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Determining and Quantifying Urban Sprawl Drivers: A Delphi-DANP Approach

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Abstract: Urban sprawl poses a significant and escalating challenge in developing countries, including Iran, leading to substantial transformations in urban areas. Despite efforts to manage urban spatial development, uncontrolled urban sprawl exerts considerable pressure on resources, infrastructure, and the environment. This study aims to identify and quantify the drivers of urban sprawl and investigate their interrelationships within Iranian metropolises. To achieve this objective, the study employs a mixed-method approach, commencing with a review of the existing literature and expert surveys based on PESTEL analysis and the Delphi method. This stage identified and categorized 40 key drivers (sub-factors) into six main categories (factors): political, economic, social, technological, environmental, and legal. Subsequently, the DEMATEL-based Analytic Network Process (DANP) method is utilized to explore the internal interrelationships among factors and sub-factors and to determine their relative weights, offering deeper insights into their relationships and relative importance. The findings reveal a complex interplay of political, economic, social, technological, environmental, and legal factors driving urban sprawl in Iran. Key drivers include political fragmentation, economic competition, social preferences for suburban living, rural-to-urban migration, increasing housing demand, weak legal regulations, natural constraints, inadequate transportation infrastructure, and the impact of technological advancements. Based on these findings, the study recommends a holistic approach to sustainable urban development in Iran, emphasizing the need for stakeholder engagement, participatory decision making, legal reforms, and significant investments in public transportation infrastructure.

Keywords: urban sprawl; spatial development; developing countries; metropolitan areas; Iran

Academic Editor: Tao Liu

Received: 23 December 2024
Revised: 25 January 2025
Accepted: 27 January 2025
Published: 2 February 2025

Citation: Soltani, A.; Azizi, P.; Javadpoor, M.; Allan, A.; Bagheri, B. Determining and Quantifying Urban Sprawl Drivers: A Delphi-DANP Approach. *Land* **2025**, *14*, 311. https://doi.org/10.3390/land14020311

1. Introduction

Urban sprawl in developing countries presents complex challenges primarily driven by rapid urban growth, population increases, and ineffective urban management. The outward expansion of cities, often spurred by rural-to-urban migration, gives rise to critical concerns such as overloaded infrastructure, environmental harm, and social instability [1]. Unlike in wealthier nations, where sprawl is often a byproduct of affluence and lifestyle

preferences [2,3], in developing regions it is a response to urgent demands for housing and living space. Weak legislation, fragmented governance and poorly enforced land use policies exacerbate the issue, leading to traffic congestion, pollution, and the growth of informal settlements or slums [4–6]. These developments intensify social inequalities and resource scarcity, heightening tensions within urban communities. Additionally, the shift of economic activities from city centers to suburban areas further complicates the socio-economic landscape [7,8]. Addressing urban sprawl in these contexts requires context-sensitive strategies that focus on sustainable urban planning, equitable infrastructure development, and the creation of resilient cities capable of accommodating future growth effectively.

Urban sprawl has emerged as a pressing issue in Iran over the past four decades, driven by an interplay of socio-economic, political, and environmental factors [9] in addition to car-oriented planning policies [10]. Rapid population growth, predominantly fueled by rural-to-urban migration, has been a key contributor to this phenomenon [11]. Additionally, speculative land markets, weak governance, evolving transportation policies, and shifting land use patterns have further exacerbated the issue [12]. The transition from an agriculture-based economy to one centered on services has drastically reshaped urban landscapes, turning traditional, dense neighborhoods into sprawling and fragmented developments extending well beyond city centers [13–15].

The challenges of urban sprawl are particularly pronounced in metropolitan regions, where its dynamics are more intricate and multifaceted. However, much of the existing research has primarily concentrated on its visible consequences rather than probing its underlying root causes. Commonly studied outcomes include land use changes, environmental degradation, and the proliferation of informal settlements [15–18]. Yet, these studies often fail to delve into the systemic drivers of urban sprawl, such as governance deficiencies, socio-economic inequalities, and policy inefficiencies [15,19,20]. An additional significant limitation in the existing research lies in its fragmented and often overly simplistic methodological approaches. Many studies adopt narrow, single-dimensional frameworks that fail to capture the interconnectedness of economic, social, and environmental factors with case studies of either large [11] or medium-sized cities [12]. Global metrics, while frequently used, often lack the contextual relevance necessary to address the unique characteristics of Iran's urban development. Furthermore, quantitative analyses frequently omit the perspectives of local experts, thereby missing critical socio-political and cultural insights that are essential to understanding the full scope of urban sprawl in the Iranian context.

To address the gaps in urban sprawl research in Iran, an integrated and multidisciplinary approach is crucial. This study tackles these challenges by a mixed-method approach combining qualitative and quantitative analyses for a comprehensive assessment of urban sprawl. The research investigates the drivers of sprawl through a PESTEL framework, considering environmental, political, economic, social, technical, and legal factors, and integrates the DANP (DEMATEL-based Analytic Network Process) multi-criteria evaluation and ISM (Interpretive Structural Modeling) approaches to incorporate expert insights into a structured analysis. By focusing on seven major metropolitan areas, this study offers a more expansive and nuanced understanding of urban sprawl dynamics, filling the gaps in previous research and contributing to more effective strategies for managing and promoting sustainable urban growth in Iran. The primary goal of this study is to address the following research hypotheses as defined below:

- H 1: Political, economic, social, technological, environmental, and legal factors contribute to urban sprawl, with political factors being the most influential.
- H 2: Social factors mediate the effects of political and economic drivers, amplifying urban sprawl in Iranian metropolitan regions.

- H 3: Urban sprawl in Iran reflects unique dynamics, differing from high-income countries, and is due to socio-economic factors and governance disparities.

2. Literature Review

Urban sprawl, characterized as a multifaceted phenomenon encompassing patterns, processes, causes, and consequences, presents a formidable challenge for scholars seeking to comprehend its intricacies. Addressing the complexities of urban sprawl requires an understanding of its diverse drivers across different contexts. By tailoring strategies to specific regional challenges and promoting sustainable development practices, policymakers can work towards creating resilient cities that balance growth with environmental stewardship and social equity.

Urban sprawl is shaped by regional socio-economic conditions, cultural values, government policies, and geography. In North America, particularly the United States, sprawl became prominent after World War II, driven by economic prosperity, affordable automobiles, and expanded highway infrastructure that enabled suburban migration [21]. The cultural ideal of the "American Dream", emphasizing homeownership in single-family homes with yards, reinforced this trend. Suburban living, associated with better schools, lower crime rates, and improved quality of life, attracted many families [22,23]. Government policies, such as zoning laws favoring single-use developments and tax incentives for suburban growth, further encouraged expansion into rural areas [24,25]. Federal investments in highway construction made suburban-to-urban commutes feasible [26]. In Europe, urban sprawl has been influenced by distinct historical development patterns and cultural preferences for compact urban living [27]. Unlike North American and Australian, where suburban expansion has been driven by rising incomes and a preference for single-family homes [28], European cities have historically favored denser development. Many cities are rooted in centuries-old urban designs that prioritize accessibility to amenities, public spaces, and community-oriented living [27]. Post-war reconstruction and economic growth did spur suburbanization in some regions, but the cultural emphasis on communal spaces and sustainable urban planning has limited the extent of sprawl [29].

In developing countries, urban sprawl presents a different set of challenges driven primarily by rapid urbanization [7] experiencing unprecedented population growth as people migrate from rural areas in search of better economic opportunities [3,7]. The socio-economic drivers of urban sprawl in these regions differ significantly from those in more developed contexts. Limited access to affordable housing within city centers forces many residents to settle in informal settlements or slums on the outskirts of cities, leading to inadequate infrastructure and services in these newly developed areas [30,31]. Governments in developing countries often struggle with effective urban planning due to limited resources and capacity; weak regulatory frameworks may allow unplanned developments that exacerbate sprawl issues [3,32]. The consequences of unchecked urban sprawl in developing countries are severe: environmental degradation occurs as green spaces are converted into housing or commercial developments without consideration for ecological balance [8]. Socially, informal settlements often lack basic services such as clean water, sanitation, and healthcare access, resulting in significant disparities between affluent neighborhoods and marginalized communities [3,7].

Researchers seek to understand the underlying factors contributing to urban sprawl. The shift from agricultural to industrial and service-based economies has transformed cities into hubs of economic activity, attracting large populations in search of employment. This influx often leads to overcrowding in central urban areas, prompting the outward expansion of cities [33]. Additionally, the affordability of suburban housing compared with central urban areas, coupled with higher land values and property taxes in city centers, incentivizes

outward migration [32]. Bhatta [34] highlighted the role of cost differentials and housing preferences in fueling suburbanization. Socio-cultural factors also play a significant role in shaping urban sprawl. Preferences for spacious housing, green surroundings, and suburban lifestyles often drive middle- and upper-class populations to relocate to suburban areas [35]. Population growth and migration also play a pivotal role in urban sprawl, particularly in developing countries [34]. Rapid population growth in urban centers leads to increased demand for housing and services, often outstripping the capacity of existing infrastructure. This results in the expansion of urban boundaries into surrounding areas [36]. Rural-to-urban migration exacerbates this trend as migrants often settle in peripheral areas where land and housing are more affordable [30]. Demographic shifts, such as the rise of nuclear families and aging populations, further influence housing demand and contribute to the expansion of urban areas [32,34,37].

Political and governance factors significantly influence urban sprawl, particularly through land use policies and planning frameworks. Weak enforcement of zoning regulations and fragmented urban governance often result in unregulated development in peri-urban areas [38]. Governance inefficiencies contribute to haphazard urban growth. In some cases, political agendas, such as promoting housing projects in suburban areas for electoral gains, can exacerbate sprawl [39]. Profit-driven land sales by municipal authorities in developing nations encourage unchecked urban expansion [30].

Investments in highways and road networks improve connectivity between urban centers and suburban areas, making it easier for people to live farther from their workplaces [10,25,26,31]. Moreover, the widespread availability of automobiles and improved transportation infrastructure has made commuting from peripheral areas feasible, further encouraging sprawl [40]. However, transportation policies that prioritize road infrastructure over public transit systems can inadvertently promote low-density residential developments. Automobile dependency is a significant enabler of suburbanization, as it reduces the need for proximity to city centers [41].

Environmental factors, including natural topography, climate conditions, and proximity to resources, shape the direction and extent of urban sprawl. Cities located on flat terrains are more likely to experience horizontal expansion compared with those surrounded by mountains or water bodies [5].

Inadequate institutional capacity, lack of cohesive urban planning policies, and speculative land markets contribute to unplanned urban growth [42]. In developing nations, these challenges are compounded by financial constraints and bureaucratic inefficiencies [35].

Technological advancements have also facilitated urban sprawl. Improvements in transportation technology, such as widespread automobile ownership, and advances in telecommunications, which reduce the need for proximity to workplaces, have made suburban living more viable [43].

3. Methodology

3.1. Case Study

The study examines all of Iran's metropolitan regions, consisting of seven areas with populations over one million, as recorded in the 2016 census by the Statistics Centre of Iran [44]. These regions include urban cores and adjacent built-up areas within defined proximity, officially classified as metropolitan areas. Threshold distances vary based on geography, urban planning, and infrastructure. For Tehran–Karaj metropolitan region, the threshold extends up to 50 kilometers due to significant sprawl, while other regions have thresholds up to 40 km, influenced by size, density, and development patterns [45]. These thresholds demarcate urban cores from surrounding rural or natural areas. Measuring urban density, such as the ratio of developed to natural land, could further refine these

boundaries. Each metropolitan area has unique spatial dynamics affecting thresholds. Accessibility to parent cities via established road networks ensures the inclusion of urban and peri-urban areas contributing to sprawl [46,47]. Smaller rural settlements with populations over 50 households are also included, providing a comprehensive analysis of urban development patterns.

This study examines population, density, and the number of peripheral settlements across seven major Iranian metropolitan regions in 2020. The Tehran–Karaj metropolitan region, with a population of 13,168,515 and a density of 188.96 persons per hectare, is the largest and most densely populated, encompassing 60 peripheral settlements. Mashhad follows with a population of 2,991,433 and a density of 89.45 persons per hectare, with 45 surrounding settlements. Isfahan and Tabriz are also significant, with populations of 2,738,660 and 1,714,082, respectively, and densities of 79.44 and 102.98 persons per hectare, including 41 and 46 peripheral settlements. Shiraz has a population of 1,607,616 and a density of 45.97 persons per hectare, with 47 peripheral settlements, while Ahvaz, with 1,354,139 people and a density of 79.27 persons per hectare, includes 38 settlements. Qom, the smallest in terms of population, has 1,103,856 residents and a relatively high density of 162.67 persons per hectare, along with 18 settlements. Altogether, these metropolitan regions encompass a total population of 24,678,301 and 295 peripheral settlements, reflecting diverse spatial and demographic dynamics across the regions (Statistics Centre of Iran) [48].

Between 1990 and 2020, there has been a remarkable transformation in the number and spatial distribution of peripheral settlements within each metropolitan region under study. Over this 30-year period, the total count of peripheral settlements witnessed a substantial increase, escalating from a mere 60 in 1990 to a notable 295 by the year 2020 across the examined regions. This significant rise underscores the dynamic nature of urban development and the evolving patterns of settlement expansion on the periphery of metropolitan areas. Figure 1 serves as a visual representation of the directional distribution of peripheral settlements for each case study, providing insights into their evolving spatial patterns over the three-decade period. The graph offers a comprehensive view of how these settlements have proliferated and shifted in location over time within the respective metropolitan regions. Notably, the graphical depiction reveals a pronounced escalation in both the number and the degree of concentration and clustering of peripheral settlements, particularly during the latter years of the study period, from 2010 onwards. Furthermore, it is evident from the data that the expansion of the road network and suburban rail systems has played a pivotal role in shaping the emergence and spatial distribution of these peripheral settlements. The development and enhancement of transportation infrastructure, including the expansion of road networks and the establishment of suburban rail lines, have facilitated improved accessibility to previously remote areas surrounding urban centers [26,28]. This increased accessibility, in turn, has spurred the growth and proliferation of settlements on the periphery, as individuals seek more affordable housing options or choose to reside in areas offering a better quality of life away from the congested urban core.

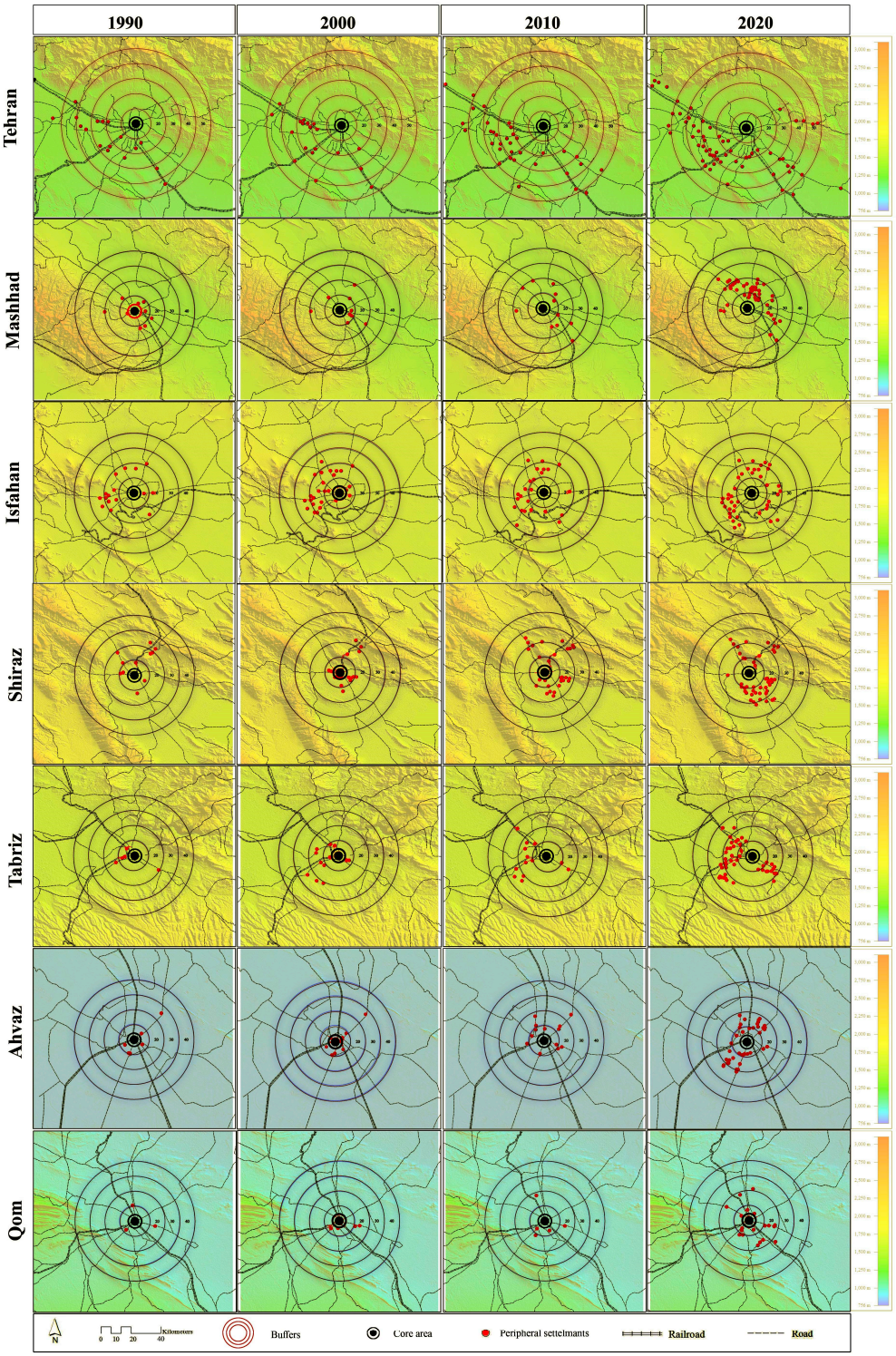

Figure 1. The spatial distribution of peripheral settlements for each metropolitan region (Source: Statistics Center of Iran, 2020 [48]).

3.2. Methods

3.2.1. Research Framework

This study uses a hybrid approach to identify and analyze the drivers of urban sprawl in Iran as a developing country. In this approach, after reviewing the research literature in order to extract the drivers of urban sprawl, a combination of PESTEL analysis, the Delphi technique, and the DANP (DEMATEL-based Analytic Network Process) multi-criteria decision-making method has been used to categorize, identify, and determine the

cause-and-effect relationships between the drivers of urban sprawl and, finally, to rank them. The process of this study is illustrated in Figure 2. Each method was selected based on its unique potential and characteristics to provide more profound and practical insights, which will be explained below.

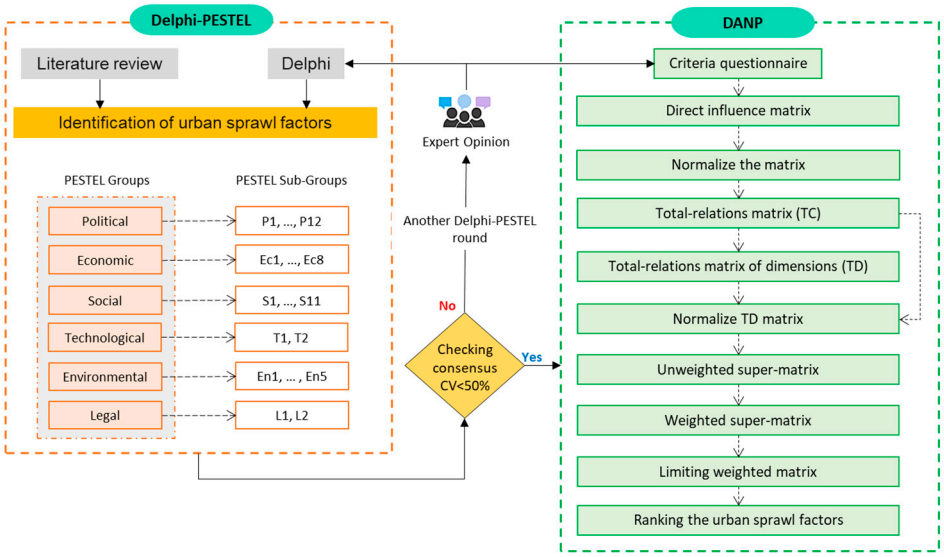

Figure 2. Research process (Source: Authors, 2025).

3.2.2. Delphi-PESTEL

Urban sprawl is a complex issue driven by numerous factors, necessitating a comprehensive understanding of its influential elements. In this study, following a review of the existing literature, drivers of urban sprawl were extracted and categorized based on PESTEL analysis. PESTEL analysis provides a valuable framework for examining political, economic, social, technological, environmental, and legal impacts on urban sprawl. This systematic approach assists researchers not only in identifying the principal drivers of sprawl but also in situating the issue within a broader context. Subsequently, the Delphi method was employed to achieve consensus among a panel of experts regarding the identification and evaluation of the drivers of urban sprawl extracted from the literature. As established, key tasks within the Delphi method include expert panel selection and questionnaire design [49,50]. Consequently, 19 experts were identified for this study, of whom 12 participated in the survey. It has also been demonstrated that a panel of 5 to 15 experts can yield reliable results [50].

The expert panel comprised academic researchers, government officials, and professional urban planners (see Appendix A) selected from the study areas. This selection ensured a more nuanced understanding of the respective urban regions' political, economic, social, and environmental contexts. Their insights were crucial in identifying and understanding the unique drivers of urban sprawl within Iranian metropolises, which broader, non-localized studies might overlook. Experts were contacted via telephone and email, and follow-ups were conducted to ensure questionnaire completion. Responses were collected through a structured questionnaire to streamline the data collection process and ensure consistency. Data collection took place between January and June 2023. The data collection process was ethically approved by the Research Deputy of Shiraz University, further ensuring the reliability and integrity of the methodology.

Firstly, the urban sprawl drivers extracted from the literature review were categorized into the six categories of the PESTEL framework, and a questionnaire employing a 5-point Likert scale was developed and administered to the experts for their evaluation. Previous

studies have utilized 10-point and 5-point Likert scales in Delphi questionnaires, with the 10-point scale typically used to assess the importance level of factors and the 5-point Likert scale used to examine the level of agreement among participants [49]. Therefore, this study employed a 5-point Likert scale to quantify expert opinions and achieve consensus regarding the urban sprawl drivers within the PESTEL framework. The experts were asked to rate the urban drivers from 1 (least important) to 5 (most important). After the experts completed the first round of the questionnaire, some overlapping factors were merged, and factors with a mean score of less than 3 were removed. The questionnaire was then redesigned and sent to the experts again. After the second round of the questionnaire was completed, the responses were collected. At this stage, the coefficient of variation (CV) fell below 50%, indicating consensus among expert opinions. Consequently, the Delphi process was terminated after the second round. A coefficient of variation below 50% has been shown to indicate a satisfactory level of consensus among experts [49]. Following the consensus among expert opinions, 40 urban sprawl drivers were identified within the PESTEL framework. Figure 3 presents a framework of urban sprawl drivers in developing countries organized within the PESTEL framework. See Appendix B for more information.

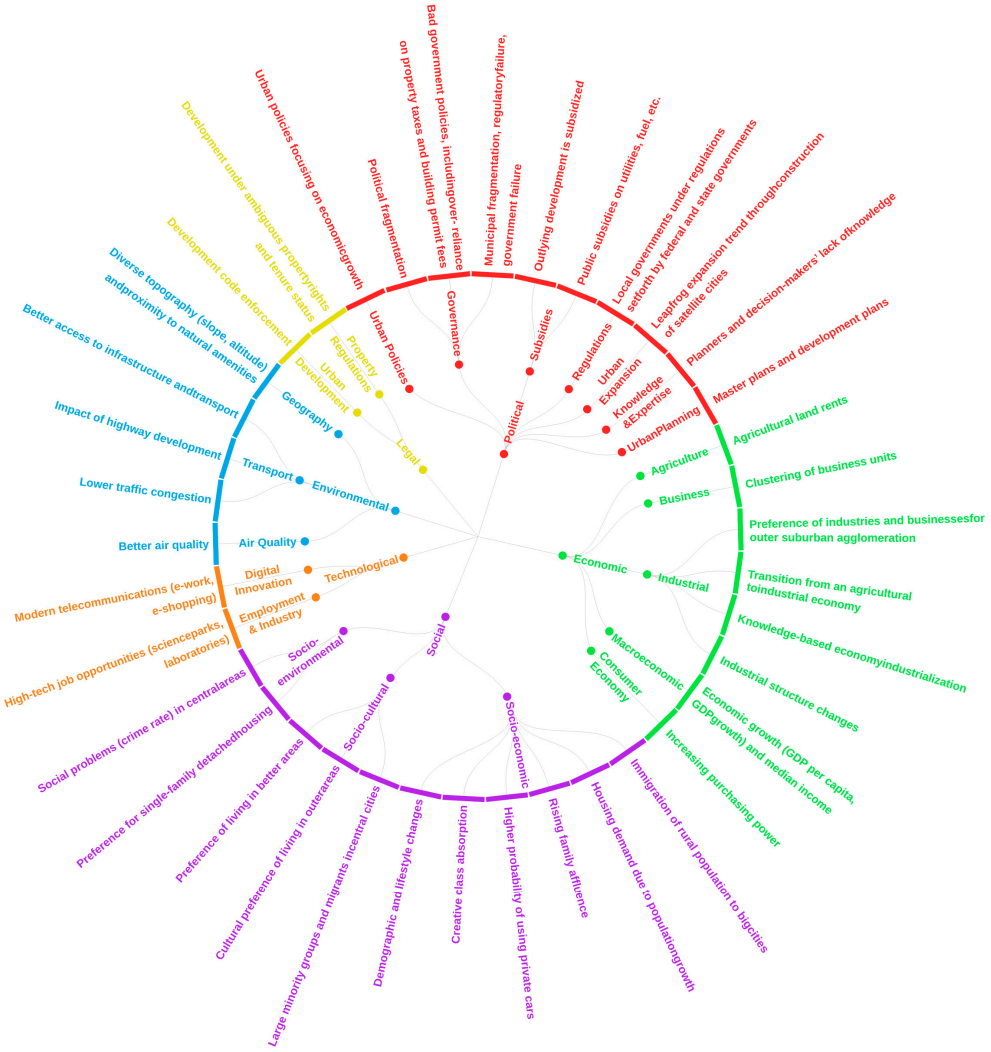

Figure 3. Framework of urban sprawl drivers (Source: Authors, 2025).

3.2.3. DANP Analysis

Following the extraction of drivers using the Delphi-PESTEL approach, a DANP-based questionnaire, structured as a matrix, was developed for the 40 sub-factors (drivers) constituting the six main factors. This questionnaire was administered to the expert panel, who were asked to evaluate the influence of each indicator on the others using a scale ranging from 0 (no influence) to 4 (maximum influence). All 12 experts participated in this phase.

The DANP method is a hybrid approach within the multi-criteria decision-making (MCDM) method. It combines the Decision-Making and Trial Evaluation Laboratory (DEMATEL) and the Analytic Network Process (ANP) [51]. The DANP method examines the influence and interdependencies among the drivers and the PESTEL factors. Specifically, this method analyzes the causal relationships between criteria and determines their importance and weights. Within DANP, the interrelationships and influences between factors (both drivers and PESTEL dimensions), as well as the magnitude of these influences, are assessed using the DEMATEL method. Subsequently, the weights of the factors are calculated using the ANP technique to confirm their relative importance.

4. Results

4.1. PESTEL Analysis of Urban Sprawl Drivers in Iran

The output of the PESTEL model is summarized in six general factors: political, economic, social, technological, environmental, and legal, with each factor consisting of several specific sub-factors as determined basically by experts' knowledge. The political factor has the highest number of sub-factors, divided into national and local levels, followed by the social factor, which includes three categories. The economic factor has seven sub-factors, the environmental factor has five, and the technological and legal factors each have two sub-factors.

4.2. Analysis of Interaction of (Sub) Factors

In this study, the direct and indirect interactions between urban sprawl drivers were determined through the DEMATEL method. The results of the DEMATEL analysis are shown in Table 1 and Figure 4. The results of analyzing the main PESTEL factors show the interaction of the drivers of urban sprawl overall. The D values in Table 1 indicate the intensity of the influence of one factor on the others. The Legal factors, with a 0.854 D value, plays a dominant role, meaning that it has the greatest effect on the other factors. The Technological factors, with a D value of 0.751, has the least impact on the other factors. The R values indicate how much one factor is influenced by the other factors. Based on this, the Social factors, with an R value of 0.812, has the most influence over the other factors, while the Technological factors has the lowest influence, with an R value of only 0.724. The D+R values indicate the importance of a factor compared with other factors—the higher the value, the greater the interaction with other factors—and, therefore, the greater importance in the system. The Social factors, with a value of 1.609, is the most important; the Technological factors, with a value of 1.475, is the least important in terms of interaction with the other factors. The D-R values indicate the final value of the impact of each factor on the set of other factors. The positive values listed under the Main Factors in D-R column indicate which factors are a cause, while the negative values indicate which factors are an effect. According to Table 1, the most important causal factors (D-R > 0) are the Legal factors, while the most important effect factors (D-R < 0) are the Environmental factors. In addition, Figure 4 depicts both the cause-and-effect factors. Furthermore, the lines demonstrate the relationship between the factors, and the directions indicate the influence flow. Factors located above the X axis are causal factors, while those located below the X

axis are effect factors. The X axis represents the magnitude of the effect. The greater the value of X, the greater the magnitude of the effect. The Political, Economic, Legal, and Technological causal factors were identified based on their importance, respectively. The effect factors were the Social and Environmental variables.

Table 1. Sum of influences given and received on factors (A) and sub-factors (B) (Source: Authors, 2025).

(A)

Main Factor	D	R	D+R	D-R
Political	0.786	0.763	1.549	0.023
Economic	0.785	0.764	1.549	0.021
Social	0.797	0.812	1.609	−0.015
Technological	0.751	0.724	1.475	0.027
Environmental	0.761	0.802	1.563	−0.041
Legal	0.854	0.808	1.662	0.046

(B)

Sub-Factor	D	R	D+R	D-R	Sub-Factor	D	R	D+R	D-R
P1	1.185	1.314	2.499	−0.129	S1	1.414	1.459	2.872	−0.045
P2	1.594	1.565	3.158	0.029	S2	1.388	1.628	3.016	−0.240
P3	1.566	1.542	3.108	0.024	S3	1.492	1.513	3.005	−0.021
P4	1.494	1.481	2.975	0.012	S4	1.617	1.284	2.902	0.333
P5	1.568	1.615	3.183	−0.047	S5	1.695	1.57	3.265	0.125
P6	1.562	1.431	2.993	0.132	S6	1.589	1.569	3.158	0.019
P7	1.35	1.377	2.727	−0.027	S7	1.464	1.642	3.106	−0.178
P8	1.607	1.646	3.252	−0.039	S8	1.336	1.427	2.763	−0.090
P9	1.502	1.701	3.203	−0.199	S9	1.458	1.439	2.897	0.02
P10	1.578	1.566	3.144	0.012	S10	1.475	1.466	2.942	0.009
P11	1.567	1.424	2.99	0.143	S11	1.367	1.299	2.666	0.068
P12	1.451	1.363	2.814	0.088	T1	0.231	0.239	0.47	−0.008
Ec1	1.14	1.051	2.191	0.089	T2	0.238	0.23	0.468	0.008
Ec2	0.869	1.066	1.935	−0.197	En1	0.624	0.669	1.292	−0.045
Ec3	1.035	0.912	1.947	0.123	En2	0.561	0.602	1.163	−0.041
Ec4	1.018	1.067	2.084	−0.049	En3	0.668	0.61	1.278	0.059
Ec5	1.041	1.137	2.177	−0.096	En4	0.721	0.651	1.372	0.07
Ec6	0.957	1.022	1.979	−0.064	En5	0.64	0.682	1.322	−0.042
Ec7	0.964	0.987	1.951	−0.023	L1	0.282	0.287	0.569	−0.005
Ec8	1.052	0.836	1.888	0.216	L2	0.259	0.254	0.513	0.005
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Considering the comprehensive analysis conducted through the D-R analysis method for each sub-model of the PESTLE framework, the findings presented in Table 1 shed light on the relative strengths and weaknesses of various factors within the Political, Social, Environmental, Legal, and Technological sub-models.

Following the Political sub-model, the results highlight several weak factors, including P1 (Urban growth (neo-liberal) policies), P5 (Urban policies focusing on economic growth), P7 (Public subsidies on utilities, fuel, etc.), P8 (Local governments under regulations set forth by federal and state governments), and P9 (Leapfrog expansion trend through construction of satellite cities). Conversely, the remaining factors within the Political sub-model are deemed influential, indicating their significant impact on urban sprawl dynamics. Notably, P1 (Urban growth (neo-liberal) policies) emerges as the most influential factor, with a D-R value of −0.129, while P7 (Public subsidies on utilities, fuel, etc.) exhibits the lowest effect acceptability, with a D-R value of −0.027. Among the cause factors, P11 (Municipal fragmentation, regulatory failure, government failure) stands out as the

most influential, with a D-R value of 0.143, while P4 (Bad government policies, including over-reliance on property taxes and building permit fees) and P10 (Planners and decision makers' lack of knowledge) exhibit the lowest effect on the set of factors within the Political sub-model.

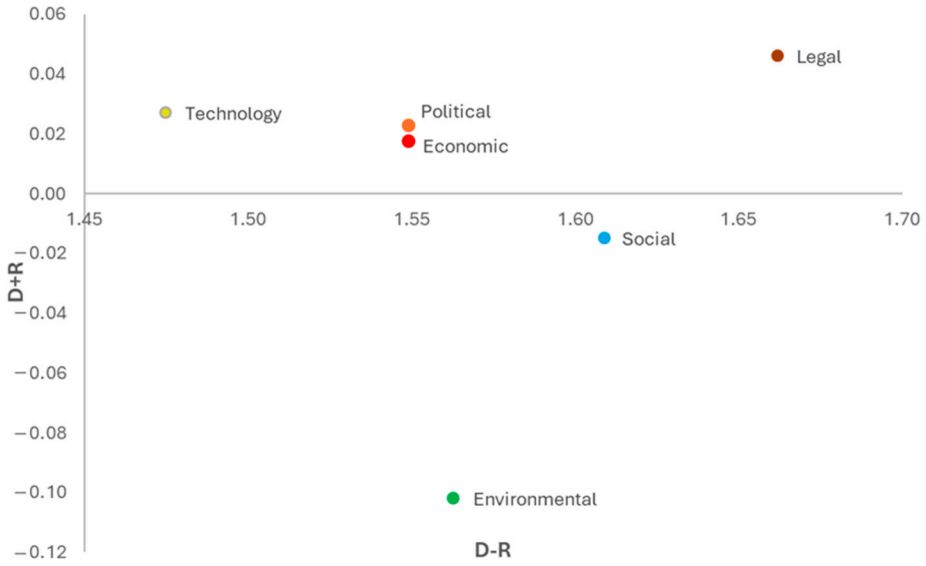

Figure 4. The cause-and-effect graph including main factors (Source: Authors, 2025).

Moving on to the Social sub-model, the analysis reveals that factor S2 (Housing demand due to population growth) holds the highest weak factor status, with a D-R value of −0.240. Factors S7 (Preference for single-family detached housing), S8 (Creative class absorption), S1 (Immigration of rural population to big cities), and S3 (Large minority groups and migrants in central cities) also rank as weak factors. Conversely, factor S4 (Cultural preference of living in outer areas) emerges as the most influential cause factor, with a D-R value of 0.333, followed by factors S5 (Rising family affluence), S11 (Preference of living in better areas), S9 (Social problems (crime rate) in central areas), S6 (Higher probability of using private cars), and S10 (Demographic and lifestyle changes).

Furthermore, the evaluation of the interaction between factors within the Environmental sub-model indicates that En4 (Diverse topography (slope, altitude) and proximity to natural amenities) exhibits the highest interaction with other sub-factors, making it the most important sub-factor with a D-R value of 1.372. En1 (Better air quality), on the other hand, is identified as a weak factor, with the highest effect acceptability (D-R value of 0.045). Meanwhile, En4 (Diverse topography (slope, altitude), and proximity to natural amenities) also displays the highest effect acceptability, with a value of 0.070.

Figure 5 provides a graphical representation of the interaction among the comprehensive factors of Iranian metropolises, offering a visual depiction of the complex relationships between various factors influencing urban sprawl within the context of Iran.

In the final stage of the analysis, the prioritization and ranking of factors and sub-factors contributing to urban sprawl in Iranian metropolitan regions were conducted using the DANP method. The results presented in Table 2 offer valuable insights into the relative importance of various factors and sub-factors in driving urban sprawl dynamics within the context of Iran. According to the findings, the Political factor, along with its sub-factors such as P3 (Political fragmentation), emerges as the most crucial determinant of urban sprawl in Iranian metropolises. This underscores the significant influence of political factors, particularly the level of political fragmentation, on the spatial expansion and development patterns observed in urban areas across Iran. The prioritization of political

factors highlights the need for effective governance and policy interventions to mitigate the adverse effects of urban sprawl and promote sustainable urban development practices. Following closely behind, the Economic factor, along with its associated sub-factors, secures the second position in the ranking of factors contributing to urban sprawl.

Figure 5. The cause-and-effect graph including sub-factors (Source: Authors, 2025). See Appendix B for labels of sub-factors.

Thus, this highlights the importance of economic dynamics, including factors such as economic growth policies, investment patterns, and income distribution, in shaping the spatial organization and growth patterns of urban areas in Iran. The high ranking of economic factors emphasizes the need for balanced economic development strategies prioritizing equitable growth and environmental sustainability. Conversely, the Technological factors ranks as the least influential factor contributing to urban sprawl in Iran, according to the DANP analysis. This suggests that while technological advancements and innovations may play a role in shaping urban development patterns, their influence may be relatively limited compared with other socio-economic and political factors. Furthermore, the sub-factor of S8 (Creative class absorption) is identified as the least important factor causing urban sprawl within the Iranian context. This demonstrates the nuanced nature of urban sprawl dynamics, with certain socio-cultural factors exerting less influence compared with other determinants such as political fragmentation and economic dynamics. Table 2 provides detailed insights into the ranking of factors and sub-factors, offering a comprehensive

overview of the relative importance of various dimensions in driving urban sprawl in Iranian metropolitan regions.

Table 2. Final weights of factors and sub-factors affecting sprawl (Source: Authors, 2025).

Factor	Final Weight	Rank			
Economic	0.222	2			
Environmental	0.101	5			
Political	0.303	1			
Legal	0.121	4			
Social	0.205	3			
Technological	0.047	6			
Sub-Factor					
Code	**Final Weight**	**Rank**	**Code**	**Final Weight**	**Rank**
P1	0.015	30	S1	0.031	11
P2	0.017	25	S2	0.027	15
P3	0.05	3	S3	0.008	39
P4	0.017	25	S4	0.01	36
P5	0.019	22	S5	0.009	38
P6	0.02	20	S6	0.011	34
P7	0.031	11	S7	0.025	16
P8	0.018	24	S8	0.011	34
P9	0.022	18	S9	0.008	39
P10	0.016	29	S10	0.033	9
P11	0.043	6	S11	0.031	11
P12	0.035	8	En1	0.015	30
Ec1	0.017	25	En2	0.01	36
Ec2	0.047	4	En3	0.022	18
Ec3	0.041	7	En4	0.03	14
Ec4	0.02	20	En5	0.024	17
Ec5	0.015	30	L1	0.07	1
Ec6	0.017	25	L2	0.052	2
Ec7	0.019	22	T1	0.014	33
Ec8	0.047	4	T2	0.033	9
Ranking Colour Ramp		1			40

5. Discussion

The study aimed to identify the causes of urban sprawl in Iranian metropolises through a literature review and expert analysis using qualitative and quantitative techniques. It identified 40 sub-factors in six categories contributing to urban sprawl and discusses the results of each primary factor based on their ranks. In contrast to the diverse factors that contribute to urban sprawl in high-income countries, Iran's sprawl is predominantly shaped by socio-economic conditions and travel patterns [11]. As illustrated in Figure 6, economic, political, and social factors are Iran's most significant drivers of urban sprawl.

The findings indicate that political factors play a significant role in the emergence of urban sprawl in Iranian metropolitan areas, contributing to the fragmentation of administration and governance, failures in regulation, and inefficiencies in the government. Political factors such as "Political fragmentation" and "Municipal fragmentation, regulatory failure, government failure", in addition to their high impact, possess a higher relative importance than other factors and can be considered the primary driving forces. Unrestricted urban expansion and ineffective utilization of resources endure in spite of endeavors to mitigate sprawl, resulting in adverse economic and social consequences [13]. The aforementioned fragmentation has led to an abundance of autonomous governmental and administrative

jurisdictions responsible for overseeing land use planning and development, thereby intensifying the issue of sprawl. Numerous studies investigating the underlying causes of urban sprawl in Iran have yielded comparable findings. According to Mehriar et al. [10], the unchecked growth of urban populations contributes to the proliferation of urban areas, frequently resulting in the emergence of informal settlements and suburban development. This demographic transition is exacerbated by political fragmentation, which has been identified as a factor that encourages urban sprawl by enabling the outward growth from urban centers into adjacent regions [20]. Additionally, the absence of integrated urban planning and governance further complicates the issue, as existing planning frameworks often inadequately manage development, resulting in chaotic urban expansion [11].

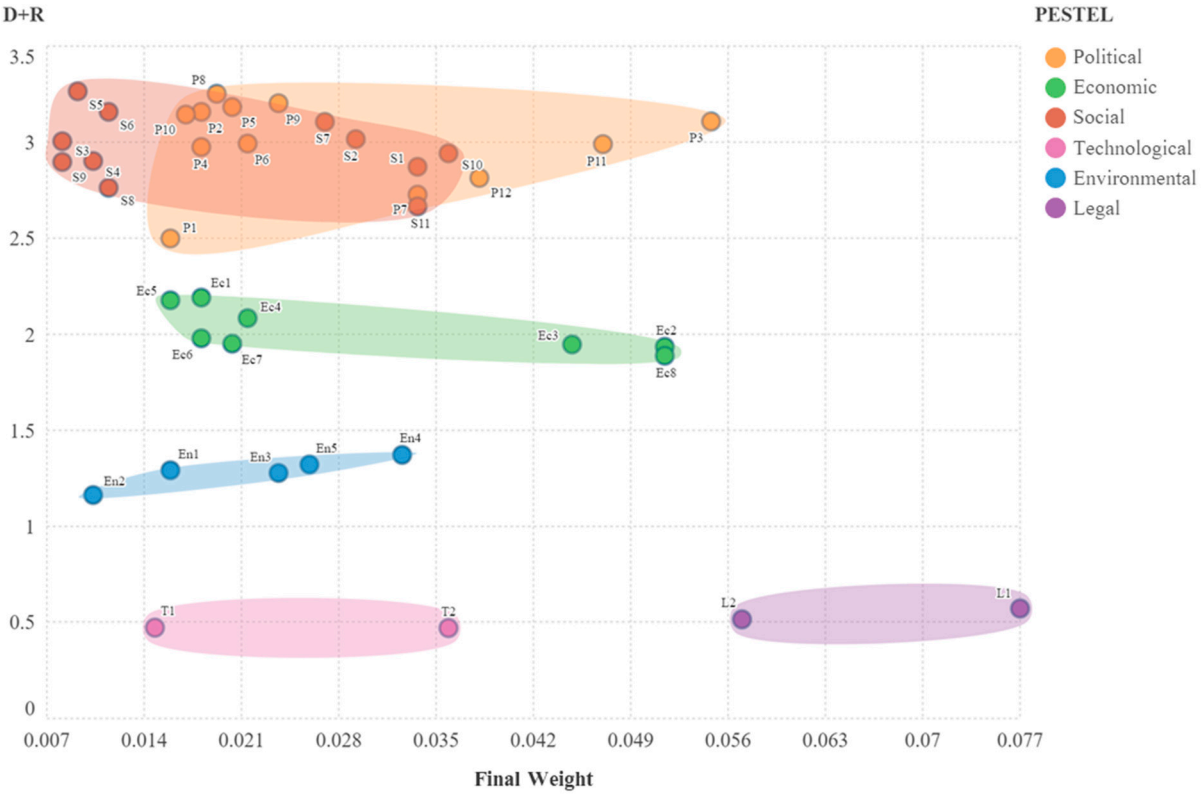

Figure 6. Influence and interdependence of PESTEL factors in urban sprawl development in Iran (Source: Authors, 2025).

There exists a worldwide correlation between political fragmentation and urban sprawl. In decentralized nations, both decentralization and local political fragmentation contribute to elevated sprawl indices [52]. A study conducted in China highlights that insufficient urban planning and governance are significant factors contributing to urban sprawl in the country. Numerous cities have faced challenges due to poorly coordinated land use strategies, resulting in ineffective transportation systems and disjointed urban growth [53]. The absence of robust spatial planning has led to the emergence of industrial and residential zones that lack proper connectivity, hindering residents' access to vital services and amenities [54]. Additionally, China's dual-track land transaction system, which integrates both state and market elements, complicates land use planning and frequently results in the misallocation of land resources [55].

The expansion of cities into suburban regions in pursuit of business opportunities, aided by reduced land costs and less stringent environmental regulations in contrast to city centers, is a consequence of globalization and economic competition that contribute to urban sprawl [35]. Sprawl is exacerbated by the economic incentive that promotes infras-

tructure expansion and business clustering [30]. Attitudes towards sprawl are additionally shaped by social factors, which encompass lifestyle preferences, climate variations, and cultural diversity [30]. Sprawl is exacerbated by economic disparities, urban amenities, and agricultural decline, all of which contribute to rural-to-urban migration [34]. Sprawl is fueled by the changing family structure and population growth-induced demand for housing, which is exacerbated by deficiencies in urban management [32]. In this context, it is important to recognize that China's swift industrialization has resulted in a considerable allocation of land for industrial activities, which has surpassed the rate of urban population growth [54]. This phenomenon of industrial expansion not only leads to the extensive consumption of land but also exacerbates environmental issues, as agricultural areas are transformed into industrial sites. Furthermore, the emphasis on economic development has frequently favored immediate benefits over long-term sustainable urban planning, culminating in urban growth that fails to take ecological factors into account [53–55].

The influence of governmental and legal frameworks on urban sprawl patterns is a critical issue in Iran and developing countries, highlighting the complex interplay between legislation, land use, and housing production. In Iran, legislation allows for significant governmental involvement in land procurement and horizontal expansion, aiming to address housing shortages [20]. However, this involvement is often undermined by land speculation driven by regulatory ambiguities, which inflate land prices and impede housing production despite a growing population [56]. For instance, the Urban Region Act of 2005 sought to consolidate existing frameworks to control sprawl but faced criticism for its lack of clarity regarding governance conflicts in urban peripheries [57]. In developing countries, similar challenges are evident. For example, in cities like Mumbai, speculative urbanism exacerbates land scarcity and complicates housing development. Authorities often respond to land shortages by incentivizing redevelopment, which can dilute protective policies and lead to increased informal settlements. This creates a cycle where unclear property rights and ambiguous regulations hinder effective urban planning and exacerbate housing crises [58]. Moreover, many developing nations struggle with ineffective enforcement of regulations that could mitigate sprawl, leading to unplanned urban growth and environmental degradation [3]. Globally, the impact of legal frameworks on urban sprawl varies significantly. In the United States and Germany, for instance, zoning laws play a crucial role in shaping urban development. Germany's comprehensive anti-sprawl measures focus on environmental considerations and sustainable land use practices [59], whereas U.S. zoning laws can be fragmented and less effective in managing urban growth [26]. The negative consequences of sprawl—such as loss of fertile land and increased greenhouse gas emissions—underscore the need for integrated legal approaches that promote sustainable urban development across different contexts.

In Iran, natural factors like topography and climate play significant roles in shaping urban development. The country's diverse geography, from mountains to deserts, affects how cities expand. For example, cities in mountainous regions face challenges in managing growth due to the terrain, while those in arid regions must contend with water scarcity and heat management [15]. In turn, urban sprawl and fragmented urban expansion have resulted in intensified urban heat islands (UHIs) and increasing land surface temperatures (LST), as evidenced in metropolitan regions of Tehran and Shiraz [60–64]. In many developing countries, rapid urbanization often occurs without comprehensive planning, leading to unplanned sprawl. Natural factors exacerbate this issue, as cities may grow in areas with challenging topography or harsh climates, complicating infrastructure development and service provision. For instance, in countries like Brazil, the Amazon rainforest's topography and climate pose significant challenges to urban planning and expansion [65].

Sprawl is facilitated by transport infrastructure systems, specifically highways, which attract residents and businesses to newly developed urban areas and improves accessibility [61,62]. The reduction in physical movement required within urban areas due to technological advancements, such as online shopping and remote work, is a factor in the phenomenon of sprawl [63]. The intricacies of the occurrence of urban sprawl in Iranian cities are influenced by a confluence of these elements, underscoring the necessity for comprehensive strategies pertaining to sustainable urban development and governance reform.

Urban sprawl is a phenomenon that is distinguished by its rapid horizontal expansion and substantial alterations in land use patterns. This is especially conspicuous in urban regions such as Isfahan, Baboland Tabriz [66–69]. Urban areas such as Mashhad and Urmia serve as prime examples of the difficulties associated with unsustainable sprawl, which are further compounded by climatic conditions and heightened automobile dependence [45]. The complexity of urban development in Iran is underscored by research that identifies density, land use, accessibility, and configuration as factors that contribute to urban sprawl [15,63]. There is considerable variation in the dynamics of sprawl expansion among different districts within cities. The enduring significance of urban expansion as a driver of spatial development is particularly evident in Tehran, where the interplay of population growth, transport infrastructure, and governance policies has shaped the city's sprawling form [42]. Over time, this expansion has contributed to inefficient land use, increased energy consumption, and reduced quality of life for residents, particularly those in peripheral areas. If left unaddressed, these trends could exacerbate urban challenges, including intensifying transit inequality [70], environmental degradation, social polarization [71], and economic inefficiencies. Furthermore, the long-term implications of unregulated sprawl may hinder efforts to achieve sustainable development goals, as sprawling cities often struggle to balance growth with environmental conservation and equitable resource distribution. Addressing the challenges posed by urban sprawl in Iranian cities requires a multi-pronged approach that integrates spatial planning, infrastructure development, and governance reforms. Policies should focus on promoting compact urban forms, enhancing public transit systems, and optimizing land use to reduce dependence on private vehicles and minimize environmental impacts. Additionally, governance reforms are essential to ensure that urban planning processes are participatory, transparent, and aligned with long-term sustainability objectives. By fostering synergies between spatial planning, transport policies, and environmental management, these strategies can mitigate the adverse effects of sprawl while supporting resilient and inclusive urban development.

Our research is subject to several limitations. Notably, the study does not directly assess the feasibility or effectiveness of the proposed policies and regulations. This gap may hinder the potential for converting research outcomes into actionable interventions. Nevertheless, it has accomplished considerable advancements.

6. Conclusions

Urban sprawl is a significant challenge faced by developing countries, where enforcing centralized planning rules and regulating land use can be difficult, leading to adverse effects on the environment, traffic, quality of life, and economic growth. In this article, the factors of urban sprawl in Iranian metropolitan areas are investigated. A comprehensive list of factors responsible for urban sprawl was compiled through a literature review and expert consultations, using the Delphi technique and PESTEL model. According to the study, political factors are the most significant drivers of urban sprawl in Iran, followed by economic and social factors. Key political factors include political fragmentation, the role of local governments under federal and state regulations, and comprehensive and urban

planning. To address urban sprawl and ensure responsible development in developing countries such as Iran, it is crucial to develop clear policies and regulations. The lack of a unified urban management system has resulted in various deficiencies in spatial land use, performance, policy-making processes, legislation, implementation, and benefits, which have all impacted the quantity and quality of urban development in Iran. Prohibited land uses, concentration of people outside the service areas of cities, and poor oversight are among the main problems that exacerbate the negative sprawl tendencies of Iran's urbanization. To prevent the formation of extensive urban regions, all stakeholders and beneficiaries must agree upon a clear and documented vision and strategy for urban development in Iranian cities. It is essential to address these challenges and effectively execute the law to ensure sustainable urban development.

The academic implication of this research is that it provides a more accurate and comprehensive understanding of the causes of urban sprawl in Iranian metropolitan areas, which can serve as a basis for further research in this area. The study employed a strategic approach that leveraged experts' opinions to analyze Iran's urban development system, assess the cause-and-effect relationships, and identify correlations between factors using the multi-criteria evaluation method (DANP). By using this approach, the study was able to identify country-specific factors that contribute to urban sprawl, which can be used to develop targeted policies and interventions aimed at mitigating its effects. Furthermore, the study highlights the importance of quantitative analysis in urban research to obtain a more accurate and nuanced understanding of the complex and multifaceted nature of urban sprawl in Iran. Moreover, the narrow focus on urban sprawl in Iranian metropolitan areas may restrict the applicability of the results to other regions or countries.

Author Contributions: Conceptualization, A.S. and P.A.; methodology, P.A. and M.J.; software, P.A. and M.J.; validation, P.A. and M.J.; formal analysis, A.S., B.B. and P.A.; investigation, A.S., A.A. and P.A.; resources, A.S.; data curation, P.A.; writing—original draft preparation, A.S., P.A., M.J., A.A. and B.B.; writing—review and editing, A.S., P.A., M.J., A.A. and B.B.; visualization, P.A. and M.J.; supervision, A.S. and B.B.; project administration, A.S.; funding acquisition, A.S. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Data Availability Statement: The data will be available on request.

Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

CV	Coefficient of Variation
DANP	DEMATEL-based Analytic Network Process
DEMATEL	Decision-Making and Trial Evaluation Library
PESTEL	Political, Economic, Social, Technological, Environmental, Legal
SCI	Statistics Centre of Iran
SWOT	Strengths, Weaknesses, Opportunities, and Threats

Appendix A. Characteristics of Participated Experts. Source: Authors, 2024

ID	Field of Expertise/Experience	Educational Level	Years of Experience	Employment Sector	City of Employment
A	Urban & Regional Planning, Urban Design, Landscape Architecture	Bachelor	Less than 5 years	Government/Public	Tehran
B	Urban & Regional Planning, Urban Design, Landscape Architecture	Masters	Between 5 and 10 years	Government/Public	Shiraz
C	Urban & Regional Planning, Urban Design, Landscape Architecture	Masters	Between 5 and 10 years	Academic	Tehran
D	Urban & Regional Planning, Urban Design, Landscape Architecture	PhD	Over 10 years	Private/Public-Private	Tehran
E	Human Geography	Masters	Between 5 and 10 years	Academic	Mashhad
F	Human Geography	PhD	Over 10 years	Government/Public	Tehran
G	Environmental Science and Engineering	Bachelor	Less than 5 years	Private/Public-Private	Mashhad
H	Environmental Science and Engineering	Masters	Between 5 and 10 years	Academic	Shiraz
I	Engineering (Water, Civil, Surveying, Construction, Mapping)	Masters	Between 5 and 10 years	Government/Public	Isfahan
J	Engineering (Water, Civil, Surveying, Construction, Mapping)	PhD	Over 10 years	Self-Employment	Tabriz
K	Engineering (Water, Civil, Surveying, Construction, Mapping)	Masters	Between 5 and 10 years	Private/Public-Private	Tehran
L	Sociology, Population Studies	PhD	Over 10 years	Government/Public	Tehran

Appendix B. PESTEL Model Output for Causes of Urban Sprawl in Iran, Source: Authors, 2024

Political Factors

Code	Category	Level (Scale)	Sub-Factor
P1	Urban Policies	National	Urban growth (neo-liberal) policies
P2	Urban Policies	National	Urban policies focusing on economic growth
P3	Governance	National	Political fragmentation
P4	Governance	Local	Bad government policies, including over-reliance on property taxes and building permit fees
P5	Urban Policies	National	Urban policies focusing on economic growth
P6	Subsidies	National	Outlying development is subsidized
P7	Subsidies	National	Public subsidies on utilities, fuel, etc.
P8	Regulations	Local	Local governments under regulations set forth by federal and state governments
P9	Urban Expansion	Local	Leapfrog expansion trend through construction of satellite cities
P10	Knowledge & Expertise	Local	Planners and decision-makers' lack of knowledge
P11	Governance	National	Municipal fragmentation, regulatory failure, government failure
P12	Urban Planning	Local	Master plans and development plans

Economic Factors

Code	Category	Level (Scale)	Sub-Factor
Ec1	Agriculture	Local	Agricultural land rents
Ec2	Business	Local	Clustering of business units
Ec3	Industrial	Local	Preference of industries and businesses for outer suburban agglomeration
Ec4	Industrial	National	Transition from an agricultural to industrial economy
Ec5	Macroeconomic	National	Economic growth (GDP per capita, GDP growth) and median income
Ec6	Industrial	National	Knowledge-based economy industrialization
Ec7	Industrial	National	Industrial structure changes
Ec8	Consumer Economy	National	Increasing purchasing power

Social Factors

Code	Category	Level (Scale)	Sub-Factor
S1	Socio-economic	Local	Immigration of rural population to big cities
S2	Socio-economic	Local	Housing demand due to population growth
S3	Socio-cultural	Local	Large minority groups and migrants in central cities
S4	Socio-cultural	Local	Cultural preference of living in outer areas
S5	Socio-economic	Local	Rising family affluence
S6	Socio-economic	Local	Higher probability of using private cars
S7	Socio-environmental	Local	Preference for single-family detached housing
S8	Socio-economic	National	Creative class absorption
S9	Socio-environmental	Local	Social problems (crime rate) in central areas
S10	Socio-economic	National	Demographic and lifestyle changes
S11	Socio-cultural	Local	Preference of living in better areas

Technological Factors

Code	Category	Level (Scale)	Sub-Factor
T1	Employment & Industry	National	High-tech job opportunities (science parks, laboratories)
T2	Digital Innovation	National	Modern telecommunications (e-work, e-shopping)

Environmental Factors

Code	Category	Level (Scale)	Sub-Factor
En1	Air Quality	Local	Better air quality
En2	Transport	Local	Lower traffic congestion
En3	Transport	National	Impact of highway development
En4	Geography	Local	Diverse topography (slope, altitude) and proximity to natural amenities
En5	Transport	National	Better access to infrastructure and transport

Legal Factors

Code	Category	Level (Scale)	Sub-Factor
L1	Urban Development	Local	Development code enforcement
L2	Property Regulations	National	Development under ambiguous property rights and tenure status

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