

RESEARCH ARTICLE

An analysis of the effects of the city physical development on urban environmental sustainability: A case study of Piranshahr city, Iran

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Abstract

The present study is aimed at investigating the spatial-temporal patterns and processes of urban development of Piranshahr city, Iran, from 1984 to 2025 by using satellite remote sensing images, spatial metrics, and Micmac scenario. Scenario techniques with partial contribution to Integrated Management in the city are examined and spatial analysis is performed on the satellite map in question using Indris in several different courses so as to estimate the role of these criteria in the physical development of the city and its instability. In fact, the present study applies the changes in agricultural land use of Shinabad in order to test the hypothesis as in the following: the annexation of an area can be influenced by the physical growth of urban spaces in Piranshahr. The findings indicate that although Shinabad has been joined to the city, it is one of the regions suffering from irregular expansion and inconsistent distribution of population due to successive migrations during the last decades.

KEYWORDS

environmental sustainability, future studies, physical development, Piranshahr, urban growth

1 | INTRODUCTION

Urban growth patterns are characteristic of spatial changes that take place in metropolitan areas (Aguilera et al., 2011). The spatial configuration and the dynamics of urban growth are important topics of analysis in contemporary urban studies (Bhatta, 2012; Wilson et al., 2003). Rapid urban growth accompanied by land cover change has turned out to be a global phenomenon observed all over the world. Several studies have tried to understand the spatial-temporal pattern of land cover change and the given driving forces (Allen & Lu, 2003; Veldkamp & Lambin, 2001). Urban growth is a broad concept that has been defined in several ways by many authors. It is generally acknowledged that urban growth constitutes physical and functional change of urban landscape due to social, economic, and political development (Black & Henderson, 1999; Kivell, 1993; Hall & Tewdwr-Jones, 2010), leading to a

transformation from rural landscape into urban forms, in turn effecting changes in land use and land cover (Belal & Moghanm, 2011).

Expansion of heterogeneous cities has worked against spatial evolution of geographical locations (e.g., urban and rural) in recent years. The reflection of the history of urbanization in Iran has occurred under the effect of various factors including political, economic, social, and geographical ones. This association has been so strong that a balanced and logical settlement system of an authentic transmittal system is disproportionate with spatial systems of villages and cities. Therefore, this irregular growth has led to unplanned construction of buildings and extreme changes in the spatial structure, particularly the expansion of cities on agricultural lands. This has, in turn, given rise to the need for conscious guidance and basic recording in addition to designing appropriate habitable space, and prevention of the destruction of agricultural lands (Gaylandeh, 2001, p. 20). The lack of plan-project synergy

and disconnection between the aims of the project and those of the comprehensive plan pose controversial issues in terms of the quality of the built form and efficiency and social justice in the city and the region (Carmona et al., 2009; Forsyth, 1999; Platt et al., 2008; Banai, 2013; Godschalk & Anderson, 2012; Rosa Pires, 2017). However, environmentalists measure urban growth via agricultural and horticultural land-use change outside the metropolitan area (Beck et al, 2003; Nelson, 1990).

In the same context, Piranshahr takes obvious dimensions of consequences in urban spatial expansion. This city is one of the most populated areas in the region (Rahnama & Sharifzadeh, 2018). Population developments and subsequent subsidiary physical expansion of the city have attracted serious attention from the Islamic revolution onwards. So, this city has merged with a peripheral village, Shinabad, a bond which has generated significant spatial and functional interactions (Consulting Engineers Armanshahr, 2009). Although the northern and southern sides of the city are surrounded by a river, the river is currently crossing through the city due to urban growth and town advances and the water is moving in a direction congruent with the slope from the side of the foot of the mountains to the plain areas and agricultural lands.

Since this city is located at the foot of the mountain and flat and fertile plains abound, this physical expansion has been concomitant with changes in land cover, degradation of agricultural lands, and annexation of Shinabad village.

Since this city is located at the foot of the mountain and flat and fertile plains abound, this physical expansion has been concomitant with changes in land cover, degradation of agricultural lands, and annexation of Shinabad village. According to rapid changes in population and physical growth of the city, urban development planning and organizing appear to be more important and urgent than ever with regard to guaranteeing the formation of physical-space extension of the city according to the factors involved in the development, involving desirable expansion along with physical development and reasonable changes in land cover, bringing about minimal damage to agricultural lands and surrounding villages.

In this study, Holder model and satellite images are drawn on to analyze and interpret the current situation. Moreover, using statistical analyses in futurology and Micmac software associated with spa-

tial analysis on topographic maps, an attempt is made to meticulously examine the current status of the city.

To sum up, this study is mainly aimed at scrutinizing the physical-spatial expansion of urbane connection with effective indices in land cover changes around the city and its surrounding villages in land use changes. With an eye for sustainable developments in answering the given questions and proposed indications in order to determine the physical and spatial developments in Piranshahr urban land cover changes, the study also pursues a number of subsidiary goals including assessing the role of physical-spatial expansion of urban areas in Piranshahr, creating changes in land cover and increasing productivity (efficiency, effectiveness), and making decisions based on practices of city managers in creation of urban sprawl, all of which are addressed in the framework of the principles of land's sustainable development.

Environmental sustainability has become an essential part of urban performance reporting and planning. In this regard, the link created between future studies, especially foresight approaches, and the urban environment has significantly contributed to the modern urban planning. Since the 1970s, the science of future studies has been an important tool for developing environmental policies (Nazemi, 2006, p. 110).

Population pressure and proximity to resource limitations, current or anticipated exogenous environmental impacts and a greater sense of global responsibility have catalyzed those planning or governing cities to be guided by studies of environmental sustainability (Baynes & Wiedmann, 2012).

The significance of the study lies in looking for changes in qualifications and factors which affect the expansion and growth of urban areas with the rate of perspective neighborhoods shaped by sustainable development and occupied a particular place in shaping cities in recent years. Sustainable urban development has mainly focus on the urban areas management. However, a number of minor, still important, issues have remained unexplored in studies of sustainable development. Sustainable development is the logical approach to spatial-physical development and it is essential to conduct research on the relationship between physical expansion of cities and proposed changes that shape the appearance of sustainable urban development in order to yield the most optimum results in the domain of land use and surrounding villages.

2 | THE SCOPE OF STUDY

As the political center of Piranshahr County, Piranshahr is located in the southwest of West Azerbaijan Province, 12 km from the Islamic Republic of Iran's border with Iraq (The Kurdistan Regional Government of Iraq). This town shares it borders with Oshnavieh and Naiade from the north, Sardasht from the south, and Mahabad from the east. Based on the Population and Housing Census of 2006, its population was 59,721 (Iran Statistical Center, 2006). It increased to 99,750 in 2016 (Ibid, 2016).

As seen in Exhibit 1 above, Piranshahr is limited to Haji Omaran Mounts as the border from west and southwest. On the other side of these mountains is located The Kurdistan Regional Government of

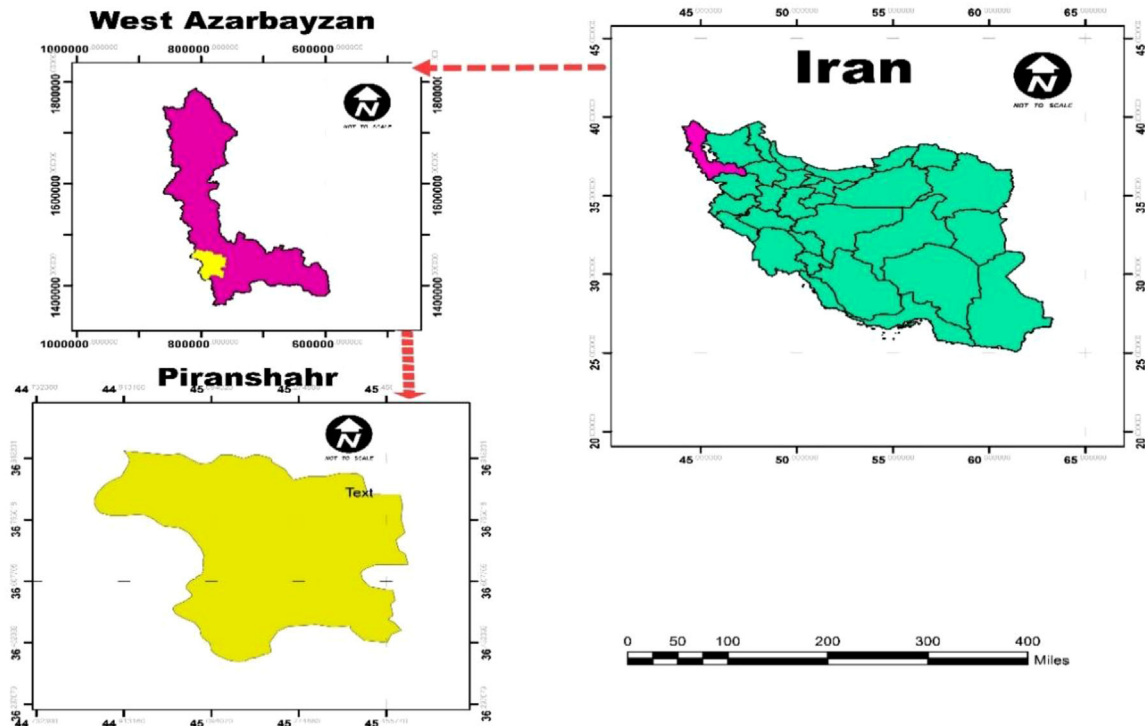


EXHIBIT 1 Geographic location city of Piranshahr.

Source: (www.irandwg.com); Authors (research findings) [Color figure can be viewed at wileyonlinelibrary.com]

Iraq, and Tamarchin Border Market is located at the zero point of the border. Moreover, Sardasht and Naqadeh are respectively located in the north and south of Piranshahr (Exhibit 1).

With an especially strategic and geopolitical situation in the northwest of Iran and adjacent to the north of Iraq, Piranshahr has proper and easy access to Turkey via Oshnavieh (Exhibit 1). Moreover, located on the Zagros mountain range, being sub montane and having a good and clean climate with excellent environmental conditions, jungle and natural resorts, a pristine and unique nature, and a variety of plant and animal species, Piranshahr has enormous potentials in various tourism sectors such as business tourism, ecotourism (such as permanent water-rich rivers, water-rich springs, dense and lush oak forests), historical places, cultural elements, the presence of traditions, unique traditional clothes of the citizens, and local music.

3 | MATERIALS AND METHODS

Different methods are ranked in scientific and qualitative categories which are selected based on theoretical issues in the present study. Due to the research's theoretical debates and existing theories, as well as the history of the physical expansion of cities, land cover changes have been selected based on historical research methodology and information provided by the library of documents and maps, Land sat 7 and 8 in the first stage; theoretical and experimental research which is gathered by analyzing the information on land use and physical features of cities were also used to integrate required data.

In the second part of the present article, using futuristic approach in the framework of indicators and factors affecting urban growth patterns in sustainable environments, a socio-cultural analysis is carried out on macro and micro scales in Iran; field studies and questionnaires are used in the framework of the Delphi model and Micmac analysis application. Required data is collected through the formation of group meetings and discussions. The sampling method is purposeful and non-randomized. The statistical population of the study consists of 30 subjects with the Exhibit 2 demographic characteristics.

EXHIBIT 2 Demographic data and area of the city of Piranshahr during 2006 and 2025

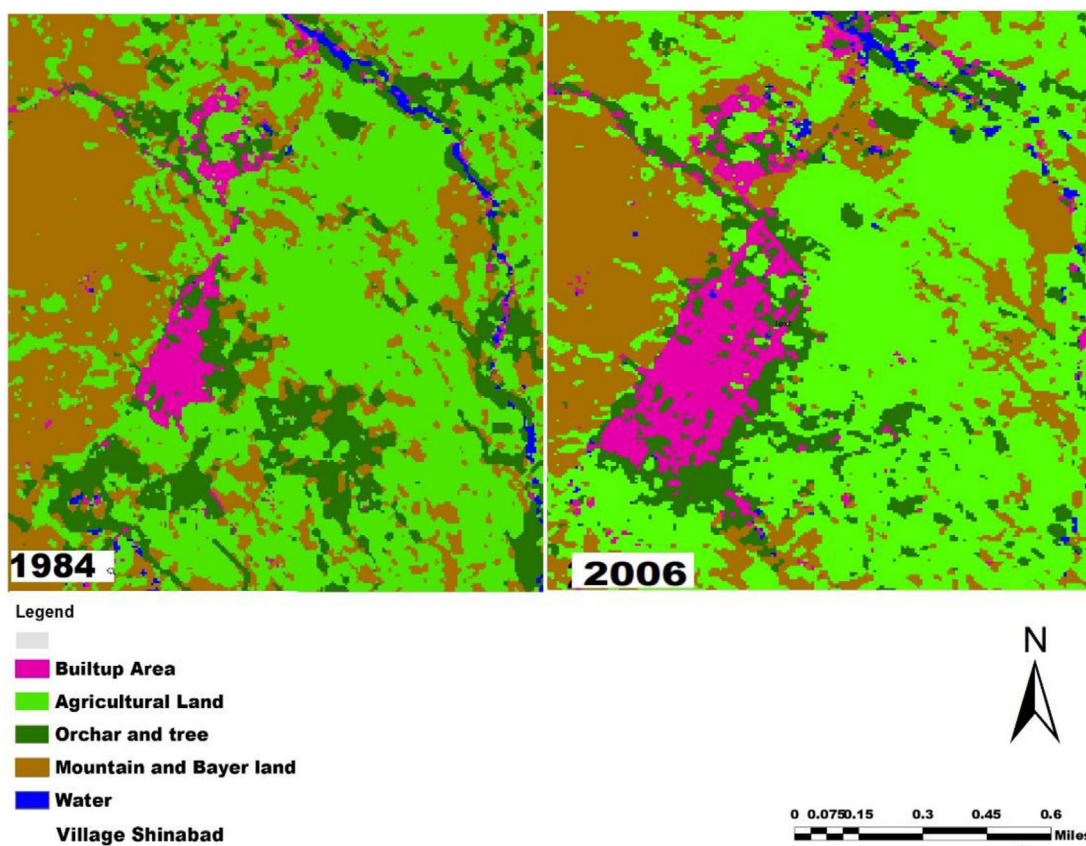
Period	Urban area (in hectares) (A)	Population (P)	Gross per capita (a)
1984	211.41	13456	157.11
2006	418.77	59721	70.1
2013	1161.27	75600	153.6
2020	1348.56	112942	119.4
2025	1548.369	137411	112.68
Confine Village Shinabad 2006	86.45	5018	-
Confine habitancy's Informal 2006	108	6748	-
In the year 2030, urban growth is expected to reach the villages of Kasoradeh village in the near future, but not yet fully integrated.			

Source: Master Plan of 2018 and Authors (Research findings).

EXHIBIT 3 Area characteristics of Piranshahr city over the period 1984–2025 (to hectares)

Legend	1984	2006	2013	2020	2025
Built-up area	211.41	418.77	1161.27	1348.56	1548.36
Agricultural land	2830.23	2941.56	1960.92	2225.16	2040.11
Orchard and tree	892.89	598.59	790.20	514.98	466.78
Mountain and Bayer land	2186.46	2160.36	2159.37	2012.13	2010.58
Water	56.61	58.32	105.84	76.77	96.77

Source: Authors (Research findings); (Results of spatial analysis in IDRISI); (www.earthexplorer.usgs.gov).

**EXHIBIT 4** Physical expansion map of Piranshahr city

Source: (www.earthexplorer.usgs.gov); Authors (research findings) [Color figure can be viewed at wileyonlinelibrary.com]

4 | RESULTS

4.1 | Section 1: Urban growth analysis

Given the rapid population dynamics and physical expansion of the city, the necessity of planned development and organization of the city in order to determine its spatial development emphasizing the factors influencing development and reasonable changes in land cover with the least damage to agricultural lands around the city and peripheral villages seems to be of paramount importance. Therefore, it was tried to consider the scientific and qualitative aspects of the research using the descriptive-analytical method and the planning of the scenario in 2025 horizons, examined by the combined indicators of the city's physical planning with the Heldren model according to the statistics and infor-

mation available. Then, ETM+TM satellite image (1984–2025) in the IDRISI software in different programming periods of the city has been used based on different planning periods in the city and its extension to the analysis on Landsat 7 and 8 maps. The models which are provided from now on will provide necessary explanation in the specific issue under discussion (Exhibits 3 and 4).

4.2 | Statistical model

4.2.1 | Heldren models

One of the fundamental methods for determining ugly urban development is Heldren method. John Heldren in 1991 used a method

for determining horizontal development of the city and the population growth. (Beck et al., 2003). Using this method can determine the extent to which the development of the city is resulted from population growth and from ugly urban development. In his model, Helder used the Gross per capita Land formula as in the following (Hekmatnia & Mousavi, 2006).

In the Helder method, using the per capita formula, $a = A/P$ (gross share [a] equals division of land area [A] by population [P]).

$$\alpha = A/P \quad (1)$$

In this way, ugly urban development in the urban development is determined. It can be concluded that the whole land that is occupied by an urban region (A) equals product of gross share (a) and population (P). So, we will have:

$$A = p \times a \quad (2)$$

According to Helder's method, if population increases by (Δp) during the period of (Δt), and the land use share changes by (Δp), all the urban lands will increase by (Δp); and then by replacing in two correlations, you will conclude. Based on the method of Helder during the period (Δt , Population increases with the growth of ΔP And per capita land use change by Δa , the total urban lands increase ΔA as the result of this relationship (Molavi & Roshan, 2018, p. 7). Arithmetically if the equation (as numerator) is divided by A (as denominator), it is possible to achieve changes in the area, $\Delta A/A$, converted to city within Δt period of time interval.

$$A + \Delta A = (P + \Delta P) \times (a + \Delta a) \quad (3)$$

By substituting Equations (2) and (3) relation and dividing it by (A), we can have the changes in boundary area ($\Delta A/A$) which has turned into a city during the period of (ΔT):

$$\frac{\Delta A}{A} = \frac{\Delta a}{a} + \frac{\Delta P}{P} \quad (4)$$

Considering this, by following Helder model, Equation (4) shows the percentage of a city growth: $\frac{\Delta A}{aA} \times 100$

In other words, Equation (4) means:

Total percentage of non-net share growth t total percentage of city's population growth = total percentage of towns extent (space).
Based on this fact, the share of population growth of the Land Sum is gained by the change ratio of the whole population in one era to the whole percentage change of land content of the same era. (5)

According to population growth model, Helder offers a general model to complete his own model.

Considering this, by following Helder model, Equation (4) shows the percentage of a city growth.

Note: Helder $A = \pi r^2$ found a general model based on population growth model equation.

$$P_t = P_{(0)} (1 + Y_{(P)})^t \quad P_t = P_{(0)} (1 + g_{(p)})^t \ln (P_{(t)}/P_{(0)}) \quad (6)$$

$$\ln (P_{(t)}/P_{(0)}) + (1/t) \ln (a_{(t)}/a_{(0)}) = (1/t) \ln (A_{(t)}/A_{(0)})$$

In which, P_t is the population in time (t), p_0 is the initial population, g_p is the population growth during a period to solve g_p you can use the following formula:

$$\ln (1 + qp) = \left(\frac{1}{t} \right) \ln \left(\frac{pt}{po} \right) \quad (7)$$

Because $\ln (1+x)$ is almost X for the values which are lower than x you can write equation as:

$$gp = \left(\frac{1}{t} \right) \ln \frac{P(t)}{P(0)} \quad (8)$$

The results of growth rate can also be written for land content (A) and share of Land usability:

$$gA = (1/t) \ln A(t) / A(0) \quad (9)$$

$$ga = (1/t) \ln a(t) / a(0) \quad (10)$$

Exhibit 2 provides information obtained from satellite mapping of Piranshahr as well as comprehensive plan data of 2025.

So, based on these growth rate Helder equation can be written as:

$$\ln (1 = g_{(P)}) g_p + g_a = g_A \quad (11)$$

Following is a statistical calculation based on Helder model.

$$\ln (P_{(2020)}/P_{(2006)}) + \ln (a_{(2020)}/a_{(2006)}) = \ln (A_{(2020)}/A_{(2006)}) \quad (12)$$

$$\ln \left(\frac{112942}{59721} \right) + \ln \left(\frac{119.4}{70.1} \right) = \ln \left(\frac{1348.369}{59721} \right) \quad (13)$$

$$(0.637) + (0.532) = (1.16) \quad (14)$$

Then, the share of the percentage of the population growth distribution and the distribution percentage of the Gross per capita growth in urban land with the division of each side of the relation to 1.16 is obtained:

$$\left(\frac{0.637}{1.16} \right) + \left(\frac{0.532}{1.16} \right) = \left(\frac{1.16}{1.16} \right) \quad (16)$$

$$(0.542) + (0.4588) = 1 \quad (17)$$

EXHIBIT 5 Components of Model Heldern

Period	$\ln (P_t/P_0)$	$\ln (a_{(t)}/a_{(0)})$	$\ln (A_{(t)}/A_{(0)})$	Relate to population growth	Sprawl growth
1984-2006	1.490	-0.80	0.683	2.18	-
2006-2013	0.236	0.784	1.02	%23	%77
2006-2020	0.637	0.532	1.16	54.2%	45.8%
2020-2025	0.196	(-0.05)	.138	-	-

Source: (www.earthexplorer.usgs.gov); Authors (Research findings).

The obtained results from Heldern model regarding Piranshahr city indicate that during 2006–2020, ~54.2% of the physical development is related to population growth and 45.8% of the city growth is related to horizontal growth and sprawl growth of the city that has reduced the Gross density of population and increased the Gross per capita urban land, all of which expanding Piranshahr city in the form of sprawl horizontal urban development (Exhibit 5).

4.3 | Section 2: Urban growth foresight

Cross – Impact Analysis: The method of analyzing Cross-Impact gives the possibility to reveal the variables essential to the evolution of the system. It is possible to use it alone (as a facilitator in reflection and/or decision making), or as part of a more complex forecasting activity (scenarios).

It is a way to analyze the probability of an issue occurring in a predicted set. The probabilities of this issue can be adjusted by judgments about the potential for interaction between the predicted issues. In fact, it can be said that some events can affect the probability of other events. Many events pave the way for extraordinary progress, because they cause other events in the course of domino effect. In the same way, the range of effects becomes wider at every moment. These relationships between events are the same as the Cross-Impact Analysis (Tomorrow Development Foundation: 2005).

The method of analyzing Cross-Impact/Structural effects is to identify key variables (explicit or implicit), in order to receive comments and encourage participants and stakeholders about the pros and cons and the complex and unpredictable behavior of a system.

In general, structural analysis is performed in four stages:

- Step: 1 Identifying the basic parameters or factors.
- Step: 2 Entering the factors and information into the Micmac software.
- Step: 3 Investigating the extent and nature of the relationships between the variables.
- Step: 4 Identifying key factors.

The Micmac Forecasting method was created by Michel Godet. The Micmac software gives the possibility to see, in real time, a part or all the players and the objectives involved and the impact of the modifications of the input data on the resulting graphs. Graphs make identify-

ing the influences and dependences between variables possible (Godet, 2000).

4.4 | Identifying the primary indices and forming the cross – impact matrix

Classifying the factors affecting physical development in the urban growth patterns in sustainable environments of Piranshahr was carried out within an n^* matrix. In so doing, eight main classes of variables (as shown in Exhibit 6), along with 48 subsidiary variables, were discovered as the study's primary variables after different discussions during meetings with the academicians and the executives and the elite as civil institutes, the ultimate result of which was the formation of a 48×48 matrix. After identifying subsidiary variables by forming the crossover influences matrix in the next step, the elite were required to evaluate the variables in question based on the level of their influence.

Also, field studies and questionnaires were used in the framework of the Delphi model and software analysis of scenarios. The data collection method was based on the formation of group meetings and discussions. The statistical population of the study consisted of 30 people, the sample population of which is as follows (Exhibit 7). The sampling method was purposeful and non-random sampling method was availed of. Data collection is done in two steps.

To analyze the urban environmental situation of Piranshahr purposefully, which is designed with a separate form, first, the variables were entered into the Micmac software; then, in the framework of the cross-impact analysis matrix, a number of experts and scholars in this research field and with the necessary experience, as statistical samples of the research, were asked to ascribe a score from 0 to 3 in addition to P to the variables based on the significance, impact, and the influence and dependence of the elements (0 = null, 1 = weak, 2 = average, 3 = strong, P = potential) (Godet et al., 2008, p. 91).

According to the basic principles of each research, a reliable measure is one which is repeated in other situations and provides considerably more efficient results. Thus, with a double rotation and repetition, the level of reliability reached to 93.9% in the current study which shows the status of indicators of physical development in the environmental sustainability of the city of Piranshahr, analyzed with the Micmac software., to be at a very high level, a point which further confirms the efficiency of the research model chosen to process data and information.

EXHIBIT 6 Direct classification, the variables are also localizable by their number on the horizon of 2025

Rank	Label	Variables	Direct influence	Direct dependence
1	S3	Master plan	128	300
2	W8	Positions dams provide drinking water	121	283
3	M5	Marginalization	118	276
4	M3	Literacy and education	115	269
5	M4	Impact of rural and inter-urban migration	113	265
6	Z1	Organic and unplanned urban development in the suburbs town	112	262
7	E8	Tension (water crisis)	108	253
8	S2	Zoning status of the land	105	246
9	N3	Spatial policies, such as protected area and conserved land	105	246
10	P2	Soil fertility Level	101	236
11	C1	Major markets for import and export of good	101	236
12	Z3	Non-standard density of residential units	98	229
13	Z4	Commercialization of land and pressure on agricultural use and ...	98	229
14	S4	Suitability of the land location for development	96	225
15	Z5	Growth of construction and renovation in the suburbs	94	220
16	W4	Underground water level	92	215
17	E7	Type of waste recovery and disposal	92	215
18	N2	Proportion of urban land in the surrounding area	91	213
19	W7	Surface water network	91	213
20	D7	Distance to urban center	89	208
21	C3	Activity diversification and the expansion of the weekly markets	89	208
22	W3	Transferring city drinking water	87	204
23	E6	Environmental and Natural diplomacy	87	204
24	W6	Pollution of water resources	86	201
25	S1	Slope	85	199
26	G1	Effect of faults on the city's headquarters	85	199
27	M1	The situation of urban green spaces	85	199
28	E4	Current status of municipal sewage network	84	196
29	D3	Distance to industrial sites	93	194
30	D6	Distance to market center	83	194
31	M2	Demographic characteristics	83	194
32	D2	Distance to minor roads	81	189
33	W5	air pollution	80	187
34	C4	Establishment of transport routes connected to the border road (Hajiomran)	79	187
35	D1	Distance to major roads	79	185
36	W2	Wind speed and direction	79	185
37	D5	Distance to rivers/streams	78	182
38	G2	Construction of tourist and recreational places close to the city	78	182
39	D4	Distance to minor city centers	77	180
40	E1	Noise pollution	77	180
41	E3	Industrial waste management, treatment and ...	77	180
42	E5	Urban waste situation	77	180
43	C2	Construction of tourist and recreational places close to the city	74	173
44	Z2	Inadequate spatial design of city tourism spaces	74	173

(Continues)

EXHIBIT 6 (Continued)

Rank	Label	Variables	Direct influence	Direct dependence
45	N1	Proportion of undeveloped land in the surrounding area	73	171
46	W1	Frost days	73	171
47	P1	Physical and chemical properties of soil	63	147
48	E2	Optical and electromagnetic pollution	39	91

Resources used to extract effective indicators in physical development: Cheng & Masser, 2003; Hersperger et al., 2010: 2004; Amer & Kuffer, 2013; De Koning et al., 1998; Hu & Lo, 2007; Kuffer & Richard, 2013; Verburg, 2006; Verburg, et al., 2004; Dubovyk et al., 2011; Huang et al., 2009 and Van Dessel et al., 2008.

EXHIBIT 7 The field of expertise and level of education of Delphi Participants

Degree of education	Number	Specialist field	Number
Master	8	Urban planning	8
A.M	9	Futures studies	5
Ph.D.	6	Urban Management	6
Post Ph.Ds.	2	Political Science	3
		Environmental Engineering	5
		Rural planning	3
Total	30	30	

Source: Authors (Research finding).

According to the statistical analysis of Mick Mac output in which the characteristics of the initial matrix are based on the viewpoints of experts in the domains of the relevant topic as the most important source of information (Godet, 2008, p. 73; Zali & sajjadi asl, 2017), it can be deduced that variables are highly fit and valid where the filling index obtained for the variables with two repetitions (high reliability) indicates 93.4%; this implies high influence coefficient and factor load in the variables and factors selected, indicating further the efficiency and credibility of the research tool. In addition, this point substantiates the efficiency of data processing in the software and the desirable level of collected information.

Based on the results of the initial state of formation of the matrices, the findings show that of the 2152 values calculated in the primary matrix of cross-effects by elites, 741 cases with the highest statistical volume have had high levels of effectiveness. Also, there turned out to be 693 moderate effects, 655 low-impact cases, and 152 ineffective, with the P (potential direct effect) being 63.

4.4.1 | Impact analysis: direct dependence on the physical development of the city of Piranshahr

In addition to meetings and brainstorming, it was imperative to extend the collection of variables by unconventional discussions with the representatives of possible players of the system under study. Detailed explanation of the variables is essential, because it allows a better perception of the relations between these variables further in the analysis (ZIRIUS, 2012).

Following the explanation and understanding of the criteria and completing the operation of the variables, the position of each item was examined, a point which is itself necessary for the interpretation of each variable with a realistic view of its present state. In the framework of Exhibit 6, the values quoted in the rows and columns of the cross-impact matrix for each variable are expressed (Weimer-Jehle, 2008, p. 369). With regard to understanding the numbers obtained in Exhibit 6, it should be noted that the sum of the values of each row indicates the extent of its effect, and the values of each column indicate the extent to which they are affected by other factors. Accordingly, the following variables obtain the highest score in order.

4.4.2 | Direct influence-dependence matrix and distribution of indices

Step 3. In completing the research software, after the formation of the primary matrix of cross-effects, the general characteristics of the spatial distribution of the variables and the calculated matrix in the case study were described in Exhibit 8. The spatial position of each variable expresses its role in explaining the subject.

4.4.3 | Decisive or influential variables

This part of the analysis is based on the premises that determine the physical development of the axis. Specifically speaking, how do influential factors with future-oriented attitudes affect the sustainability of urban bio-market systems? Which variables have a more decisive role in the future? How do managers see the impact of variables affecting the urban environmental situation in the sample? These are all fundamental questions about futurism in the physical expansion of the urban environment which is, by itself, understood by the graph of determinants or influential variables. As the spatial position of the variables is deduced in the graph, these variables are more influential and less affected, and is located in the northwest sections of the chart (Zali & Ahmadi, 2014). Also, these variables simultaneously have a two-way application; they both solve the crisis in the system and generate a crisis in the urban environmental situation of Piranshahr; hence, it is strategically important to identify and plan for them. These variables are not controlled by the system because they are out of optimal position. Accordingly, in sustainable ecosystems, the axis x and y as the distribution space of variables and the determinant variables are more

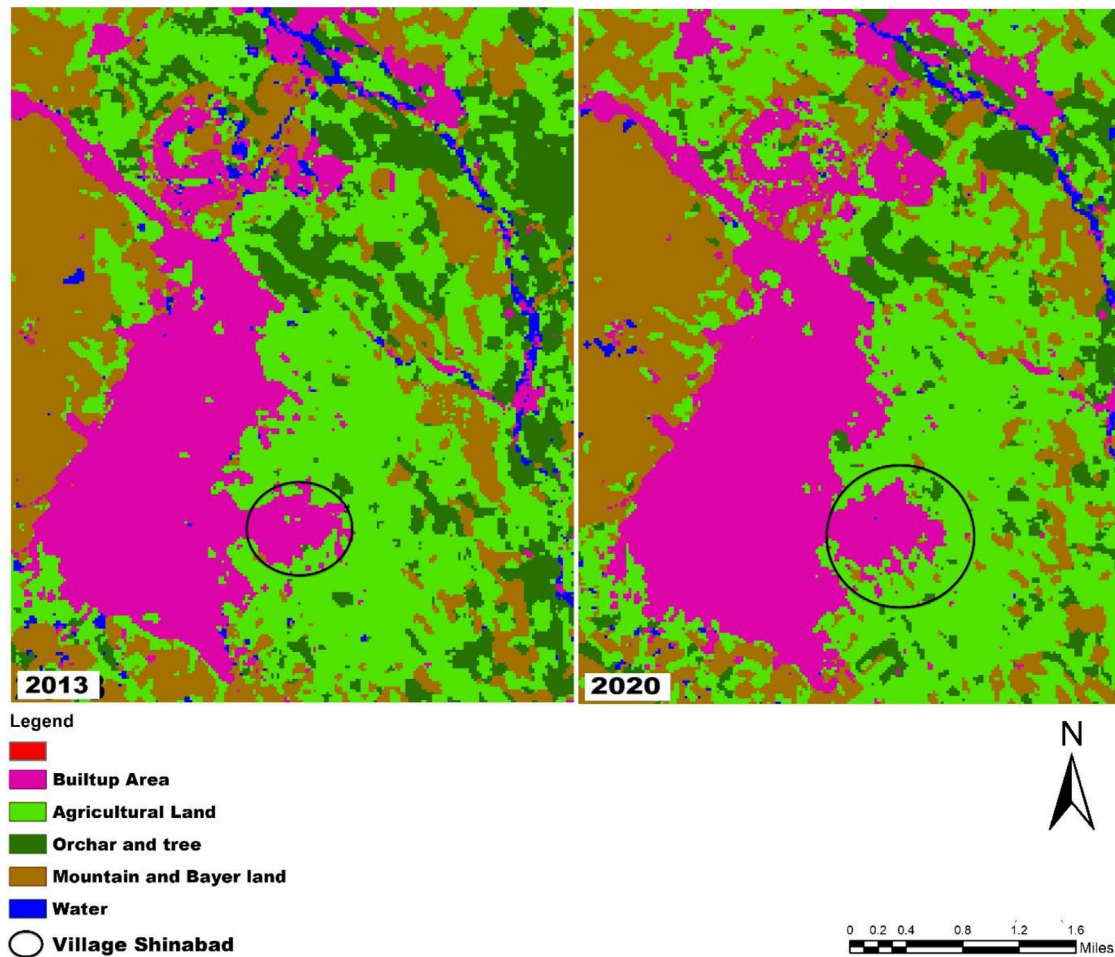


EXHIBIT 8 Physical expansion map of Piranshahr city

Source: (www.earthexplorer.usgs.gov); Authors (research findings) [Color figure can be viewed at wileyonlinelibrary.com]

closely aligned with the parallel of the x-axis and close to the perimeter diameter of the graph. In the meantime, the variables that have the greatest proximity to the x-axis, and happen to be highly effective are called contextual determinants. Given the sustainability issue, there are only five contextual variables in the present study:

4.4.4 | Double-faced or dual variables

Analyzing the impact of daily tangible factors and identifying possible changes and alternatives to the analysis of the status of variables in a graph produced by MICC software process, which can be a great solution and deployment, are among the main methods of identifying real events employed by urban planners. Based on the fact that dual variables influence the physical development on the urban environment, the distribution of these variables is more in the northeastern part of the graph. According to the findings of the present study, most of the variables studied in the upper, middle, and lower range are within the range of dual variables and northeast variables distribution pages, which have the potential to transform the nature of the dual variables into determinants; conversely, they might also transfer into

quite destructive elements in that specific situation. These elements are as follows:

As the subset of the initial set of dual variables, risk variables are of a detachable nature in the tourism system; that is, they can form the core of another variable group through integrating into a variable group and the disruption of the current order of the variables, this will result in a much different pattern of distribution in comparison with the initial version (Exhibit 9).

4.4.5 | Affected or outcome variables

These variables can be considered as the result of the operation of the risk and purpose elements (Kippenberger, 1999, p. 18) in the physical expansion of the urban environment, so that any attempt to change, reduce or increase the levels of effect in key variables, known as influential elements, influences such elements which are shown in the south-east of the graph. Formation of elements in (5-5) in the group of outcome variables indicates the emphasis of these variables on indicators such as ..., etc., in accordance with the form which might remain in this category through changes in the elements and variables of risk

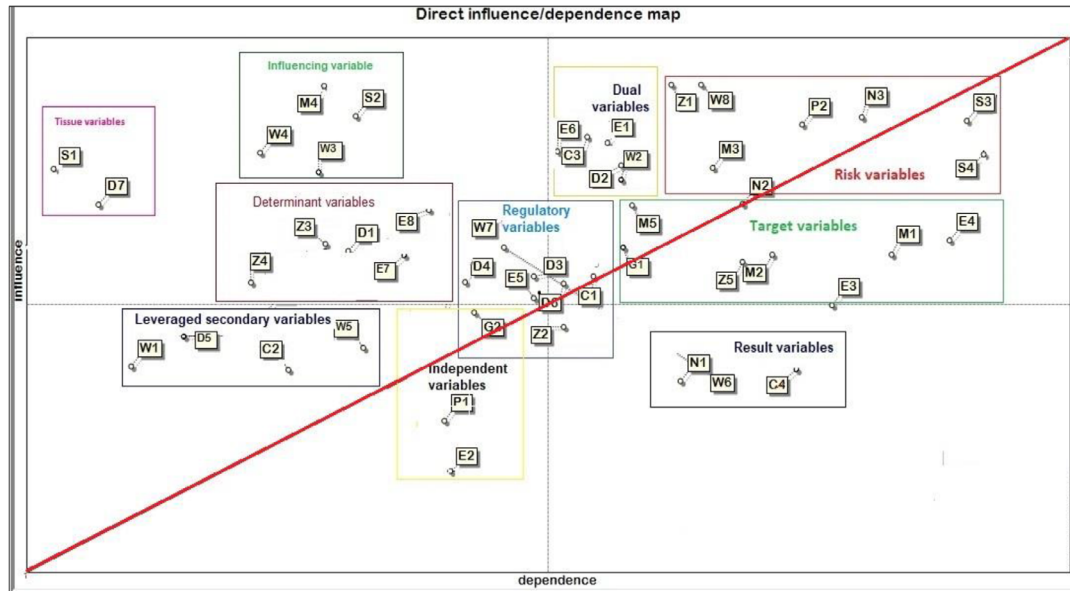


EXHIBIT 9 The graph of direct influence-dependence analysis of urban growth patterns in sustainable environments of Piranshahr. Source: Authors (research findings); (Delphi participants) [Color figure can be viewed at wileyonlinelibrary.com]

and purpose, or by changing the nature of the group and replacing them with new indices (Exhibit 9).

- Proportion of undeveloped land in the surrounding area (N_p1)
- Disrupting the order of water resources (W_R6)
- Establishment of transport routes connected to the border road (Hajiomran) (C_E4)

4.4.6 | Independent or exceptional variables

Based on the findings of the research and according to the principles stated in chapter 3, such variables do not cause the evolution of the main variables in the physical expansion to the urban environment, nor can they stop them. In fact, such variables are not related to the system or, if there is any link with the physical development of the city of Piranshahr, they are more affected by rather than being effective on other factors.

- I. Physical and chemical properties of soil) P_C1)
- II. Construction of tourist and recreational places close to the city (C_C2)
- III. Optical and electromagnetic pollution (E_O2)

4.4.7 | Regulatory variables in the physical development of Piranshahr

In addition to the other variables mentioned, another group of variables can be identified as regulatory within the framework of the physical development analysis factors of the city of Piranshahr. These indicators are located in the center of gravity of the chart and, according to their position, they have the potential to play a role in the pres-

ence or absence of any of the elements of risk, purpose and secondary leverage, and affect the overall physical development of the city of Piranshahr.

Micmac software offers the possibility to visualize only a certain percentage of relationships, those deemed most important, as well as part of the variables concerned in urban growth patterns in sustainable environments of Piranshahr (Exhibit 9).

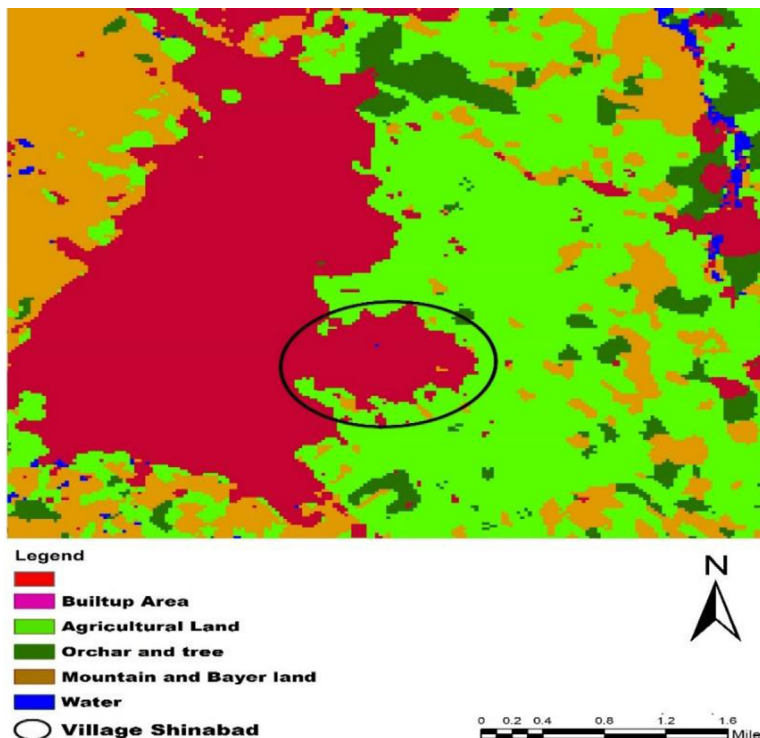
Direct classification: The total of the connections in a row indicates the importance of the influence of a variable on the whole system (level of direct influence). The total in a column indicates the degree of dependence of a variable (level of direct dependence).

In this regard, according to the analysis of the direct effect of the variables on each other, the discussion of direct independence can also be calculated within the framework of the row values, and, as shown in Exhibit 6, can be calculated by identifying the highest values against the least effect level. Considering the direct and indirect dependence effect of each variable on the physical development of the city of Piranshahr. The last 10 variables with a very high influence as key driving variables affecting the physical development of the city on the horizon in 2025 were selected. So, in order of value, the top ten indexes are the most important factors influencing the physical development of the city. Exhibit 6 includes the indexes for operating variables in the software used in the present study.

4.5 | Explaining key forces in the physical development of the city of Piranshahr on the horizon of 2025

Explaining key forces in the physical development of the city of Piranshahr:

EXHIBIT 10 The physical development of the city of Piranshahr on the horizon of 2025 Source: (www.earthexplorer.usgs.gov); (Authors, research findings)
[Color figure can be viewed at wileyonlinelibrary.com]



Focusing on the future of cities and trying to increase the quality of life of citizens and public welfare have occupied a significant position for several decades. In the meantime, individual and collective creativity has moved toward idealism in the physical expansion of urban environment, in search of environmental goals and sustainable development and its requirements by looking at the futuristic approach and the use of innovation.

The strategy development process can reflect the necessary reforms in facilities and services and should also emphasize marketing opportunities. In order to achieve the best strategy for the physical expansion of the urban environment, the necessary cooperation in research, information, development of indigenous products, human resources, and marketing and monitoring of the implementation of laws are all necessary. It should be noted that the border towns of Iran, with the under-study city being one of them, are of particular importance in the urban boundary cities in terms of urban environmental issues. The lack of reliable proof and the overshadowing due to military and security conditions have greatly diminished its importance in the area, and precise analysis with the strategic approach can identify the key drivers in this area in order to illuminate and explain the most important challenges and existing potentials, the ultimate purpose of which would be constructing and designing efficient plans (Zahradníčková & Vacík, 2014, p. 40). Accordingly, scenario planning attempts to offset two common mistakes in decision making, namely those of large and low estimates (Weimer-Jehle, 2008, pp. 244-243). Therefore, the present study defines the strategic analysis of the physical development of the city of Piranshahr as its main problem and attempts to analyze various dimensions of the issue. Therefore, for the purpose of prevention, it should be noted that an increase in the difficulties arising from physical expansion (sprawl) in

future would make the selection of future expansion patterns very important.

According to the software outcomes, activator parameters were determined and individually with respect to the level of influence of each parameter in urban sprawl, the status of Piranshahr city for 2025 was considered. Eventually regarding probable scenarios, provisions for urbanization in terms of urban sprawl for 2025-time horizon was planned (Exhibit 10). In development and expansion of the city, a variety of factors, particularly environmental geomorphologic phenomena must be studied in various aspects. Moreover, evaluation of effective factors has indicated that having flat topography, issues such as a higher rate of migration and integration of Shinabad rural area in the city have posed some challenges. Among other challenges, facing the city is ambiguity in the urban law and provisions and inappropriate, non-essential implementations such as military use and frequently changes of urban managers (Exhibit 11).

5 | CONCLUSIONS

A model for urban environmental studies was to be obtained in the framework of the new methods. Moreover, consulting with the university elite and executives in Piranshahr in different stages of the research, from defining the variables of research through scoring and evaluating to sharing the final results of the analysis of possible situations in terms of uncertainty and certainty about research descriptors decreased the error percentage quite significantly; all the scenarios obtained were rehearsed in the meetings, and, in the meantime, the mistakes in the framework of the correction of variables and scenarios were revised. Therefore, the reliability of the research tool

EXHIBIT 11 Key forces in the physical development of the city of Piranshahr on the 2025 horizon

Key factor	Scenario feature	Assumption quality	Scenario situation in 2025	Scenario realization
Master plan	Lack of application of international standards in the codification of indicators; Position and coordination of urban land use; Applicant offender, Legal bugs and weak repeated	Disastrous scenario	Continuation of the current situation, Imbalance between urban neighborhoods in urban type cities capital; Discrimination in the allocation of facilities and amenities; the change in utilities and urban per capita	Medium
Positions dams provide drinking water	Establishment of six water dams in this area and its neighboring towns, unsuitable and excessive use of natural resources; The evacuation of residents of more than 100 villages by the construction of new dams	Disastrous scenario	Disruption of environmental degradation of the region; Increased regional, national and transnational conflicts with neighboring provinces and neighboring countries. Destruction of valuable land in the area due to damping of dams; The increased migration of the residents of the village to the city and the lack of reasonable accommodation for them. Increasing marginalization, unemployment, etc.	High
Marginalization	Increasing rural migration and spread of urbanization on the land of value to the region; Housing construction without a predetermined plan	Disastrous scenario	Expansive construction on the outskirts of the city and the non-implementation of urban planning rules; Converting suburban villages to unsustainable urban neighborhoods.	Medium
Literacy and education	Lack of awareness in encounter with the phenomenon of environmental hazards in the formation of independent NGOs; The extreme limitations for the development of non-governmental organizations	Disastrous scenario	Increasing the awareness of the people of the region in dealing with environmental phenomena, increasing more NGOs Organizational activity of the city's, environmental adventurers; Creating and developing sustainable land use patterns	Medium
Impact of rural and inter-urban migration M4	Increase in irregular migration to the city of Piranshahr	Disastrous scenario	Lack of attention to rural employment and strengthening immigration, increasing poverty and deprivation	High
Organic and unplanned urban development in the suburb's town	Instability and extensive degradation of land use in the environmental dimension	Middle scenario	Continue current status	Medium
Organic and unplanned urban development in the suburbs town	Eliminate the proportion urban per capita; Not paying attention to the rules of urbanization; Increasing lawlessness and corruption of urban managers; Increasing stakeholder's power in unconstrained construction	Middle scenario	Trampling on the rights of future generations in the use of green spaces, health, and ...	High
Zoning status of the land	Relatively favorable zoning master plan; Relatively favorable planning in downtown area, but poor zoning in new and marginal areas	Disastrous scenario	Lack of attention to spatial equity in the enjoyment of equal opportunities; Ignoring rural and deprived class of young immigrants	High
Spatial policies, such as protected area and conserved land	The lack of interconnection between the institutions of the urban ruler in spatial optimal politics, The weakness of sustainable urban management	Disastrous scenario	Due to political and military conditions, we see an imbalance in physical development between different directions of the city (lack of development in the direction of worn out military uses); Lack of Strategic and Strategic Plans for the Future	High

(Continues)

EXHIBIT 11 (Continued)

Key factor	Scenario feature	Assumption quality	Scenario situation in 2025	Scenario realization
Soil fertility level	Excessive development of the city on fertile and suitable land, the loss of fertile land based on the build-up of capacity	Disastrous scenario	Expanding the city toward fertile land around the city and swallowing agricultural land; Crisis management and inefficient environmental management	High

Source: Authors (Research findings); (Delphi Participants).

was measured through discussion sessions, modification of the basic assumptions, the formulation of key assumptions, and the correction of the questionnaire based on the expert views.

In Helder model, it was shown that population attraction was at its peak due to informal residents along with villages' connection to the cities in recent years. One of these patterns is Shinabad village, which is connected to the city, despite ruination of a great deal of agricultural lands. Hence, relying on the findings of the research, it can be stated that should the situation in the field of urban expansion continue to affect the environment of the city of Piranshahr, the disaster scenario (the red state) would be highly probable and urban environment would experience massive destruction. The results of the Micmac software showed the factors including master plan, dam positions provide drinking water, marginalization, literacy and education, impact of rural and inter-urban migration, organic and unplanned urban development in the suburbs town, and the tension in question (water crisis) were the most efficient factors leading to the growth in urban area of Piranshahr city and, at the same time, are known as highly compatible key parameters. In all cases, it was observed that many open spaces are available and rivers on the edges of the city are under unbridled pressure resulting from increasing construction in the area under study.

There is a notable difference between Piranshahr and neighboring cities as are constructed blocks which were among worthy lands for agriculture. Accordingly, the results of Helder model indicate state the fact that the population of towns and immigrants from suburban areas to the city grows rapidly, and natural resources on the outskirts of the city are being depleted daily in addition to the disproportionate growth of the population and physical expansion of the city. Moreover, regional sensitivities marking political matters have come across challenges facing sustainable development of environment and uniform management system and governing border towns. Outcomes driven from corresponding scenarios signal a critical situation in the future.

Suggestions

- Use of strategic plans on a long-term horizon with the prospects for sustainable environmental development
- Regulation of municipal activities and coordination between all organizations in order to develop a balanced and integrated urban management
- Improvement and development of management structures in determining the pattern of urban development in the future

- Emphasis on strategic and futuristic planning to prevent environmental damages
- Strengthening NGO and environmentalists in cities to raise public awareness of environmental sustainability.

DATA AVAILABILITY STATEMENT

The author has provided the required Data Availability Statement, and if applicable, included functional and accurate links to said data therein.

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