productive Urban Landscape (CPUL) is introduced as a novel approach that establishes a link among urban form, agricultural production, and ecological infrastructure; although CPUL primarily emphasizes continuity at the city-region scale and its localization at the neighborhood scale has been less examined, its operational localization in specific urban fabrics still requires investigation, and the present study seeks to develop these dimensions at the neighborhood scale (Viljoen & Bohn, 2020; Marat-Mendes et al., 2020). The fundamental characteristic of this approach is its multifunctionality. The productive urban landscape is not limited solely to food provision, but simultaneously enhances the physical quality of the city, supports social participation, strengthens local livelihoods, and contributes to enhancing urban resilience (Marat-Mendes et al., 2020; Sanjari et al., 2023). Another pillar of this concept is the continuity of green space; meaning that orchards, agricultural lands, vacant intra-urban lands, and neighborhood spaces are connected to one another within a continuous network, establishing continuity between productive urban and peri-urban realms (Antunes et al., 2026; Sanjari et al., 2022). Within this framework, the concept of integration, going beyond a superficial link, entails three distinct and intertwined dimensions: first, spatial-physical integration, meaning the physical connection and linear continuity of scattered urban patches and orchards through green corridors and river margins; second, functional integration, meaning the multifunctionality of space and the simultaneous combination of food production, ecological management (flood control), and active recreation; and third,

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institutional integration, meaning horizontal coordination and cross-sectoral cooperation among governing institutions (especially the municipality and the Agricultural Jihad) in the protection and management of these zones (Viljoen & Bohn, 2020).

Accordingly, the theoretical foundations of CPUL can be organized into five main dimensions, which provide an appropriate conceptual framework for analyzing and explaining its components: the health dimension, the economic dimension, the social dimension, the environmental dimension, and the physical dimension.

In the present study, these five dimensions extracted from the theoretical literature were employed as a guiding framework for formulating the interview axes. However, during the process of collecting and analyzing the field data of Tonekabon, given the close linkage of environmental components with citizens' health on the one hand, and the deep entanglement of the economic issues of lands with institutional mechanisms and management regulations on the other, these dimensions were reorganized through the iterative process of thematic analysis into four final integrated dimensions: (1) physical-spatial, (2) socio-cultural, (3) environmental and health, and (4) economic and governance.

These four dimensions show that the Continuous Productive Urban Landscape is a multilayered phenomenon whose effects are simultaneously reflected in public health, the local economy, social cohesion, ecological quality, and the spatial structure of the city (Sanjari et al., 2023; Khazaee & Babajani, 2024). This definition is consistent with the official definition of the U.S. Department of Agriculture, which regards urban agriculture as including community gardens, rooftop farms, hydroponic/aeroponic/aquaponic facilities, and vertical cultivation, and places it within the official legal framework (the 2018 Farm Bill) (Murugesan, 2024).

In the literature, urban agriculture approaches can be formulated within three distinct paradigms: the human-centered approach, prioritizing food security and social justice at the neighborhood scale; the nature-centered approach, prioritizing ecological restoration at the corridor or city scale; and the landscape-based approach, which integrates these two across all scales and through cross-sectoral governance (Huan et al., 2026).

Urban agriculture, as the driving engine for realizing this landscape, consists of the production, cultivation, processing, and distribution of food and other products through the growing of plants and the raising of livestock within or on the margins of cities to respond to residents' needs. This approach, beyond being a productive activity, is regarded as a mechanism for reconnecting humans with nature and re-linking citizens to the process of local food production (Khazaee & Babajani, 2024; Gunapala et al., 2025). However, to avoid conceptual confusion, the distinction between these two concepts is necessary: urban agriculture is defined as content and functional activity (with its specific components of food production, crop diversity, local horticulture, and small-scale livelihoods) that can occur in scattered patches; whereas the Continuous Productive Urban Landscape (CPUL) acts as the container and the physical-ecological substrate (with its essential components of spatial continuity, the green-blue network, and connective corridors). Thus, urban agriculture is the functional driving engine, while CPUL constitutes the spatial structure that organizes it. Like CPUL, urban agriculture is also a multifunctional approach, and its functions can be analyzed within the same five dimensions of health, economic, social, environmental, and physical.

In the environmental dimension, urban agriculture plays a role by enhancing ecological quality, supporting biodiversity, contributing to climate adaptation, and reducing the impacts arising from food transportation. In this regard, the recycling of green waste and the link between waste production and compost consumption pave the way for the formation of decentralized biological cycles and the city's circular metabolism (circular economy) (Xie et al., 2025; Sanjari et al., 2022). In the social dimension, the strengthening of social interactions, the increase of neighborhood participation, and the reconnection of people with nature are highlighted, and in the economic dimension, reducing the cost of food provision, strengthening local supply chains, supporting livelihoods, and the potential for tourism gain importance (Gunapala et al., 2025).

Among these functions, food security holds a special place; because urban agriculture reduces cities' dependence on importing food from beyond urban borders, improves urban food self-

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sufficiency, and strengthens resilient local supply chains against price fluctuations and supply shocks; a matter that gains particular importance especially for cities under the pressure of urbanization and climatic tensions (Gunapala et al., 2025; Xie et al., 2025). The realization of these functions takes place in diverse species and forms of urban agriculture, including urban gardens, home gardens, urban farms, vertical cultivation, the productive use of vacant lands and neighborhood spaces, and peri-urban agriculture. Among these, productive green roofs have been specifically emphasized as an effective strategy for enhancing urban food self-sufficiency (Xie et al., 2025). When these scattered productive spaces are connected to one another and integrated into the physical structure of the city, the ground is prepared for the formation of a Continuous Productive Urban Landscape (Antunes et al., 2026; Marat-Mendes et al., 2020).

Conventional green-blue infrastructures generally focus on stormwater runoff management, flood control, the protection of water margins, and the enhancement of landscape aesthetics with a recreational use, and are often regarded as costly structures that consume resources for maintenance. In contrast, the concept of the productive green-blue network, which in this research is explained as the operational mechanism for implementing CPUL in the city of Tonekabon, possesses two central distinctive characteristics: first, a synergistic productive-ecological function, such that urban waterways and stream channels (such as Cheshmeh Kileh) are not only flood conduits but also suppliers of water to agricultural lands and peri-urban farms; and second, livelihood and social productivity, in which river-margin corridors, marginal orchard lands, and green movement routes simultaneously provide a platform for local markets, agricultural tourism, and small-scale employment. Thus, this network transforms the ecological structure of water and vegetation from a passive role into an active, productive, and stabilizing driver.

In this regard, the realization and implementation of this landscape model in mid-sized cities entails a different planning logic compared to metropolises. Based on specialized definitions and the literature of urban development, mid-sized cities are centers with a specific population size (generally in the range of 50,000 to 250,000 people) that play a connecting and mediating role (the interposition position) between metropolises/regional centers and the surrounding rural settlements, and are regarded as the main center of exchange of goods, services, and regional support (Hossein Abadi, 2026). This definition is also aligned with Iran's planning literature; within this literature, mid-sized cities functionally occupy an intermediate position between small settlements and metropolises and are mainly classified on the basis of population size (Ghadiri, 2014). In the classification of the national land-use planning (Amayesh) basic plan studies, cities of 50,000 to 100,000 inhabitants are counted as "medium-small" and cities of 100,000 to 250,000 inhabitants as "medium to large" (Plan and Budget Organization, 1985; cited in Ghadiri, 2014). Accordingly, in the present study, a mid-sized city refers to a city with a population of 50,000 to 250,000 and an intermediate role between surrounding rural settlements and larger centers (Hossein Abadi, 2026; Ghadiri, 2014).

Also within this theoretical framework, the concept of the orchard-agricultural capacity of mid-sized cities is operationally defined on the basis of three structural indicators: first, the share and extent of productive green zones, such that the major part of the inner fabric and the immediate margin of the city consists of active agricultural and orchard lands; second, the diversity and sustainable function of the cultivation pattern (such as the integration of horticulture and intensive cultivation dependent on natural water networks); and third, the antiquity and livelihood-identity continuity in which small-scale agricultural production and horticulture constitute an inseparable part of the economic structure and the collective memory of native residents. The aggregation of these three indicators prepares the ground for the functional redefinition of mid-sized cities on the axis of safeguarding and integrating existing agricultural lands.

3.Methodology

The present research is applied in terms of its objective and has a qualitative approach in terms of its nature, and spatial analysis (GIS) has been used to support the findings. The research strategy is thematic analysis based on the approach of Braun and Clarke (2006). The selection of this strategy aligns with the nature of the research, as the goal is not merely to list components, but to

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discover the relationships among them and explain a coherent model for mid-sized cities with orchard and agricultural capacity. The research participants consist of experts and specialists in the fields of urban planning, landscape architecture, environment, urban agriculture, and urban management, who were selected using purposeful and snowball sampling methods, and the sampling process continued until theoretical saturation was achieved. Data collection was carried out through three complementary sources: in-depth semi-structured interviews as the main tool; documentary studies, including the theoretical literature on CPUL, urban development plans for Tonekabon, and related higher-level documents; and field observation in the agricultural areas, orchards, and productive spaces of Tonekabon city to gain a deeper contextual understanding of spatial capacities and limitations.

In this process, documentary data (including functional statistics and land-use change data from the Agricultural Jihad management and zoning regulations from Tonekabon's urban development documents) and evidence from field observations (examining the actual condition of the Cheshmeh Kileh river corridor and the distribution of small orchards) were used as the basis for triangulating sources to refine interview questions and then to match and verify the extracted themes with the realities of the field.

Data analysis was conducted in six stages according to Braun and Clarke: (1) deep familiarization with the data through repeated reading of interview transcripts; (2) systematic generation of initial codes; (3) searching for themes within the generated codes; (4) reviewing and revising themes to ensure internal coherence and external distinction; (5) precise definition and naming of themes; and (6) preparation of the final report with interpretation and explanation of themes in relation to the research question. The final output of this process is a conceptual model that explains the key components of the Continuous Productive Urban Landscape and the relationships among them in the context of mid-sized cities with orchard and agricultural capacity. Furthermore, to objectify and spatially assess the components in Tonekabon city, the Geographic Information System (GIS) was utilized; in such a way that after preparing and standardizing the four layers (accessibility, land-use structure, spatial coherence, and developability), the synthesis map and the final zoning of the suitability for the establishment of the productive urban landscape were extracted by implementing a weighted overlay model. The use of weighted overlay of layers in GIS, along with expert-based weighting, has also been employed in domestic research for urban agriculture site selection (Hajilu & Haghlesan, 2026). The validation of findings was carried out based on Lincoln and Guba's four criteria (1985): credibility through member checking and data source triangulation; transferability through rich and detailed descriptions of the study context; dependability through accurate documentation of the analysis process; and confirmability through an audit of the coding process by a research associate. In line with the research methodology, data obtained from interviews with 10 expert participants (including managers from the municipality, Agricultural Jihad, the Engineering Organization, and university faculty members) were analyzed based on Braun and Clarke's six-stage model. The coding process continued until the tenth interview; such that from the ninth interview onwards, no new themes or codes emerged, indicating the achievement of theoretical saturation. Also, to maintain the confidentiality of the experts' identities, codes M1 to M10 were used. For standardizing the reporting of findings, a quantitative measure of expert agreement was defined separately: complete consensus (10 out of 10 experts; 100%), high consensus (8 to 9 out of 10 experts; 80% to 90%), and majority (6 to 7 out of 10 experts; 60% to 70%) were considered as the basis for analysis.

The selection of participants was based on four purposeful competency criteria, including having expertise and overlapping knowledge in the fields of urban planning, landscape architecture, agriculture, and environmental sciences, possessing at least five years of work experience (executive, research, or supervisory) within the Tonekabon city and county, achieving balance and institutional diversity among urban management, Agricultural Jihad, the private sector, and academia, and being directly involved with issues of land-use change, urban development, and orchard management.

Table 2. Characteristics of Participants and the Process of Reaching Theoretical Saturation

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No.	Code	Expertise / Position	Organization / Institution	Experience (Years)	Interview Date	Duration (Min)	Venue	New Codes
1	M1	Technical Director of Municipality	Tonekabon Municipality	4	May 2025	60	Tonekabon Municipality	18
2	M2	Ph.D. in Urban Planning, Architecture & Environment	University	11	June 2026	70	Faculty of Art and Architecture	13
3	M3	Urban Planning Specialist	Private Sector / Consulting Engineers	9	June 2026	50	Engineering Office	10
4	M4	M.Sc. in Agriculture	Private Sector / Plant Clinic	8	June 2025	55	Workplace	8
5	M5	Plant Protection and Horticulture Expert	Tonekabon Agricultural Jihad Directorate	12	July 2026	65	Agricultural Jihad Office	6
6	M6	Land Affairs, Water and Soil Expert	Tonekabon Agricultural Jihad Directorate	10	August 2025	45	Agricultural Jihad Office	5
7	M7	Urban Planning Engineer	Tonekabon Construction Engineering Organization	7	August 2026	50	Engineering Organization Office	3
8	M8	Associate Professor and Agricultural Faculty Member	University	7	September 2025	60	University	1
9	M9	M.Sc. in Urban Planning	Tonekabon Municipality	6	September 2026	45	Tonekabon Municipality	0
10	M10	M.Sc. in Agriculture with Executive Experience	Private Sector / Orchardists Cooperative	5	October 2025	50	Cooperative Office	0

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This multi-stakeholder composition enabled the triangulation of perspectives from different institutional angles (executive, technical, academic, and consultative), contributing to the credibility of the findings. Although the research's analytical framework encompassed four dimensions and a diverse range of components, the generation of conceptual codes reached zero in the ninth and tenth interviews, achieving theoretical saturation. The reason for this was the high convergence and shared understanding among experts regarding fundamental issues in Tonekabon city, such as the crisis of construction in orchards and stormwater management. Furthermore, conducting initial interviews with key and experienced individuals led to the formation of the main structure of the thematic network with sixty initial codes within the first six interviews, while interviews seven through ten played a role in consolidating and verifying the pattern.

3.1.Study Area

The realization of a continuous productive urban landscape depends, first and foremost, on understanding the environmental and agricultural capacities of its spatial setting; therefore, prior to analyzing the components, it is necessary to explain the geographical location, climatic

characteristics, and agricultural potential of the study area. Tonekabon County (Shahsavar) is one of the counties of Mazandaran Province in northern Iran, bounded to the north by the Caspian Sea, to the west by Ramsar County, to the east by Abbasabad and Chalus counties, and to the south respectively by the plain, villages, forests, and then the Alborz heights (Mashayekhi, 2001). This county holds a special governorate status, and its center is the city of Tonekabon. Based on the latest census (2016), the total population of the county was 166,132, and with an area of about 2,140 square kilometers, it is the largest county in western Mazandaran Province after Chalus.
From a climatic perspective, the average elevation of the region is about 18 meters above free sea level, and its special location at the interface between the Caspian Sea and the Alborz mountain range, along with its distance from the subtropical high-pressure center, has created favorable weather conditions with relatively warm summers and mild winters (Abolhasaninejad, 2003). This intermediate position, serving as a connecting link between Gilan and Mazandaran provinces, has endowed Tonekabon with natural landscapes, water-rich rivers, and verdant mountains. In terms of agricultural capacity, Tonekabon has historically been a major center for rice production and products such as silk fabrics and Alijeh (Mashayekhi,2001). Possessing agricultural and orchard lands, favorable natural conditions, and agricultural landscapes, this area has transformed into a suitable platform for the development of agritourism and, beyond that, the realization of a continuous productive urban landscape a capacity whose precise understanding provides the basis for identifying and prioritizing the key components of the present research.

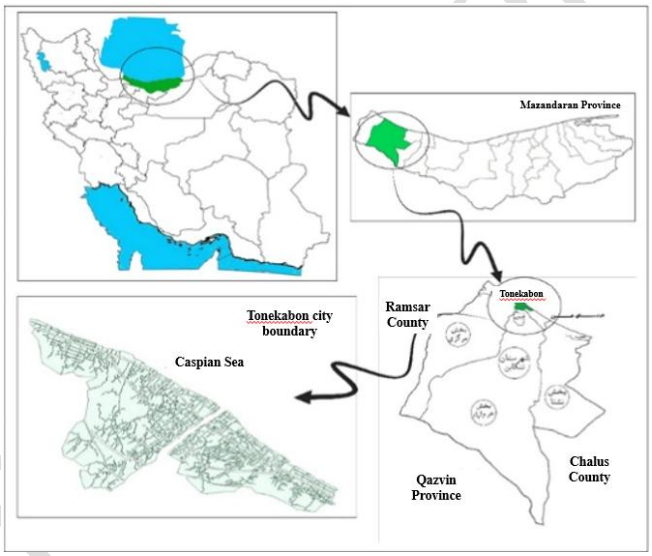


Figure 1. Geographical location of the study area

Based on the results of the 2016 Population and Housing Census, the population of Tonekabon city was 55,434 (Statistical Center of Iran, 2016), which falls within the 50,000–250,000 range defined in the theoretical framework section, placing it in the "medium-small" category (50,000–100,000). In addition to the demographic criterion, Tonekabon is classified as a mid-sized city due to its intermediary role between provincial centers and the rural settlements of western Mazandaran. The attribution of orchard-agricultural capacity to this city is also based on three operational indicators:

1. **High share of lands:** more than 40% of the city area and its immediate margin being allocated to orchards and active agricultural lands;
2. **Diversity of cultivation:** the simultaneous presence of citrus orchards, tea fields, kiwi orchards, and paddy fields relying on the hydrological network of the Cheshmeh Kileh river;
3. **Antiquity and livelihood dependence:** the historical tradition of horticulture as a source of identity, collective memory, and the basis of the native residents' subsistence economy.

These characteristics have turned Tonekabon into a distinctive platform for testing the productive

urban landscape model in mid-sized cities.

4.Findings

4.1.Thematic Analysis of Interview Data

Although in the initial theoretical framework of the research, the dimensions of CPUL were presented in the form of five separate conceptual domains, in the process of thematic analysis and the theme-definition stage (Braun & Clarke's approach), health was integrated into the environmental dimension due to the intertwining of ecological effects with the well-being and psychological security of citizens. Furthermore, since economic sustainability, incentives, and land management were not possible without institutional-managerial mechanisms, the governance component was added to the economic dimension, and the final empirical model was formulated in the form of four combined dimensions (physical-spatial, socio-cultural, environmental-health, and economic-governance).

Physical-Spatial Components

The thematic analysis of the data shows that the most important physical-spatial driver for the realization of a continuous productive urban landscape in Tonekabon is the principle of spatial continuity meaning that, instead of creating separate and isolated cultivation points, scattered gardens and agricultural lands must be connected to one another through linear elements. The majority of participants (7 out of 10) expressed a similar spatial pattern with close wording, which can be formulated under the theme of a productive green-blue network: production cores, including existing citrus orchards, tea, and rice paddies; connection axes, including river margins—especially the Cheshmeh Kileh river—and green corridors; a connection loop, including pedestrian and cycling routes; and socio-economic nodes, including local markets and product training and supply centers at the connection points of the network.

In this regard, one of the experts, emphasizing the fundamental difference between Tonekabon and conventional Western models, points out: "In cities like Tonekabon, there is no need to build farms from scratch; tea and citrus orchards are alive in the heart of the city, and we just need to sew them together with pedestrian corridors and the Cheshmeh Kileh margins to form a continuous network" (M1).

This finding is consistent with the basic definition of CPUL, which describes a green infrastructure composed of continuous corridors containing pedestrian and cycling routes and urban farms (Antunes et al., 2026; Viljoen & Bohn, 2020); however, it also reveals an important difference: while the classical European pattern begins from vacant and barren urban space, the Tonekabon participants unanimously emphasized the necessity of starting from the living and pre-existing agricultural capacity.

Regarding the role of rivers as the backbone of the productive network, there was high consensus among participants, although some of them (M5, M6, M7, M10) considered this function conditional on respecting the river margin and flood considerations; as one expert stated: "Cheshmeh Kileh is the city's main artery, but any landscape design along its edge must take into account the flood discharge and the riverbed margin; otherwise, the entire structure will be threatened during seasonal rainfall" (M7). This point, given Tonekabon's rainy climate, is an important design limitation for the proposed model. This statement was also verified against the evidence from the researchers' direct field observation in the Tonekabon urban area; the objective recording of the orchards' locations showed that the densest and most continuous existing citrus orchard zones extend precisely along the eastern and western margins of the Cheshmeh Kileh river, whereas within the depth of the physical fabric, agricultural patches have become blocked and fragmented due to fencing and isolated constructions. This field evidence is aligned with the interview findings, supporting the experts' claim that the Cheshmeh Kileh bed should act as the backbone of linear connection of fragmented areas.

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Another prominent finding of this research is the broad consensus (9 out of 10 participants) on the neglected importance of the neighborhood scale. From the participants' perspective, residents' daily participation, continuous maintenance of spaces, and practical education are formed precisely at this scale, whereas the initial literature on productive urban landscapes has emphasized more the continuity of metropolitan structure and regional networks (Viljoen & Bohn, 2020). This finding, in line with the research gap raised in the introduction of the present study regarding the necessity of paying attention to the neighborhood scale, has provided the basis for developing the initial conceptual framework of this research.

Socio-Cultural Components

In the socio-cultural dimension, Tonekabon's local agricultural culture—particularly the cultivation of tea, citrus, and rice—was identified unanimously by participants as a core element in shaping the identity of the productive landscape. This finding is consistent with the theoretical literature's emphasis on place attachment and local culture as an underexplored dimension in previous CPUL studies (Sanjari et al., 2022). A subtle point raised explicitly in the majority of interviews (7 out of 10), particularly by M5, was concern about the gradual loss of this agricultural identity among younger generations and their growing inclination toward alternative occupations. One participant remarked: "The younger generation has no desire for the mud of orchards and rice paddies; unless urban agriculture is linked to modern technologies and economic value, this local subculture will fade away with the older generation" (M5). This reflects a tension between the aspiration to preserve local identity and the demographic reality of younger generations, which can be taken into account when designing participatory mechanisms for the proposed model.

The data analysis also revealed a clear two-sided pattern of factors that strengthen or weaken residents' social participation. Strengthening factors include local social capital and trust among neighbors, a family history of farming, clear and tangible economic benefits, and genuine public participation in decision-making. Conversely, distrust of implementing agencies, ambiguity over ownership and maintenance responsibilities, lack of education and awareness, and the absence of tangible economic benefits were identified as the main factors weakening participation. This finding accords with the prominent role assigned to social participation in the theoretical literature on urban agriculture (Gunapala et al., 2025). In addition, the difference in outlook between native residents who view the productive landscape primarily through the lens of livelihoods, family ownership, and collective memory and newer residents who have migrated from metropolitan areas who are more attentive to aesthetics, tranquility, and health—was affirmed with high consensus (8 out of 10). As one interviewee put it: "Migrants from Tehran have come here for visual tranquility and a green atmosphere, while local residents are worried about fertilizer costs and selling their produce; the art of planning lies in linking the former's sense of calm with the latter's tangible benefits" (M3). The shared solution proposed by participants was to design an integrated model that combines local residents' knowledge and experience of production with the needs and perspectives of newer residents regarding the use of space.

Environmental and Health Components

In the environmental dimension, participants' views converged unanimously around water management as the dominant theme: protecting river margins, managing stormwater and preventing waterlogging and flooding, and maintaining ecological connectivity between the city, the river, and the Alborz forests. This finding is fully consistent with Tonekabon's distinctive climatic conditions—its temperate-humid climate and water-rich rivers—and indicates that, unlike many European CPUL models, in which water is managed primarily as a scarce resource, the main environmental-design priority in Tonekabon is managing surplus water and controlling floods. This fundamental difference underscores the need to adapt the model to local conditions rather than apply European frameworks unchanged. A faculty member in agriculture emphasized: "Our problem in the north, unlike in Europe, is not water scarcity but controlling the volume of

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surface runoff; urban orchards act like natural sponges, and if construction swallows them up, the entire urban fabric will be submerged during torrential rains" (M8). Participants also described a clear causal chain linking unauthorized construction to the loss of environmental connectivity: unauthorized construction fragments orchards and agricultural lands; this interrupts natural water-flow paths; soil permeability and water-absorption capacity decline; and, ultimately, the risk of waterlogging and the destruction of natural habitats increases. A review comparing Tonekabon's comprehensive and detailed plans with existing physical conditions also supports this analysis. Comparison of land-use areas shows that, over recent decades, a considerable area of absorbent, permeable orchard zones has been converted through land-use change into hard, impermeable surfaces, substantially increasing the city's surface-runoff burden. This finding is consistent with evidence from the Wuhan, China, case study, where the expansion of impermeable urban surfaces in peri-urban areas directly led to flooding and waterlogging, revealing the need to integrate nature-based solutions into planning for these areas (Nuanla-or & Xu, 2024).

Regarding the role of productive landscapes in residents' physical and mental health, high consensus (8 out of 10) was observed around the contribution of walking, gardening, and access to green space and fresh produce to reducing urban stress and improving mental health. This finding aligns with previous research emphasizing the multiple functions of productive landscapes beyond food production (Hino et al., 2023; Iida et al., 2024). The shared proposal for institutionalizing this dimension was to design safe, accessible walking routes for people of all ages especially children, older adults, and people with disabilities along green corridors.

Economic and Governance Components

The findings of the economic dimension align with Akyol and Tunçay (2013), who highlight the role of governmental regulations in the sustainability of productive landscapes. In the economic dimension, the tangible rather than merely theoretical opportunities of urban agriculture in Tonekabon were formulated around four main axes: reducing intermediaries and increasing farmers' income shares through local markets and direct sales; processing and packaging local produce (especially citrus and tea) with higher added value; agritourism and orchard tours as supplementary income; and micro- and home-based employment, particularly for rural women. This finding is consistent with the literature's emphasis on the role of urban agriculture in strengthening local supply chains and livelihoods (Gunapala et al., 2025).

Regarding the challenge of land ownership and competition with the construction industry, the core theme supported by high consensus (8 out of 10) was that purely regulatory and restrictive measures are insufficient, and preserving agricultural land use must be economically viable for landowners. In this regard, one academic expert stated: "One cannot simply tell an orchard owner through administrative circulars not to build on their land; when the added value of construction is many times that of orchard management, the municipality must employ mechanisms such as Transfer of Development Rights (TDR) or special municipal fee discounts so that maintaining the orchard remains economically worthwhile for the owner" (M2). The analysis of documents and building regulations of Tonekabon's approved detailed plan also reveals this structural challenge: in existing regulations, no effective incentive mechanism (such as TDR or compensatory floor area ratio [FAR] incentives) is foreseen for preserving orchards, and the economic pressure of the land market automatically drives owners toward land-use conversion.

In addition to urban development documents, examining the yearbooks and recorded statistics of Tonekabon's Agricultural Jihad Administration clearly substantiates this challenge; according to these figures, between 2016 and 2023 (1395–1402 AP), more than 75 hectares of agricultural lands and fragmented citrus orchards within the city's legal boundary and peri-urban buffer experienced land reduction or faced official land-use change filings. These reliable documentary records lift the experts' recurring warnings about the necessity of enacting economic incentives to curb land market pressure out of a purely perceptual realm, grounding them in empirical reality.

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The tools proposed by the research include the Transfer of Development Rights (TDR), institutionalizing agricultural zones in the detailed plan, tax incentives, low-interest loans, and Payments for Ecosystem Services (PES) to landowners. These findings correspond with the obstacles identified in international literature, such as the lack of legal formalization of food production, land-use risks, tax impediments, and landlord-tenant dilemmas (Murugesan, 2024).

Regarding institutional roles, a pattern of complementary division of labor emerged from the responses: the Municipality holds an advantage in terms of executive-spatial capacity (land provision, public space design, permit issuance), while the Agricultural Jihad Administration possesses superior technical knowledge and ties with producers. Near-unanimous consensus among participants (9 out of 10) on the necessity of joint management and inter-sectoral coordination between these two entities alongside the Engineering Council and local councils underscores this as the primary prerequisite for the successful implementation of the model; a finding consistent with the literature's emphasis on local governance and cross-sectoral collaboration in realizing urban agriculture (Gunapala et al., 2025).

Key Conflicts and Resolution Mechanisms

The realization of a productive urban landscape in Tonekabon faces three primary conflict nodes that demand concrete institutional solutions:

1. Institutional conflict between the Municipality and the Agricultural Jihad Administration arising from the competing demands of construction fee revenues versus agricultural land conservation. This is resolved through establishing a joint working group for productive land management under the County Governorship and substituting construction fees with revenue-sharing derived from complementary orchard activities and agritourism.
2. Conflict of smallholders with the construction industry stemming from the substantial profitability of villa development compared to traditional agriculture. This is resolved by deploying the Transfer of Development Rights (TDR), granting floating FAR within designated target zones, and issuing multipurpose operational permits.
3. Conflict between landowners and tenants or young operators resulting from short-term leasing contracts and the consequent lack of incentive for infrastructural investment. The solution lies in formalizing long-term productive lease agreements monitored by the Engineering Council, while conditioning stream-dredging and irrigation equipment subsidies on the institutional stability of these contracts.

Overall, the interview data indicate that the concept of integration in Tonekabon's localized model materializes across three levels: spatial integration through the physical connection of orchards with the Cheshmeh Kileh river corridor; functional integration through the concurrent synthesis of agricultural production, flood management, and public recreation; and institutional integration through operational alignment between the Municipality and the Agricultural Jihad Administration.

Based on these findings, the hierarchical structure of key components and subordinate indicators for each of the four main dimensions of the model, alongside its localization axes relative to the classic European framework, is presented in the diagram below:

Table 3. Frequency Matrix and Level of Expert Consensus on Key Components Across the Four CPUL Dimensions in Tonekabon

Conceptual Dimension	Extracted Key Component	Codes of Agreeing Participants	Agreement Frequency	Percentage	Quantitative Consensus Level
Physical-Spatial	Spatial continuity and the Cheshmeh Kileh corridor	M1, M2, M3, M4, M5, M6, M7, M8, M9, M10	10	100%	Full Consensus
	Significance and neighborhood scale	M1, M2, M3, M4, M5, M6,	9	90%	High Consensus

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Conceptual Dimension	Extracted Key Component	Codes of Agreeing Participants	Agreement Frequency	Percentage	Quantitative Consensus Level
		M7, M8, M10			
	Orchard and paddy cores (Green-Blue network)	M1, M5, M6, M7, M8, M9, M10	7	70%	Majority
	Slow-mobility connecting loop and neighborhood nodes	M1, M5, M6, M7, M8, M9, M10	7	70%	Majority
Socio-Cultural	Physical identity and native agricultural culture (tea, citrus, rice)	M1, M2, M3, M4, M5, M6, M7, M8, M9, M10	10	100%	Full Consensus
	Perceptual divergence between native residents and new migrants	M1, M2, M3, M4, M6, M7, M8, M10	8	80%	High Consensus
	Concerns over the decline of native identity among younger generations	M1, M3, M4, M5, M6, M7, M9	7	70%	Majority
Environmental and Health	Surface runoff management, drainage, and flood control	M1, M2, M3, M4, M5, M6, M7, M8, M9, M10	10	100%	Full Consensus
	Ecological fragmentation driven by unauthorized construction	M1, M2, M3, M4, M6, M7, M8, M9, M10	9	90%	High Consensus
	Physical and mental health via active pathways and urban gardening	M2, M3, M4, M5, M6, M7, M8, M10	8	80%	High Consensus
Economic-Governance	Direct supply, local markets, and intermediary reduction	M1, M2, M3, M4, M5, M6, M7, M8, M9, M10	10	100%	Full Consensus
	Inter-sectoral coordination and co-management (Municipality & Agricultural Jihad)	M1, M2, M3, M4, M5, M6, M7, M8, M9	9	90%	High Consensus
	Economic viability and incentive mechanisms (e.g., TDR)	M1, M2, M4, M5, M6, M7, M8, M10	8	80%	High Consensus
	Agro-processing and complementary agritourism	M1, M3, M4, M6, M7, M8, M10	7	70%	Majority

Table 4. Hierarchical Structure of Key Components Across the Four Main Dimensions of CPUL Realization in Tonekabon and Localization Axes Relative to the European Model

D1: Physical-Spatial Dimension	D2: Socio-Cultural Dimension	D3: Environmental & Health Dimension	D4: Economic & Governance Dimension
Strategic Principle: Spatial continuity	Native Agricultural Identity: Tea, citrus, rice	Surplus Water Management & Flood Control	Intermediary Reduction & Local Markets

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Production Cores: Existing tea and citrus orchards, rice paddies	Intergenerational Tension: Concerns over identity decline among the youth	Ecological Connectivity & River Corridor Protection: Cheshmeh Kileh margin	Agro-Processing & Packaging: Value-added citrus and tea products
Connection Axes: River margins (Cheshmeh Kileh) and green corridors	Participation Enablers: Social trust and clear, tangible economic benefits	Causal Risk Chain: Unauthorized construction →→ ecological fragmentation	Complementary Agritourism & Orchard Touring
Connection Loops: Pedestrian and cycling mobility networks	Participation Inhibitors: Institutional distrust and property ownership ambiguity	Physical & Mental Health: Active walking, stress reduction, and urban gardening	Micro- & Home-Based Employment: Targeted at rural and local women
Socio-Economic Nodes: Local market hubs and community supply points	Social Integration: Bridging perspectives of native residents and new in-migrants	Universal Access: Green space proximity and fresh produce accessibility	Land-Use Conservation Incentives: Municipal fee waivers, TDR, guaranteed purchasing
Operational Focal Point: Neighborhood scale	—	Inclusive Active Mobility: Safe, universally accessible walking paths	Institutional Coordination: Co-management between Municipality and Agricultural Jihad
Localization Axes Relative to the Classic European CPUL Framework • **Starting Point:** Grounded in living, pre-existing agricultural capacity *(rather than vacant or brownfield urban plots)* • **Environmental Priority:** Managing surplus water runoff and seasonal flood control *(rather than water scarcity and conservation)* • **Property Structure:** Fragmented and privately owned smallholdings *(rather than consolidated public land)* • **Implementation Focus:** Neighborhood scale *(rather than metropolitan-regional scale)*			

In order to physically realize the vision of a continuous productive urban landscape and in response to the necessity of spatial linkage between production areas and demand hubs, the spatial structure of Tonekabon's green-blue network was redefined in the form of four interconnected structural layers (Figure 2):

1. **Agricultural and Orchard Production Cores:** Comprising dense citrus and tea orchards in the southern and south-western piedmont zones, scattered orchard patches in the west, and lowland rice paddies in the east, which constitute the primary sources of bioproduction and local food security.
2. **Main Connection Axis (Natural Backbone):** The hydrological corridor of the Cheshmeh Kileh River, extending from southwest to northeast, plays the role of a vital artery linking the upstream foothills to the Caspian Sea coastline.
3. **Soft and Multipurpose Connection Loop:** The network of pedestrian paths, bicycle tracks, and traditional branching irrigation streams (*anhār*) along the river's green riparian buffer, establishing non-motorized and ecosystem-friendly access between production zones and the residential fabric.
4. **Socio-Economic Nodes (Exchange and Supply Hubs):** The location of daily and traditional open-air bazaars in the central urban core (adjacent to the Cheshmeh Kileh Bridge), along with the southern ecotourism-distribution terminal and the coastal fisheries-tourism node at the river mouth, completes the local farm-to-table chain without reliance on heavy vehicular trips, fostering the reinforcement of place identity and sustainable urban economy.

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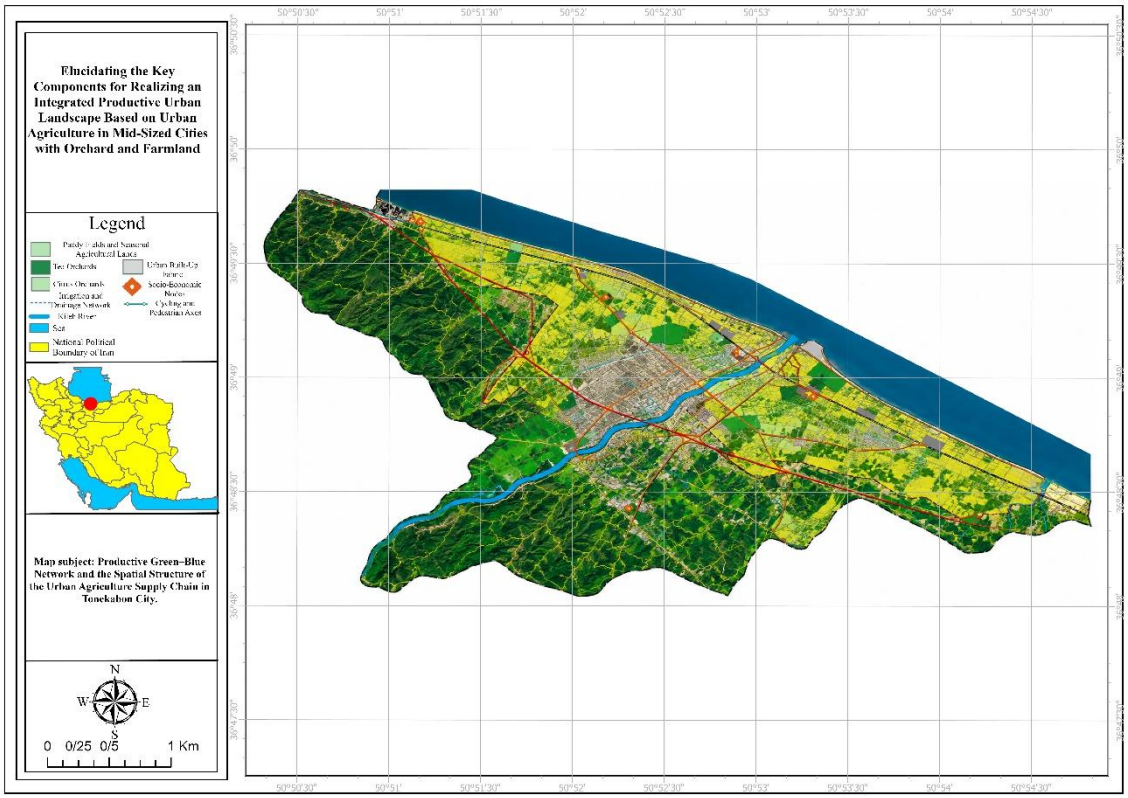


Figure 2. Map of the Productive Green–Blue Network and the Spatial Structure Linking Production Cores, the Connection Corridor, and Socio-Economic Nodes in Tonekabon City

To clarify the analytical pathway and enable the auditing of the theme extraction process, an example of the transformation chain of raw data from semi-structured interviews (M_1 to M_{10}) into initial codes, sub-themes, and the four main dimensions is presented in Table 5. It is worth noting that the codes from interviews $M_9$and M_{10}aligned with prior codes and served to consolidate theoretical saturation:

Table 5. Example of the Analytical Chain for Interview Data: From Raw Text to Initial Codes, Subthemes, and Main Dimensions Based on Braun and Clarke's Method

Expert ID	Participant's Expertise	Excerpt from Raw Interview Data	Initial Code	Subtheme / Component	Final Main Dimension (Source: Table 3)
M1	Urban Planning	"The citrus orchard zones and rice paddies must be linked to the urban fabric via the banks of the Cheshmeh Kileh; otherwise, they will gradually become fragmented and disappear."	Linear connection of productive lands; riverbank green corridor	Spatial continuity of productive areas	D1: Physical-Spatial
M2	Landscape Architecture	"Designing pedestrian and cycling routes along irrigation channels and orchards transforms the physical form of the city from merely consumptive to productive."	Integration of slow-mobility routes with orchards; green connectivity network	Connection axes and green mobility routes	D1: Physical-Spatial

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Expert ID	Participant's Expertise	Excerpt from Raw Interview Data	Initial Code	Subtheme / Component	Final Main Dimension (Source: Table 3)
M3	Urban Sociology	"Citrus cultivation and rice farming are not merely land uses; they are part of the collective memory and historical identity of Tonekabon's people."	Preservation of local heritage; linking local identity with production	Native agricultural identity (tea, citrus, and rice)	D2: Socio-Cultural
M4	Urban Environment	"Encroachment by construction into river channels and their buffer zones has disrupted the natural drainage network and increased the risk of seasonal floods."	Obstruction of natural runoff pathways; degradation of ecological buffers	Surplus water management and protection of riparian zones	D3: Environmental and Health
M5	Urban Planning	"The younger generation is not interested in maintaining small urban orchards; without tangible economic benefits, the land will be abandoned and subdivided."	Changing generational preferences; risk of subdivision of small urban orchards	Decline of agricultural identity among the younger generation	D2: Socio-Cultural
M6	Urban Economics	"Establishing local daily markets for the direct sale of tea and kiwifruit cuts out intermediaries and helps orchard owners stay in business."	Eliminating intermediaries; direct, neighborhood-level sales	Local markets and small-scale supply chains	D4: Economic and Governance
M7	Urban Management	"Conflicting regulations between the Agricultural Jihad Organization and the Municipality are harming agricultural lands: one prohibits development while the other issues subdivision permits."	Overlapping intersectoral responsibilities; lack of organizational coordination	Institutional coordination (Municipality and Agricultural Jihad Organization)	D4: Economic and Governance
M8	Environment and Health	"Active public engagement with productive green spaces and neighborhood farms reduces the stress of urban life and fosters psychological well-being."	Improving mental health through contact with soil and plants	Promoting citizens' physical and mental health	D3: Environmental and Health

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The hierarchical structure of the extracted themes, comprising four main themes and fourteen subthemes, together with the number of experts who agreed with each, is presented in Diagram 1.

Diagram 1. Thematic Tree Derived from Expert Interviews on Realizing a Continuous Productive Urban Landscape in Tonekabon

Realizing a Continuous Productive Urban Landscape (CPUL) Based on Urban Agriculture in the Intermediate City of Tonekabon
Thematic Analysis of Interviews with 10 Experts

D4 — Economic-Governance Dimension	D3 — Environmental and Health Dimension	D2 — Socio-Cultural Dimension	D1 — Physical-Spatial Dimension
Direct sales, local markets, and fewer intermediaries (10 out of 10)	Runoff management, drainage, and flood control (10 out of 10)	Local built and agricultural identity (tea, citrus, and rice) (10 out of 10)	Spatial continuity and the Cheshmeh Kileh corridor (10 out of 10)
Intersectoral coordination and joint management (Municipality and Agricultural Jihad Organization) (9 out of 10)	Ecological fragmentation caused by unauthorized construction (9 out of 10)	Differences in attitudes between native residents and new migrants (8 out of 10)	The importance of the neighborhood scale (9 out of 10)
Economic viability and incentive instruments (e.g., Transfer of Development Rights—TDR) (8 out of 10)	Physical and mental health (active routes and gardening) (8 out of 10)	Concern about the decline of local identity among the younger generation (7 out of 10)	Orchard and rice-paddy cores (green-blue network) (7 out of 10)
Product processing and complementary agritourism (7 out of 10)			Slow-mobility connection loop and neighborhood nodes (7 out of 10)

Localization axes relative to the European model: Starting from existing, active agricultural capacity · Prioritizing surplus-water management and flood control · Small-scale and private land ownership · Implementation focus: Neighborhood scale

Number below each component: Number of participants in agreement (out of 10)

Relationships Among the Four Dimensions and Localization of the Model Relative to European CPUL

One of the key findings of this study—directly related to its main objective of identifying and explaining the key components for realizing a Continuous Productive Urban Landscape (CPUL) through urban agriculture in intermediate cities with garden and agricultural capacities—is the remarkable consensus among participants (8 out of 10) regarding the existence of a positive reinforcing cycle among the four main dimensions of the model. This cycle was articulated in the independent responses of several participants (including M6, M9, and M10) with an almost identical sequence: appropriate spatial and physical design enhances environmental quality; this improvement increases public presence, participation, and, consequently, physical and mental well-being; increased presence and participation lay the groundwork for economic activity and value creation; and finally, the resulting economic value strengthens the incentive to maintain and reproduce physical quality, thereby sustaining the cycle.

This empirical finding provides a well-documented basis for delineating the final conceptual model of the study, demonstrating that among the four dimensions, the physical-spatial dimension acts as the initial trigger, while the economic dimension serves as the long-term stabilizer of the model. This finding aligns with the multi-functional and interconnected nature of CPUL in the theoretical literature (Mendes et al., 2020; Sanjari et al., 2023). The reciprocal causal relationship among these four dimensions is depicted in the diagram below as a reinforcing feedback loop (in the manner of causal loop diagrams within system dynamics methodology): the physical-spatial dimension plays the role of the initial trigger, and the economic dimension acts as the long-term stabilizer of this loop.

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Figure 3. Causal Loop Diagram (CLD) of the Interactions among the Four Dimensions of Productive Urban Landscape Realization in Tonekabon: The Contrast between the Positive Reinforcing Loop (R_1) and the Negative Vicious Loop (B_1)

As shown in Figure 3, the productive landscape system in Tonekabon is caught in a tension between two opposing loops: in the absence of institutional intervention and if orchards remain economically unviable, the negative loop (B_1) rapidly transforms valuable lands into rigid built surfaces. Therefore, the key urban planning objective in Tonekabon is to curb the negative loop (B_1) through economic incentives and activate the reinforcing loop (R_1) via the physical connectivity of orchards.

Regarding the fundamental difference between the indigenous model and European CPUL examples specifically the foundational framework of Viljoen & Bohn there is near-complete consensus among participants that the European model focuses primarily on creating new productive spaces predominantly in vacant and underutilized urban spaces (Viljoen & Bohn, 2020). In contrast, the approach suited for intermediate cities like Tonekabon must be grounded in the preservation, organization, and connection of existing agricultural capacity. The proposed indigenous localization axes put forward by the participants include: a humid, high-rainfall

climate versus the European emphasis on water scarcity, thereby prioritizing stormwater and flood management over water-shortage management; fragmented private landownership of agricultural lands versus public and municipal lands in many European examples; indigenous cultivation products and knowledge (tea, citrus, rice) instead of imported cropping patterns; and a relative weakness in institutional coordination and local executive capacity compared to the European urban context.

Synthesis of Thematic Analysis Findings

The thematic analysis of the ten interviews provided evidence of considerable convergence among experts from various specialized fields, while also revealing subtle yet important points of differentiation—particularly regarding the younger generation's concern for the continuity of agricultural identity and the differing attitudes of native residents versus newcomers. The collective findings of this section can be summarized into five main propositions that form the basis for developing the final conceptual model of the research: First, the overarching strategic principle governing intermediate cities with garden and agricultural capacities is the preservation and connection of existing capacity rather than creating productive space from scratch; second, the spatial backbone of the model is formed by the green-blue network consisting of river margins and green corridors; third, the neighborhood scale contrasting with the prevailing focus of existing literature on the metropolitan scale is the focal point for the implementation and sustainability of the model; fourth, the long-term sustainability of the model depends on the economic justification of maintaining agricultural land use for landowners; and fifth, the four dimensions of the model operate in the form of a mutual reinforcing cycle, in which the physical-spatial dimension acts as the initial trigger and the economic dimension serves as its long-term stabilizer. In the discussion and conclusion section, linked with the theoretical foundations and research background, these propositions will serve as the basis for developing the final localized continuous productive urban landscape model for the city of Tonekabon.

4.2.Evaluation and Physical-Spatial Zoning of the Productive Urban Landscape in Tonekabon

To realize the data triangulation approach and bridge the perceptions derived from qualitative interviews with the physical realities and baseline documents of the city, this section of the research is based on spatial analyses and four key information layers including spatial accessibility, land use structure, spatial cohesion, developability capacity, and ultimately the final synthesis:

Evaluation and Spatial Zoning of Accessibility to Urban Productive Areas

This map has been prepared with the aim of evaluating permeability and citizens' ease of access to potential urban agriculture areas through the overlay of street network and population center layers. The results indicate a concentration of the highest pedestrian accessibility in the central core and around the Cheshmeh-Kileh River; in contrast, the northern and northwestern strips of the city, which fall into the weak accessibility category, require an emphasis on intra-parcel agriculture and home gardens.

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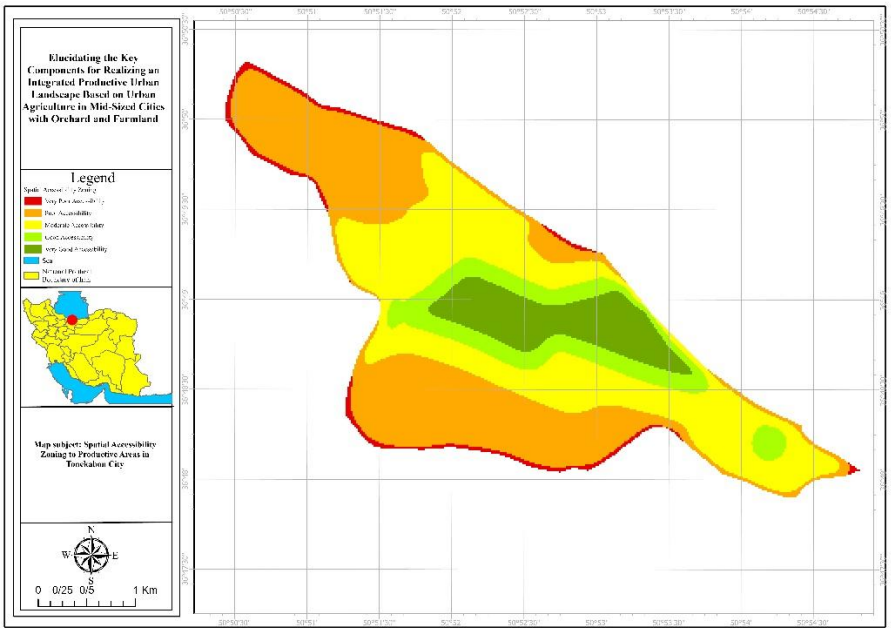


Figure 4. Zoning of spatial accessibility to productive areas in Tonekabon

Evaluation and Zoning of Land Use Structure

This map has been prepared with the aim of identifying potential lands, vacant patches, and intra-urban orchards. The highest suitability for cultivation lies in historical orchard patches, marginal lands, and vacant lands around secondary axes; whereas dense central areas and compact residential blocks have the lowest potential for direct cultivation and should be directed toward vertical farming and green roofs.

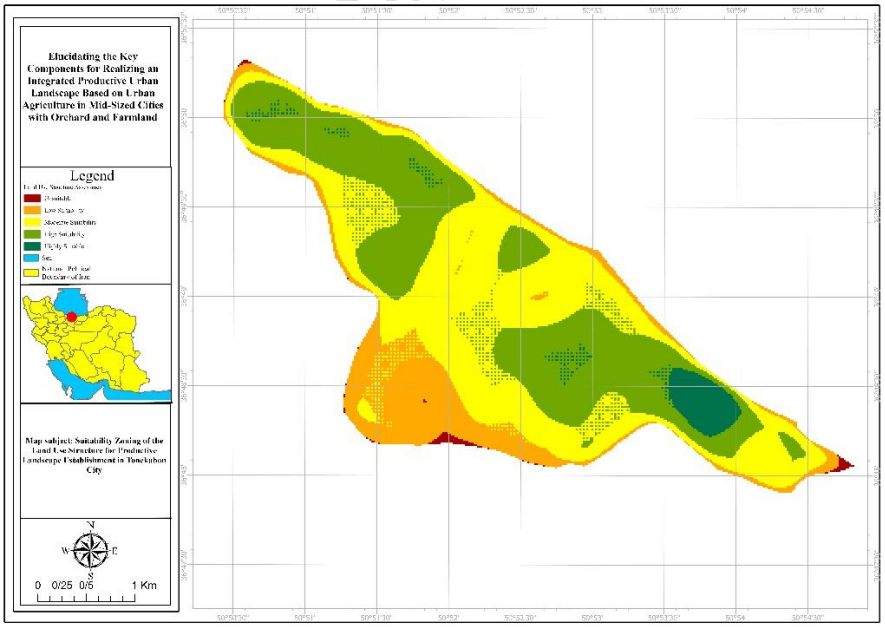


Figure 5. Zoning of land use structure suitability for establishing a productive landscape in Tonekabon

Assessment of Spatial Cohesion of Productive Patches

The purpose of this map is to evaluate structural continuity and the absence of spatial fragmentation among green spaces. The highest integration is observed along natural corridors and river corridors; meanwhile, intermediate fabrics have suffered ecological fragmentation due

to discontinuous construction and require connecting small patches through greenways and garden-streets.

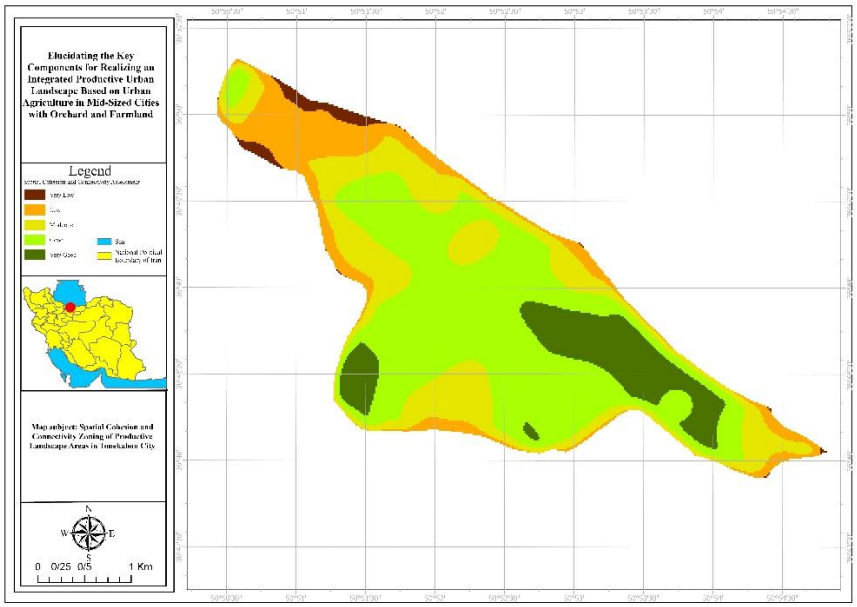


Figure 6. Zoning of spatial cohesion and continuity of productive landscape areas in Tonekabon

Evaluation of Physical Developability Capacity

This map has been prepared with the aim of evaluating the physical flexibility of the fabric and the feasibility of developing new urban agriculture areas. High-potential zones are mainly located in vacant lands and low-density peripheral areas; in contrast, robust and dense fabrics fall into the lowest developability category and require a focus on the optimal use of unused micro-spaces.

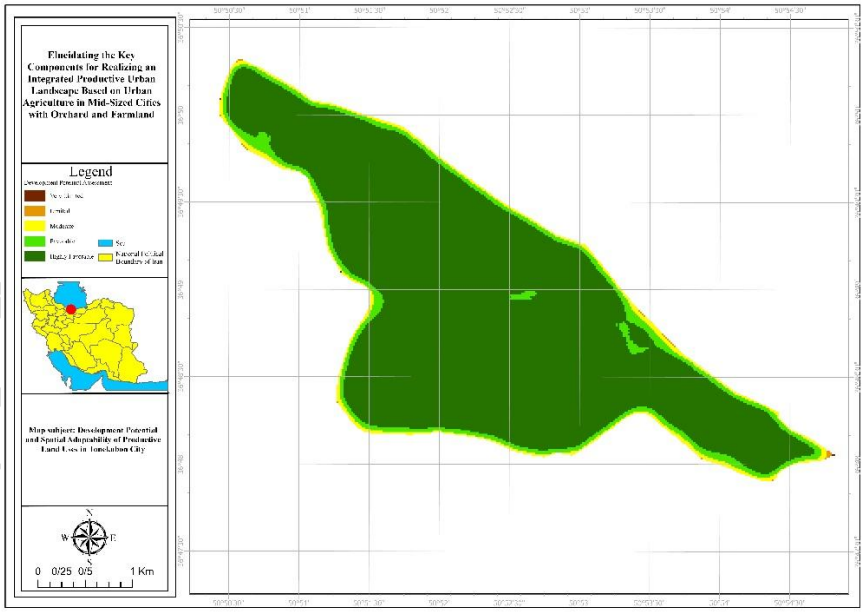


Figure 7. Zoning of spatial developability capacity and spatial adaptability of productive land uses in Tonekabon

Zoning of Spatial Priorities for Establishing the Productive Urban Landscape

This map is the result of the final synthesis and overlay of the four preceding criteria. Mid-green cores and lands adjacent to environmental corridors are placed in the very high priority category; medium-priority zones are suitable for small-scale neighborhood horticulture; and low-priority parts require indirect approaches such as home agriculture and upgrading access infrastructure.

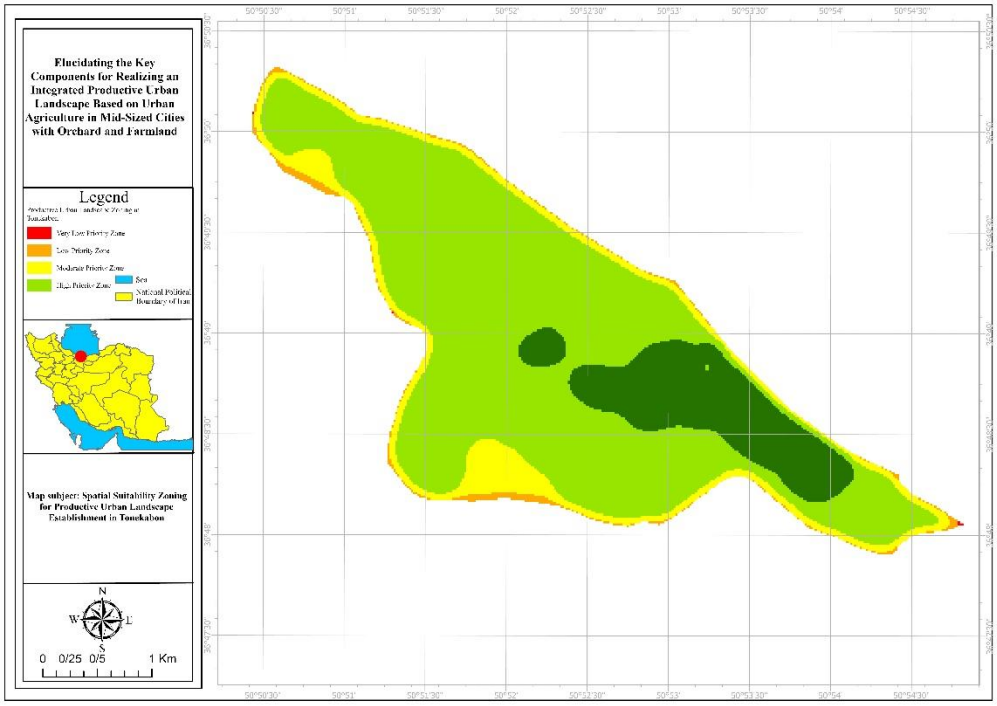


Figure 8. Final synthesis and spatial suitability zoning for establishing a productive urban landscape in Tonekabon

Spatial analysis overlay of the layers shows that the success of the productive landscape model in Tonekabon requires dividing executive actions into the regeneration of vacant lands and connected orchards (in high-priority cores) and the application of micro-neighborhood methods in dense zones, thereby linking food security, social interactions, and physical-ecological sustainability.

5.Discussion and Interpretation of Findings

The research results, compared to previous studies, indicate that the proposed productive urban landscape model in Tonekabon is formulated within a localized green-blue productive network. Its structure relies on spatial connections among production cores (citrus orchards, tea fields, and rice paddies), natural connection axes (especially the Cheshmeh-Kileh River buffer zone), calmed pedestrian and bicycle communication loops, and socio-economic nodes such as local markets. This four-dimensional hybrid model exhibits fundamental distinctions from classical European productive landscape frameworks, such as the perspectives of Viljoen and Bohn (2020) and Antunes et al. (2026). First, the starting point in Tonekabon is the preservation and revival of existing living and active agricultural substrates rather than redesigning and planting vacant lands or abandoned urban spaces. Furthermore, the predominance of fragmented and private land ownership, contrary to the predominantly public spaces in Western examples, renders reliance solely on prohibitive regulations inefficient and necessitates the implementation of economic incentive mechanisms such as transfer of development rights (TDR).

In the environmental-health dimension, the fundamental difference between this model and common European approaches becomes evident in dry or moderately rainy climates; here, Tonekabon's primary issue is not wastewater recycling or water scarcity management, but rather managing increasing surface runoff, land drainage, and controlling seasonal floods of the Cheshmeh-Kileh River. Consequently, the green-blue infrastructure plays a passive defense role in safeguarding agricultural cores rather than merely securing water resources, an orientation that

aligns with the nature-based approaches of Nuanla & Xu (2024) regarding the harmonization of green infrastructure with hydrological cycles.

The analysis of internal relationships within this model reveals a reciprocal impact cycle in which appropriate physical design of axes and nodes acts as the initial trigger, and the economic value added from agro-tourism serves as the cycle's stabilizer. Thus, enhancing local sustainable incomes and involving the younger generation strengthens the motivation for voluntary preservation of orchards and prevents land-use changes. Conversely, any inefficiency in the economic chain or neglect of joint management among the municipality, Agricultural Jihad, and engineering system gives rise to a weakening feedback loop that transforms orchards into tourist and villa developments. Therefore, similar to the findings of Rahimi et al. (2025) in Marivan, the sustainable success of this productive landscape depends on adopting institutional preventive policies and cross-sectoral coordination to protect the agricultural nature of lands against the physical pressures of urban development a reality that Sanjari et al. (2023) and Hassandaie et al. (2025) previously noted as relying on institutional coordination and the multi-functionality of infrastructures.

6.Conclusion

The issue of realizing an integrated productive urban landscape in Tonekabon, beyond mere physical intervention or general green space recommendations, requires a phased and priority-driven action plan in which the preservation of agricultural lands is linked to the economic interests of the local community and the institutional structure of the city. Given that the findings of this research rely on the qualitative analysis of local expert perspectives and lack independent validation of the model up to this stage (e.g., through an expert panel, quantitative structural methods, or field testing), the claim of the present research is limited to providing an initial conceptual framework and a preliminary step for understanding the dimensions of the issue in intermediate cities with garden-agricultural capacities. Broad generalizability of the results requires future empirical tests and validations in similar contexts. Furthermore, the main contribution of this research is the localization of the CPUL framework for intermediate cities with conditions similar to Tonekabon. Therefore, the theoretical and applied generalizability of the presented model to other intermediate cities is conditional upon the presence of three matching structural characteristics: first, a temperate and high-rainfall climate with a chain of fragmented garden-agricultural activities; second, a pluralistic ownership pattern and micro-parcel lands under intense speculative pressure from housing and villa development; and third, a local governance structure requiring cross-sectoral coordination between the municipality and Agricultural Jihad (such as the plain and coastal cities of the Caspian Sea basin like Ramsar, Lahijan, and Chalus). Naturally, applying this model in intermediate cities located in arid zones or possessing large-scale ownership structures will necessitate redefining ecological dimensions and incentive mechanisms appropriate to their local context.

Accordingly, the proposed measures are organized into a logical, three-stage sequence: in the short term, legal and physical stabilization of orchards; in the medium term, ecological management and economic empowerment; and in the long term, structural connection of the green-blue network and neighborhood-level actions. The responsible institution and monitoring indicator for each action are presented in Table 6.

Table 6. Priority-Based Action Plan: Time Horizon, Responsible Institution, and Monitoring Indicator

Priority	Action	Horizon	Responsible Institution	Monitoring Indicator
1	Legal and physical stabilization of orchards and conservation zoning	Short-term	Municipality of Tonekabon, Agricultural Jihad	Cessation of land-use change cases in Article 5 Commission; stability of registered orchard areas
2	Ecological management (runoff	Medium-term	Governorate, Municipality, Water Resources Management	Reduction of flood damages

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Priority	Action	Horizon	Responsible Institution	Monitoring Indicator
	control, Cheshmeh-Kileh buffer improvement)			
2	Economic empowerment (incentives, agro-tourism)	Medium-term	Municipality, Agricultural Engineering System, Cultural Heritage	Youth seasonal employment rate; number of agro-tourism permits

The placement of these neighborhood-level actions in subsequent tiers does not imply that they are of lesser importance; rather, it reflects a logical policy-making sequence. This means that civic identity and utilization will only become achievable once the vitality of agricultural lands has first been stabilized, runoffs managed, and the economic justification of horticulture guaranteed. Accordingly, it is suggested that researchers in future studies focus on the quantitative validation of this initial conceptual framework using structural methods and spatial scenario testing within Geographic Information Systems (GIS) to enable a more precise generalization of this model to other intermediate cities.

Author Contributions

The authors contributed equally to all sections of this research.

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Conflict of Interest

The authors declare that there is no conflict of interest in this research.

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