



## Research article

## Spatial distribution of regional infrastructures in the northeast of Iran using GIS and Mic Mac observation (A case of Khorasan Razavi province)

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## ARTICLE INFO

## Keywords:

Spatial futures studies  
Passive defense  
Regional infrastructure  
Regional development

## ABSTRACT

Nowadays, recognizing the current situation and forecasting the desired status of spatial analysis of infrastructures regarding security and defense considerations is of great importance. Besides, the use of approaches such as futures studies and its simultaneous application with GIS has the most fundamental contribution to the field of decision-making and appropriate planning method in studies on the spatial defense planning. Accordingly, this paper aims to evaluate the spatial distribution of regional infrastructures in the northeast of Iran using a passive defense approach. In this regard, a descriptive-analytical research methodology, library-documentary studies, and statistical surveys were used in the model framework along with software (Mic Mac and Scenario Wizard) and system analysis (GIS) to achieve the research objective. The statistical population of the study was defined in two human and spatial scales. The entire geographical space of Khorasan Razavi province made the spatial scale. On the human scale, 40 experts (n = 15) and elites (n = 25) in the field of this study were selected as the statistical sample using a purposive non-random model. It is noteworthy that all of the subjects had the required scientific and executive knowledge. According to the total research indicators, the vulnerable zones of the study area could be distinguished into five categories of areas with very high (7.33%), high (16.52%), moderate (29.78%), low (16.94%), and very low (29.4%) vulnerability. Also, according to the results, the density and dispersion patterns of the study area infrastructures were concentrated, clustered, and randomly self-clustered, respectively. In the meantime, factors such as legal, policy, and institutional infrastructure criteria were identified as key drivers influencing the spatial distribution of the province infrastructures. Therefore, it is possible to realize the future models in three scenarios of high desirability (green status), acceptable (yellow status), and crisis (red status). Finally, the paper concludes with some suggestions to increase the desirability of infrastructures in Khorasan Razavi province.

## 1. Introduction

By the end of the 1990s, approximately 15% of the global population lived in urban areas. As estimations show, over 90% of the world population will live in cities by 2100, and the urban world will change the dominant identity of the geographical spaces (Carreon and Worrell, 2018). A major transformation will also occur in the harvest of resources. Accordingly, cities will consume 80% of the resources as areas occupying less than 5% of the earth's surface area, replacing the producer space with the dense demographic space (Carreon and Worrell, 2018). Therefore, the unsatisfactory distribution of spatial facilities and different levels of access to development indices is a serious warning to regional planners

on how to overcome the existing challenges and increase the potentials for regional development (UNEP, 2015; Ghaedi et al., 2013; Heydari and Bakhtar, 2018). Thus, it is necessary to take the principles and applications of passive defense into account with an emphasis on regional and partial infrastructures, using spatial analysis approach in land defense planning (Kamera and Mohammed-Ali, 2011).

According to the above-mentioned, sustainable development concerning defense analysis of strategic and vital infrastructures of any human settlement is a multi-dimensional process whose understanding of the dedication on the problems or development capabilities of the spatial organization of each country depends on the correct analysis of its complexities and often contradictory dimensions. Thus, recognizing the

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Key assets (Infrastructures)	The Importance of Factor	Ranking				Rating
		Vital	Sensitive	Important	Protectable	
Holy Shrine	75	*	--	--	--	1
Hasheminejad Airport	70	--	*	--	--	2
Provincial Government	69	--	*	--	--	3
Toos industrial city	68	--	*	--	--	4
Doosti Dam	68	--	*	--	--	5
Toos Power Plant	67	--	*	--	--	6
Mashhad Railway	65	--	*	--	--	7
Khorasan IRIB	65	--	*	--	--	8
Sarakhs Airport	63	--	*	--	--	9
Sabzevar Airport	61	--	*	--	--	10
Gonabad Airport	55	--	*	--	--	11
Neishabour Combined Cycle	53	--	*	--	--	12
Shariati Power Plant	52	--	*	--	--	13
Northeastern Iran military base	50	--	*	--	--	14
Abbaspour Power Plant	45	--	--	*	--	15
Sangan Khaf Iron Ore Complex	45	--	--	*	--	16
Khorasan Steel Complex	45	--	--	*	--	17
Hasheminejad Sarakhs Refinery	43	--	--	*	--	18
Iran Khodro Khorasan	42	--	--	*	--	19
Mashhad wheat Silo	28	--	--	*	--	20
Sabzevar Industrial Town	28	--	--	*	--	21

Source: Authors, 2020

Figure 1. Prioritization of infrastructures in Khorasan Razavi province based on vulnerability.

current situation and forecasting the desired status of spatial analysis of infrastructures regarding security and defense considerations is of great importance. Besides, the use of approaches such as futures studies and its

simultaneous application with GIS has the most fundamental contribution to the field of decision-making and appropriate planning method in studies on spatial defense planning (Raggers et al., 2016; Edward, 2017;

Table 1. The most important studies on different aspects of the subject.

RESEARCHERS	DEFINITION RESOURCES
	In their research "The Decisive Role of Futures Studies in Crisis Management", the passive defense is regarded as a fundamental element in the continuation of urban life. Also, they have introduced the correct location of land uses and simultaneous attention to crisis management indicators as a detrimental issue in the development of urban facilities.
Liu and Pan (2010)	Optimization of the urban land use refers to enhancing the level of the acceptable environmental standards and its adaptability to humans, ensuring a proper balance between population and the capacity of urban infrastructures, maintaining the intensity of the land use effect, and safe levels of development and population and, in general, the urban land location.
	Categories of localization, regionalization, and activity-complex economies, in external terms, as composing agglomeration economies. These spatially-constrained economies also have the internal scale, scope, and complexity elements, and they involve horizontal, lateral, and vertical integration, respectively. As revealed by Weber (1909 [1928]) in his location-triangle analysis, agglomeration economies are trade-offs against transportation costs. Such spatial factors can affect the decision-making of individuals and firms concerning location.
Whitney et al. (2015)	It is possible to consider the necessity of defense planning programs on a regional scale in the decentralization of strategic facilities, proportional to population and settlement points. Thus, there is no major threat due to the non-standard concentration of infrastructure in the case of danger, or there is no disruption in the provision of basic services to people deployed in different territorial and regional zones. Accordingly, centralization in the establishment of infrastructure, imbalance, irregularities, and disturbances among the functions assigned to each of the infrastructure facilities and the necessities of human defense and geographic space in case of any crisis can be defined as threats in the field of defense planning of the land.
Heli et al. (2017)	In their research, they tried to analyze the spatial infrastructures and measure their vulnerability in crisis. According to their research, proper distribution of infrastructure and adherence to the correct principles of space planning is the most appropriate way to reduce risks when facing a crisis.
	An article entitled "Urban Spaces and Strategic Threats" implicitly investigated the destruction of infrastructure resources following terrorist incidents in European cities. For this purpose, the author categorized the most significant threats ahead using strategic and future studies while expressing the strengths and opportunities of each country in the face of such conditions. The author presented his proposals within the framework of the SWOT matrix.
Alizadeh and Sharifzadeh (2020)	According to this research, given the significance of critical infrastructures in maintaining the quality of urban life, improving their resilience is of high importance to planners and policymakers. The main objective of this study is to spatially analyze the resilience of water, electricity, and gas critical infrastructure networks in Ahvaz, a major Iranian city that has been hit by various disastrous events over the past few years. The selected criteria used for spatial analysis were related to the physical texture, the design pattern, and the scale of service provision of the critical infrastructure networks. Results showed that overall, critical infrastructure networks in Ahvaz do not perform well against the measurement criteria.
Pursiainen (2020)	The resilience of the regional infrastructure has been linked to various characteristics such as preparedness, robustness, reliability, redundancy, resourcefulness, rapidity, flexibility, recoverability, and adaptability for operationalization. Preparedness refers to actions that need to be taken proactively and before the occurrence of the disruptive event to reduce potential damage and ensure the availability of adequate capacity for a timely recovery. The study highlights the need to make improvements in terms of the robustness, redundancy, and flexibility of the critical infrastructure networks in the area.
Jane et al. (2021)	They analyzed the issue from the view of the position of distributing regional infrastructure in reducing human-economic crimes. The results of their field study showed that spatial crimes (economic and social) had a direct relationship with the inappropriate development of urban and regional infrastructures.

Source: Research Findings, 2020.

**Table 2.** Prioritization of infrastructures in Khorasan Razavi province based on vulnerability.

Indexes	Valuation			Source
	Intervals	Rates	Concept	
Waterway	0–500 m	5	Relatively vulnerable	Regulations on river beds and privacy, legal and inspection office of Iran Water and Wastewater Engineering Company
	500–1000 m	1	Very low vulnerability	
	1000–1500 m	3	Low vulnerability	
	1500–2000 m	7	High vulnerability	
	More than 2000 m	9	Very high vulnerability	
Land Use	Industrial-Military Land Use	9	Very high vulnerability	Experts
	Communication-Access Land Use	7	High vulnerability	
	Settlement Land Use	5	Relatively vulnerable	
	Green Space Land Use	3	Low vulnerability	
	Empty Area	1	Very low vulnerability	
protected areas	0–1000 m	7	Relatively vulnerable	Experts
	1000–2000 m	3	Very low vulnerability	
	2000–3000 m	1	Low vulnerability	
	3000–4000 m	5	High vulnerability	
	More than 4000 m	9	Very high vulnerability	
urban areas	0–5 km	9	Very high vulnerability	Experts
	5–10 km	7	High vulnerability	
	10–15 km	5	Relatively vulnerable	
	15–20 km	2	Low vulnerability	
	More than 20 km	1	Very low vulnerability	
water dams	0–5000 m	9	Relatively vulnerable	Khorasan Razavi Regional Water
	5000–10000 m	8	Very low vulnerability	
	10000–15000 m	7	Low vulnerability	
	15000–20000 m	2	High vulnerability	
	More than 20,000 m	1	Very high vulnerability	
Wetlands	0–3000 m	7	Very high vulnerability	Iran's Environmental Protection Agency
	3000–6000 m	4	High vulnerability	
	6000–9000 m	5	Relatively vulnerable	
	9000–12000 m	2	Low vulnerability	
	More than 12000 m	9	Very low vulnerability	

Source: Authors, 2020.

Faraji et al., 2015; Zeng et al., 2019; Li, 2018). It should be noted that achieving high levels of development in any territorial space requires the existence of spatial and future-oriented plans before, during, and in the crisis time to minimize the vulnerability factor of these facilities while protecting the existing infrastructures. Formulation of related scenarios and identification of the driving forces that affect the analysis of infrastructures also contribute to preventing the loss of human and financial capital of societies through crises and threats (Turner, 2016; Fanni et al., 2014; Todaro, 2008) to the next dimension considers the necessity of defense planning programs on a regional scale in the decentralization of strategic facilities proportional to the population and settlement points. Accordingly, there is no considerable threat due to the non-standard concentration of infrastructures in the case of danger, preventing disruption in the provision of basic services to people in different territorial and regional zones (Heydari and Bakhtar, 2018; Movahedinia, 2007; Collins, 2008).

Accordingly, centralization in the establishment of infrastructure, imbalance, irregularities, disturbances between the functions allocated to each of the infrastructure facilities, and the necessities of human defense and geographic space in the event of any crisis can be defined as a threat in the field of defense planning of the land (Heli et al., 2017; Parizei and Kazemina, 2015; Taghavi, 1998; Nazmfar et al., 2019; Venkatesh, 2002). In other words, instability of the country's essential infrastructures, instability and power of administration in the executive agencies of the country, and the low ability to manage and respond to the needs of the people in case of a threat can be a kind of wrong territorial planning and lack of coordination with the basic needs of human beings,

which is the security of defense against the aggressor (Coaffee, 2009; Zhou, 2011; Lotfi and Shabani, 2012; Ela and Schwartz, 2014; Soleymani et al., 2016; Sasanpour et al., 2015). Therefore, passive defense in the field of land use and concerning the spatial and future-oriented analysis of regional infrastructures includes all spatial strategies, programs, and requirements such as decentralization, balancing, allocating appropriate performance, and selecting the optimal scale, etc. The aim is to respond to the damages and risks posed by military and civilian threats, while achieving relative sustainability in the infrastructures by carrying out this set of measures and formulating the resulting prospects (Kazemi and Tabrizi, 2015; Zhou et al., 2019). Accordingly, there have been serious post-Islamic Revolution political, economic, and military threats to the country due to its political situation and unique geographical location. Consequently, the necessary grounds were formed to consider the protection of the country's critical infrastructure on large and regional scales in the context of passive defense planning.

In the meantime, incidents such as the eight-year imposed war on Iran and Iraq, the First Persian Gulf War, the U.S. military attacks on Iraq and Afghanistan, Iran's placement on the list of ten most dangerous countries in the world, laws approved by the Fifth and Sixth Economic and Social Development Plans of the Islamic Republic of Iran in the field of passive defense and regional structures, and the Supreme Leader's special emphasis on the importance of passive immunity of these facilities in the territorial space with new approaches highlight the necessity to consider the management of these incidents in terms of risk reduction and vulnerability. Besides, the ever-increasing crises (both natural and unnatural), critical role of correct management methods and technologies,

**Table 3.** Distance from infrastructure index in the study area.

Indexes	Valuation			Source
	Intervals	Rates	Concept	
Industries & Mines	0–5 km	5	Relatively vulnerable	Article 3 Guidelines and Criteria for establishment of industries and mines
	5–10 km	1	Very low vulnerability	
	10–15 km	3	Low vulnerability	
	15–20 km	7	High vulnerability	
	More than 20 km	9	Very high vulnerability	
Airport, fuel distribution centers, and storage centers	0–2 km	9	Very high vulnerability	Experts
	2–4 km	7	High vulnerability	
	4–6 km	5	Relatively vulnerable	
	6–8 km	3	Low vulnerability	
	More than 8 km	1	Very low vulnerability	
Medical Centers	0–5000 m	7	Very low vulnerability	Experts
	5000–10000 m	3	Low vulnerability	
	1000–15000 m	1	Relatively vulnerable	
	1500–20000 m	5	High vulnerability	
	More than 20,000 m	9	Very high vulnerability	
Military Centers	0–5 km	9	Very high vulnerability	Experts
	5–10 km	7	High vulnerability	
	10–15 km	5	Relatively vulnerable	
	15–20 km	2	Low vulnerability	
	More than 20 km	1	Very low vulnerability	
Radio & Television Centers	0–2 km	9	Relatively vulnerable	Experts
	2–4 km	8	Very low vulnerability	
	4–6 km	7	Low vulnerability	
	6–8 km	2	High vulnerability	
	More than 8 km	1	Very high vulnerability	
Warehouse & Shelter	0–2 km	9	Very high vulnerability	Experts
	2–4 km	7	High vulnerability	
	4–6 km	5	Relatively vulnerable	
	6–8 km	3	Low vulnerability	
	More than 8 km	1	Very low vulnerability	

**Table 4.** Primary affecting variables the spatial analysis of infrastructures in Khorasan Razavi province.

N°	Variable	Abbreviation	Description
1	M1	M1	Expert and efficient management
2	M2	M2	Crisis Management in the Regional Area
3	M3	M3	Integrated and flexible management
4	PS1	PS1	Observing passive defense protocols in the field of infrastructure
5	PS2	PS2	Efficient political-security hierarchy in the field of passive defense
6	PS3	PS3	Observing the principles of protection in the field of infrastructures and their deployment
7	LP1	LP1	Updating the infrastructures safety rules
8	LP2	LP2	Resolving legal challenges in the field of passive defense
9	LP3	LP3	Codification of the required thematic laws in this field
10	LP4	LP4	Legal requirements to pay attention to spatial management of infrastructure
11	FS1	FS1	Preparation of required software and hardware
12	FS2	FS2	Providing appropriate financial support for the expansion of passive defense infrastructure
13	FS3	FS3	Solving the lack of technical knowledge challenge by investing and creating the necessary infrastructure
14	FS4	FS4	Providing the infrastructures for facing new threats such as electronic warfare, etc.
15	FS5	FS5	Providing the necessary incentives to the successful areas in the passive defense field
16	SC1	SC1	Educating citizens about passive defense frameworks and regulations
17	SC2	SC2	Attracting citizens' participation and institutionalizing it
18	SC3	SC3	Using the capacity of religious institutions in the field of infrastructures passive defense
19	ST	ST1	Paying attention to strategic planning in the infrastructure field
20	ST2	ST2	Developing future documents about solving the existing challenges

Source: Authors, 2020.

**Table 5.** Ranking the direct and indirect influence and dependence of variables in the spatial analysis system of Khorasan Razavi.

Rank	Title	D-I	Title	D-D	Title	In-I	Title	In-D
1	FS5	568	ST2	568	FS5	567	ST2	562
2	M1	556	M3	544	FS4	555	FS4	543
3	M2	556	FS4	544	M2	554	M3	538
4	FS4	556	LP2	532	M1	552	SC2	533
5	M3	544	FS2	532	LP4	540	FS2	532
6	LP4	544	SC2	532	M3	536	ST1	531
7	PS1	532	SC3	532	FS1	531	LP2	530
8	FS1	532	ST1	532	PS1	531	SC3	529
9	SC2	532	FS3	520	SC2	528	FS3	522
10	LP3	508	FS5	520	LP3	509	FS5	521
11	LP2	497	SC1	508	LP2	497	SC1	509
12	ST1	497	LP4	485	ST1	496	FS1	488
13	FS3	485	FS1	485	FS3	494	LP4	484
14	LP1	473	M1	473	LP1	473	PS3	472
15	ST2	473	PS3	473	ST2	470	M1	470
16	PS3	461	PS2	449	PS3	466	LP3	454
17	FS2	461	LP1	449	FS2	466	LP1	453
18	SC1	437	LP3	449	SC1	442	PS2	452
19	SC3	437	PS1	437	SC3	439	PS1	438
20	PS2	343	M2	426	PS2	344	M2	429

Source: Authors, 2020.

**Table 6.** Ranking the potential direct and indirect influence and dependence of variables in the spatial analysis system of Khorasan Razavi.

Rank	Title	D-PI	Title	D-DI	Title	In-PI	Title	In-DI
1	FS5	568	ST2	568	FS5	567	ST2	562
2	M1	556	M3	544	FS4	555	FS4	543
3	M2	556	FS4	544	M2	554	M3	538
4	FS4	556	LP2	532	M1	552	SC2	533
5	M3	544	FS2	532	LP4	540	FS2	532
6	LP4	544	SC2	532	M3	536	ST1	531
7	PS1	532	SC3	532	FS1	531	LP2	530
8	FS1	532	ST1	532	PS1	531	SC3	529
9	SC2	532	FS3	520	SC2	528	FS3	522
10	LP3	508	FS5	520	LP3	509	FS5	521
11	LP2	497	SC1	508	LP2	497	SC1	509
12	ST1	497	LP4	485	ST1	496	FS1	488
13	FS3	485	FS1	485	FS3	494	LP4	484
14	LP1	473	M1	473	LP1	473	PS3	472
15	ST2	473	PS3	473	ST2	470	M1	470
16	PS3	461	PS2	449	PS3	466	LP3	454
17	FS2	461	LP1	449	FS2	466	LP1	453
18	SC1	437	LP3	449	SC1	442	PS2	452
19	SC3	437	PS1	437	SC3	439	PS1	438
20	PS2	343	M2	426	PS2	344	M2	429

especially regarding the safety of regional services and infrastructures, and the importance of preserving national capitals in various areas such as defense, industry, energy, economy, health, information, communications, security, etc. have added to the importance of spatial analysis of the country's critical infrastructure on daily possible conditions (Mirzakhani and Barandak, 2014; Sabagh Kermani, 2001; Heydari, 2020; Khammar and Saleh Gohari, 2013). Meanwhile, Khorasan Razavi province is one of the critical areas in the northeastern region of Iran. Given the considerable geographical extent of this province compared to other neighboring regions, it has significant strategic defense and border importance. Also, the Holy Shrine of Imam Reza in the center of this province has added to the importance of defense in the study area

regarding the location of regional infrastructure (Heydari, 2020; Koomen et al., 2011). Although this province is the hub of commercial, economic, cultural, political centralization in the north and northeast of Iran, like other major provinces of the country, it suffers irregular distribution of infrastructures relative to the population and settlement units. In this regard, Mashhad metropolis, as the capital of this province and the Economic Corridor of Neyshabur-Sabzevar, has the largest volume and concentration of infrastructures in the province (Elenge Molayi, 2008; Nourqolipour et al., 2016).

However, the concentration and distribution of these infrastructures are extremely unsympathizing in more than 23 urban and 200 rural areas of the province (northern, southern, and southeastern



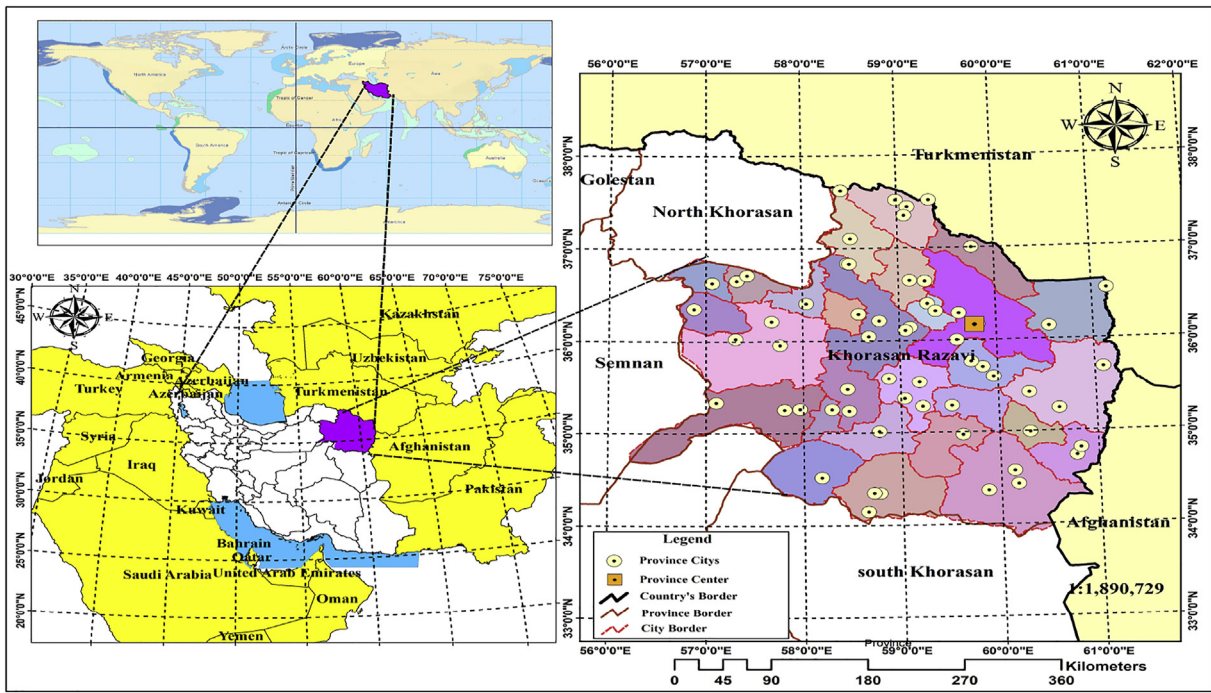


Figure 2. A view of the study area (Source: Authors, 2020).

regions). This amount is much lower than the common standards related to population, geographical space, and settlement covered (density), reflecting a moderate to low utilization situation in most of

these areas. Accordingly, there can be many direct and indirect threats in the first stage due to excessively dense infrastructures of the province (economic, social, medical, educational, relief, transportation,



Figure 3. Research process diagram (Source: Authors, 2020).

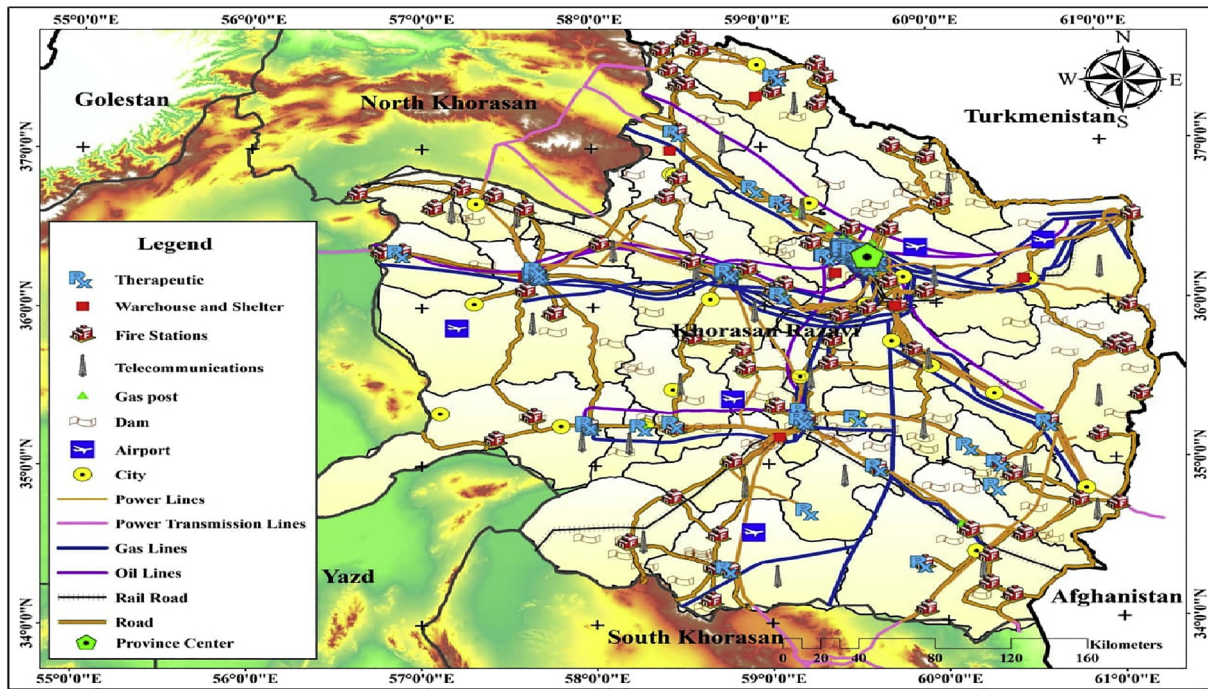


Figure 4. A view of total infrastructures of Khorasan Razavi province (Source: Authors, 2020).

etc.) in the specific settlement and geospatial nodes. Failure to consider the principles of passive defense in the discussion of the proper location of the infrastructures will expose them to the most severe damages and a high amount of material and life losses. et, it is not possible to compensate such losses in the short and medium-term. In the second stage, such a non-standard density of infrastructures on the geographical spatial scale of the province without comprehensive territorial defense planning will lead to considerable challenges in providing infrastructure services to other areas of the province in the

event of a crisis (Rahnama et al., 2020; Fanni et al., 2014). Therefore, in explaining the problem of the present study, it is necessary to identify the key drivers affecting the spatial analysis of the infrastructures of Khorasan Razavi province with passive defense approach. It is also important to determine the density and dispersion patterns of the studied area infrastructures using the geographical information system and appropriately present the scenarios related to these infrastructures in the medium-term horizon.

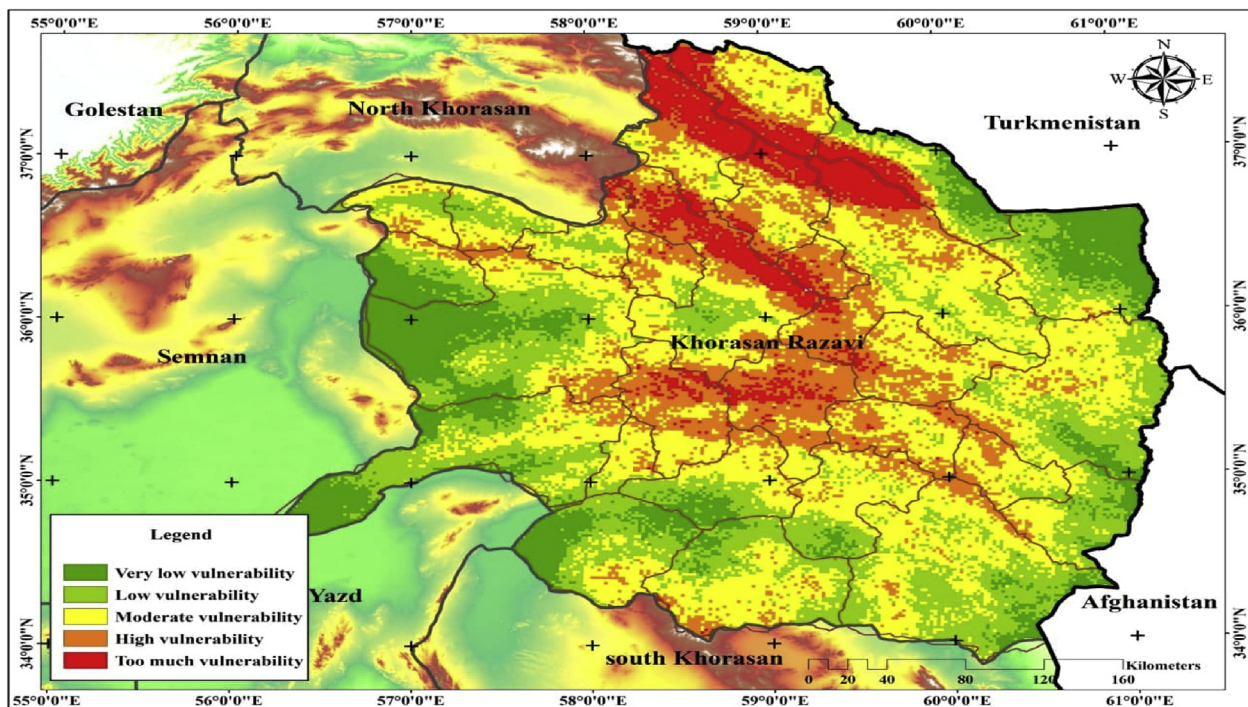


Figure 5. Zoning the vulnerability of Khorasan Razavi province's infrastructures in terms of natural indicators (Source: Authors, 2020).



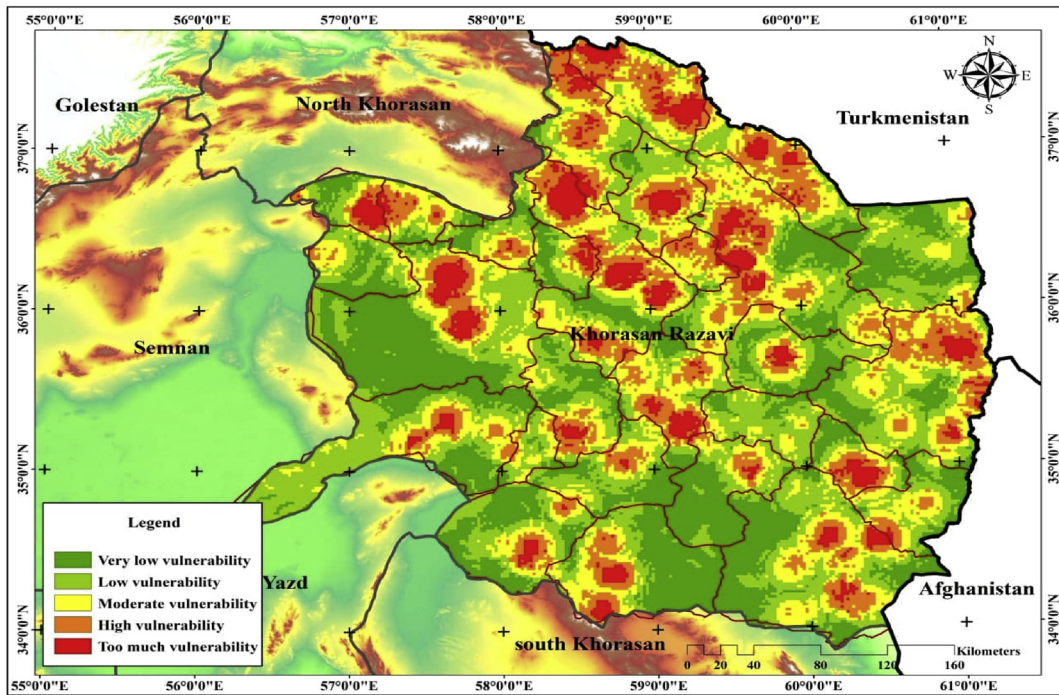


Figure 6. Zoning the vulnerability of Khorasan Razavi province infrastructures in terms of biological indicators (Source: Authors, 2020).

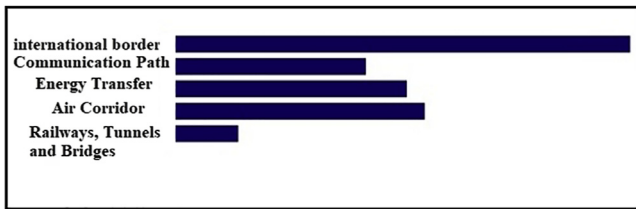


Figure 7. ANP score of access indicators in Khorasan Razavi province. Source: Authors, 2020.

## 2. Theoretical and background bases of research

In the field of spatial analysis studies, the spatial distribution of fundamental infrastructures of each human range is regarded as an essential part of the process of identifying the propellants affecting that space. Hence, the combined analysis of spatial and futures studies approaches within the framework of defense dimensions is an important development point in the field of studies on the analysis of secure areas and indefensible supply on a regional scale (Rezaei, 2019; Moradi, 2018). As a notion connoting excellence, development is the fruit of long-term evolutions (UN, 2020). It has changed with the public needs and

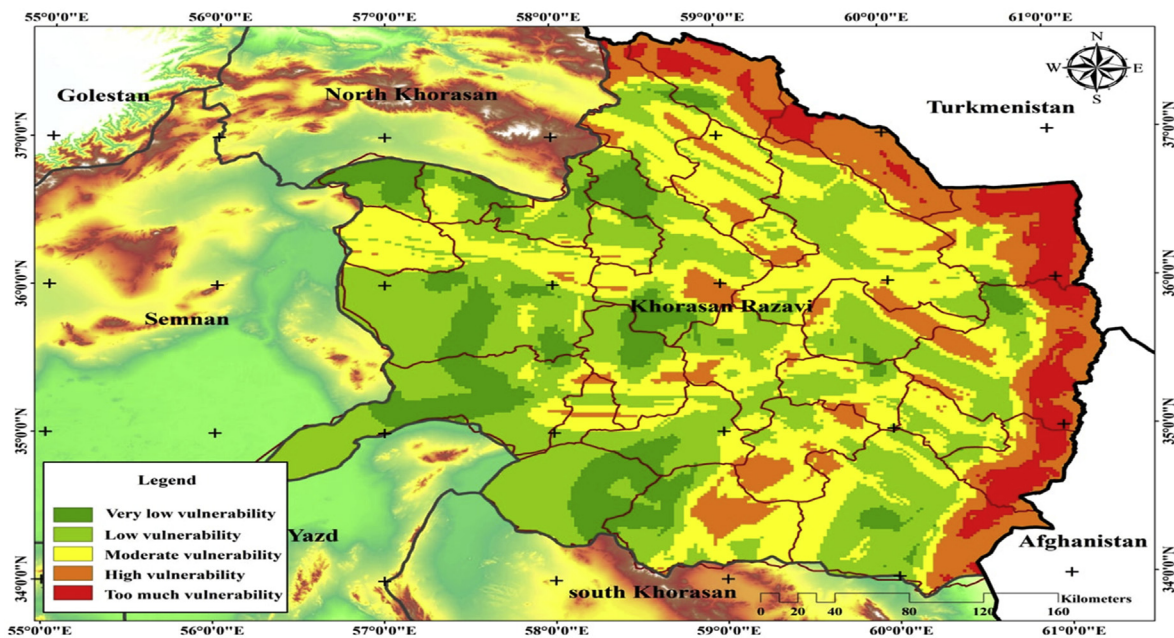


Figure 8. Zoning the vulnerability of Khorasan Razavi Province's infrastructures in terms of Access and Communication Indicators (Source: Authors, 2020).



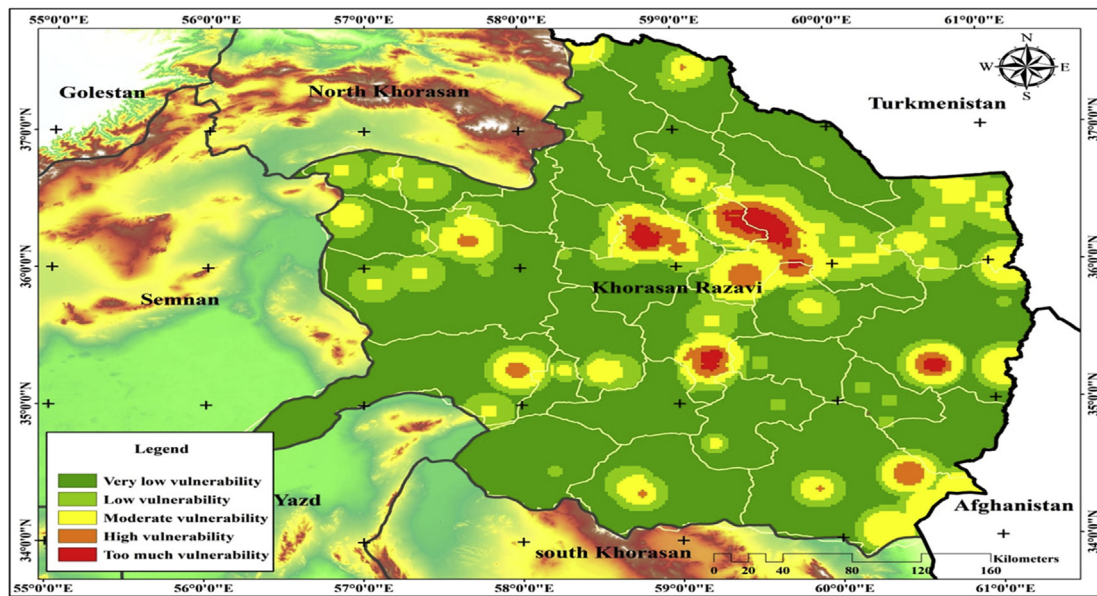


Figure 9. Zoning the vulnerability of Khorasan Razavi province's infrastructures in terms of distance from Infrastructure Indicators (Source: Authors, 2020).

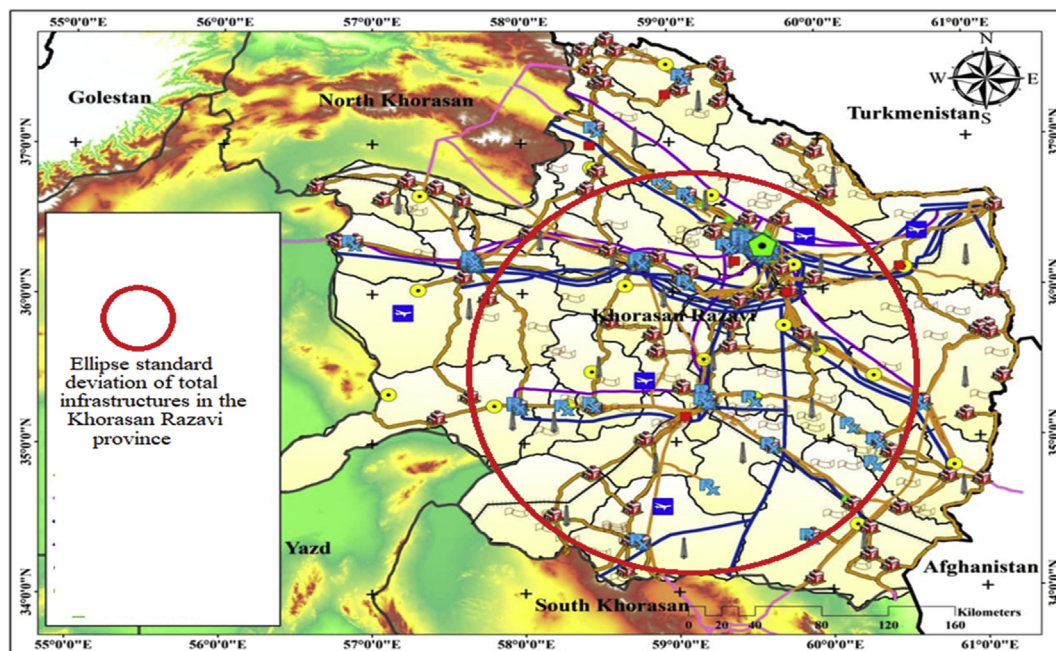


Figure 10. Ellipse standard deviation of total infrastructures in Khorasan Razavi province. Source: Authors, 2020.

demands by economic, social, and environmental conditions in the modernization process (Michael et al., 2014). Hence, given the general notion of development, its actualization relies on concurrent successes in areas such as drastic economic growth, acquisition of vast technical knowledge, the achievement of spatial balance on the local, regional, and national levels, the establishment of social and economic welfare, cultural promotion of people and groups, and attempts at constant modernization of society and enhancement of social and economic relations (Saeedi, 1998; Anabestani and Hosieni Kahnouj, 2014). Various theories such as the growth and economic development, modernization sociology, Marxism and Neo-Marxism, post-structuralism, post-development, postcolonial, and feminist development theories, which explain the development of the global and national levels contribute to the analysis of development and underdevelopment (Heydari and Bakhtar, 2018).

### 3. Study area

Khorasan Razavi is located in the northeastern of Iran between 56°, longitude 14 min to 61° and 17 min and latitude 33°, and 28 min to 37° and 39 min. The province has 28 counties, 70 districts, 73 cities, and 164 rural districts (Iran Statistical Center, 2019). According to the latest statistics collected in 2018, the population of Khorasan Razavi province was more than 7400,000 (Khorasan Razavi Governorate, 2019). In terms of natural geography, it is noteworthy that more than half of the study area is in the young mountains of the Tertiary age, which have general characteristics of Alpine-Himalayan folding and play an important role in the survival of the plains of the province (Geological Survey of Iran, 2018). Also, Khorasan Razavi province is located in the northern temperate region has a variable climate in general. The temperature of the province increases from north to south but the annual rainfall decreases (Khorasan Razavi Meteorological

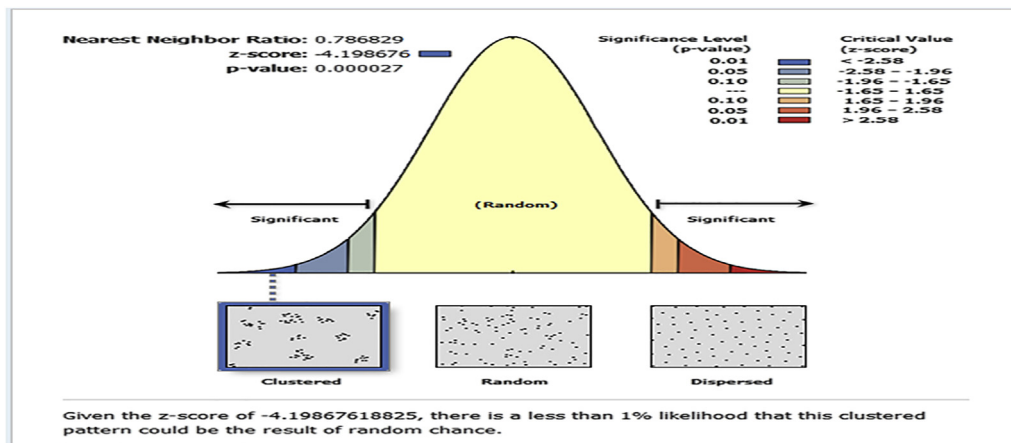


Figure 11. The model of the nearest neighboring infrastructures in Khorasan Razavi province (Source: Authors, 2020).

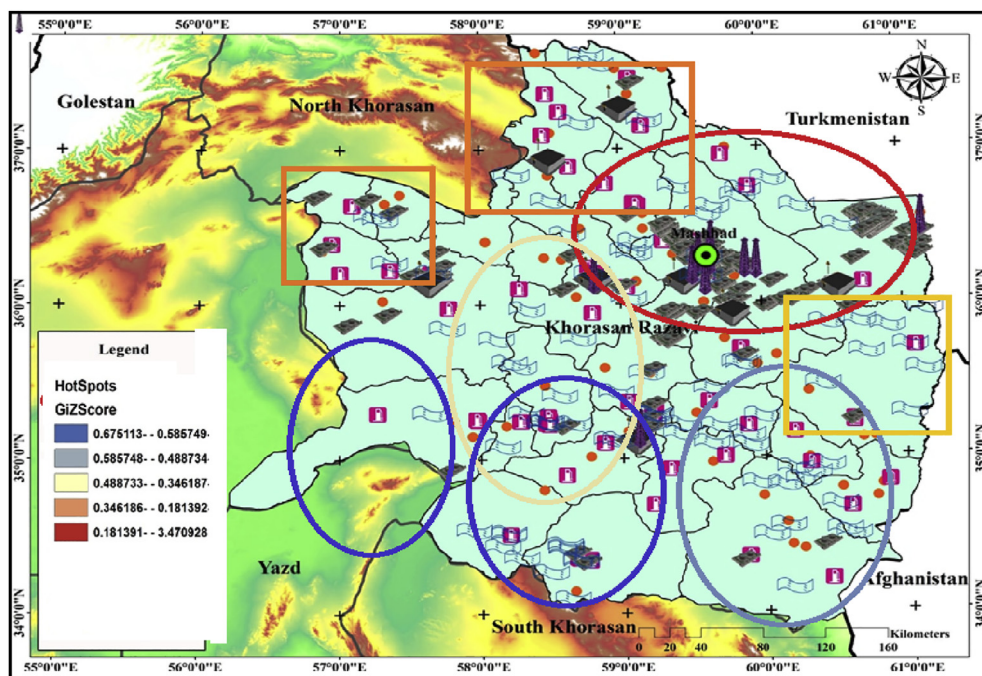


Figure 12. Analysis of the hot spots of Gi in the Khorasan Razavi province infrastructures. Source: Authors, 2020.

Table 7. Key affecting driving forces on the spatial distribution of infrastructures in the study area.

Direct Drivings	Indirect Driving	Potential Driving
FS5	FS5	FS5
M1	FS4	M1
M2	M2	M2
FS4	M1	FS4
M3	LP4	M3
LP4	M3	LP4
PS1	FS1	PS1
FS1	PS1	FS1
SC2	SC2	SC2
LP3	LP3	LP3

Source: Authors, 2020.

Organization, 2019). After dividing Khorasan Razavi province into three provinces of Khorasan Razavi, North and South Khorasan in the summer of 2004, this province took on a new geographical form as the core of Greater Khorasan. Khorasan Razavi is home to 7 percent of the territory of the Islamic Republic of Iran and is about 11993 square kilometers. The province extends 531 km north and northeast, bordering the Republic of Turkmenistan and 302 km from the east with Afghanistan. In terms of internal borders, the province is limited to North Khorasan, South Khorasan, Yazd, and Semnan provinces (Entezari, 2013). The stated cases show that Khorasan Razavi province is always under serious military, natural, economic, and other threats. According to Figure 2, conducting the present research has an important role in the future spatial distribution of regional infrastructures in the study area.

#### 4. Materials and methods

The research methodology is descriptive-analytical, based on library-documentary studies and statistical surveys within the framework of

**Table 8.** Spatial analysis scenarios of infrastructures in Khorasan Razavi province.

Score	Critical (red)	Score	Acceptable (yellow)	Score	Desirable (green)
1	Inefficient and divergent management	2023	Divergent management	4000	Integrated dynamic and efficient management
1	Lack of a specific study and executive approach in the field of passive defense	1940	Classic look at infrastructure security	3850	Strategic Thinking in Infrastructure Studies
1	Central bylaws instead of pivotal participation	1916	Limited and topical participation of citizens	3740	Citizen participation and providing appropriate cultural education
1	Paying close attention to the field of new strategic threats	800	Maintaining the status quo and working properly to defend against new threats	3560	Paying attention to new threat forms (electronic, etc.)
1	The private sector is not reluctant to invest in the infrastructures field	650	The not-so-favorable desire of the private sector to invest in infrastructure	3400	Utilizing private sector capacities in the field of infrastructure development
1	Partial and inefficient policy-making	460	Improving policy-makings according to the national considerations	3300	Improving policies in the field of infrastructure vulnerability
1	Lack of attention to amending laws and not creating up-to-date laws	351	Not-so-efficient amendment of laws and addressing limited ahead challenges	3260	Creating and amending thematic laws and resolving legal challenges in the field
1	Protocols are not considered as a part of passive defense policy	300	Continuation of existing protocols in the field of infrastructure	3114	Updating passive defense portfolios in the field of infrastructures
1	Continuation of the current financial challenges	240	Project definition of financial infrastructures	2950	Resolving the financial challenges of passive defense projects in the infrastructure discussion
1	Disregard to infrastructures intelligence	200	Not so desirable but suitable intelligence	2600	Providing intelligent and networked passive defense model
1	Tendency to undesirable conditions and destruction of infrastructure	180	Upgrading the quo status and moving towards the desired situation	2200	Paying appropriate attention to land use considerations in defense planning of infrastructure

Source: Authors, 2020.

Geographic Information System (GIS) and software models of Mic Mac and Scenario Wizard. Then, the characteristics of the sample people were investigated in the descriptive stage while explaining the overall status of

the study area in terms of spatial analysis indicators in the scale of the province's infrastructures. In the first stage, a review of the other researcher's experiences and studies was conducted, along with library-

**Table 9.** Research suggestions.

❖ Creating energy channels with appropriate depth in border regions and vulnerability prone zones of Khorasan Razavi province.
❖ Accelerating the preparation of operational measures and annexes facing new threats along with classic crises with a passive defense approach in the holy shrine of Razavi.
❖ Construction of antenna communication infrastructures in threatened and susceptible areas of the province.
❖ Using new methods in the field of camouflage, hiding, and covering threatened infrastructures (such as household refineries, energy and fuel distribution terminals, etc.)
❖ Appropriate spatial distribution of critical, sensitive, and important infrastructures of Khorasan Razavi province under far-right documents and passive defense plans.
❖ Providing infrastructure and study plan for realization and feasibility of intelligent infrastructures in Khorasan Razavi province.
❖ Preparing a joint partnership plan with neighboring countries to secure and reduce vulnerability to these threats with considerations and standards in the field of water resources with a passive defense approach.
❖ Economic development of border regions and precising threats of these regions based on new spatial and defense approaches.
❖ Combined attention to future studies in the form of study projects considering the necessity of increasing flexibility in the field of threats and leveling future prospects according to the urgency level.
❖ Identifying modern and new threats in the field of infrastructure vulnerability because of the strategic importance of Khorasan Razavi province and preparing passive plans tailored to each of them.
❖ The necessity of using up-to-date satellite images and remote sensing to improve the safety and security of Khorasan Razavi province infrastructures with passive defense approach.
❖ The necessity of accelerating the establishment of bioterrorism headquarters and comprehensive bioterrorism plan in Khorasan Razavi province.
❖ Preparing social-spatial organizing plans of Khorasan Razavi province with emphasis on border cities of the province with passive defense considerations.
❖ Paying attention to transformational and strategic management with passive defense dimensions.
❖ Distribution of the province's major propulsion industries at high-security space levels.
❖ Increasing diplomatic ties to prevent terrorist groups from operating in the neighboring countries.
❖ Policy-making and organizing the use of new technologies to reduce the vulnerability of space infrastructures.
❖ Identifying and locating suitable and safe areas in the cities and public centers based on their vulnerability to temporary settlement of all necessary activities during war or crisis can be fruitful in reducing vulnerability.

Source: Authors, 2020.



documentary surveys, a reference to the internet resources, observation, and study of meta-documents and designs on the subject to clarify the theoretical foundations. Also, field visits and surveys were conducted by referring to organizations and departments to collect the required data and investigate the current situation of the study area. In this way, the research concepts were obtained from operational and applied definitions while getting deeper insights into the research literature. Besides, the main parameters of this field were identified by reviewing the most significant spatial and defense aspects of infrastructure distribution with a spatial analysis approach. The future analysis patterns were discussed by examining the current status of these infrastructures in the form of GIS and related tools. Then, the ground was provided for identifying the key drivers affecting the spatial analysis of infrastructures in Khorasan Razavi province by analyzing the common characteristics in the form of Delphi studies. Thus, the imaginable scenarios in the future were presented to explain the strategic dimensions of the subject. Finally, the necessary proposals were made according to the findings and problems to address the existing challenges. Accordingly, the statistical population of the research can be defined and differentiated in two human and spatial scales. Hence, on the spatial scale, the entire geographical space of Khorasan Razavi province, the experts and elites scale, the statistical population can be considered as a collection of people who have been working as scientific and executive experts and elites in the study area and have the necessary knowledge and experiences on the application of future studies in the field of distribution of regional infrastructures in Khorasan Razavi. In this study, 15 experts in the field of study were selected throughout the province together with 25 scientific and executive elites, including 15 university professors and 10 local and regional officials in the study area as the sample, considering the maximum state through purposeful non-random sampling. Then, the spatial distribution pattern of the infrastructure was evaluated by separating the infrastructures in related areas (such as energy, industrial, therapeutic, etc.), and the distribution of these infrastructures was obtained on the spatial scale of the province by calling the relevant layers in the GIS environment and its spatial analysis tools. In the next step, the accumulation rate of the study area was determined by calculating the density coefficient of different infrastructures. Also, the indicators were measured and scored to calculate the vulnerability of infrastructures in times of crisis according to the obtained densities and in the form of compiling the related questionnaire. Finally, the rank of infrastructure with the highest to lowest vulnerabilities was obtained, and the proportional classification of this infrastructure was presented. Then, the votes obtained from the questionnaires were classified in the framework of Mic Mac's software in the form of effects 0 to P (0: neutral effect, 1: poor effect, 2: moderate effect, 3: high effect, and P: potential effect) and uncertainties 0 to 5 (in a very low to very high range). The obtained outputs were calculated in the form of an effect-uncertainty diagram. Then favorable, acceptable, and critical scenarios based on elite (qualitative) votes, quantifications in the form of 3+ (severe positive) to -3 (severe negative) validation, and the related prospects to each of these scenarios were formulated. The situation of Khorasan Razavi province was considered due to the dominant role of passive defense considerations. Accordingly, the last section of this paper presents the most significant challenges (threats) along with the operational plans of Khorasan Razavi province.

## 5. Findings

### 5.1. Density of Khorasan Razavi province infrastructures

Density, such as many human phenomena, is a complex and multi-dimension issue whose organization requires a macro and comprehensive approach. The use of specific policies, methods, models, and tools applied in the local, regional, and even global conditions follow such an approach while paying attention to the effects of that technology on this phenomenon. In this regard, after calling the corresponding layers of

each complication in the spatial analysis toolbox, the section related to density is selected, and the rate of each complication is determined according to this command. Thus, the system calculates density based on the proximity of the infrastructures to each other. In this research, the density of all major infrastructures of Khorasan Razavi province such as industrial centers, energy lines (gas, oil, electricity, and gasoline), airports and dams, the rural and urban road networks of the province, density of hospitals and medical centers, and educational and university centers, was considered and applied in the final analysis as Figure 4 to achieve the accurate spatial analysis. Finally, the total density of infrastructure was examined after a separate review of each infrastructure, and Figure 4 was prepared to analyze the infrastructure status in Khorasan Razavi province. This form shows the infrastructure status of high-density counties with dark and low-density counties with light colors. According to this figure, cities with a high density of infrastructure include Mashhad, Neyshabur, Sabzevar, Torbat Heydariyeh, Gonabad and Torbat-e-Jam, while other cities of the province such as Firoozeh, Khoshab, Davarzan, Taybad, Bardaskan, Rashtkhar and Zaveh have a low density. In another analysis of these densities, it is noteworthy that despite the maximum density in the mentioned areas, the vulnerability coefficient of these areas will be significantly high, which will lead to serious challenges in the event of a crisis while increasing the damage caused by the threat. Among the counties of the province, Jovain County has the best status in accessing the province railway network. More than 99 percent of the Jovain County's area is less than 10 km from the railway tracks. Also, the total number of high-pressure power transmission lines in the province is 2052,867 m. It can be said that on average, there is 1 km of high-pressure power transmission lines per 57 square kilometers of the province. Meanwhile, the largest area of the province is 10–30 km from high-pressure power lines, which is 38.8% of the province area in total. Considering the extent of the study area, it is noteworthy that there is 1 km of gas transmission line in every 49 square kilometers of the province. Nearly 30 percent of the province's area is less than 10 km far from the gas transmission line, which can be used as a potential for the development of various parts of the province. The petroleum products of the province are supplied by the main 20-inch pipe of Shahroud- Mashhad. Petroleum products (engine gasoline, white oil, and gas oil) of Sabzevar area are supplied by a 6-inch pipeline with a length of 8 km from the main pipeline. In general, 60% of the province's petroleum products are transferred by pipelines to reservoirs of the city from the Tehran refinery. In terms of industrial infrastructure, the establishment model should be considered as polar-central. This model represents a type of establishment in which industrial activities are concentrated around a central point, and this concentration gradually extends towards a certain axial format. The most prominent pattern has been formed around Mashhad city and along the Mashhad-Chenaran communication road. The analysis showed that the density and distribution of infrastructures in Khorasan Razavi province did not follow the principles of correct spatial planning. Accordingly, it is necessary to review these densities and compile the defense planning documents related to future-oriented approaches. The damage coefficient should decrease to the least possible during the crisis while redistributing the standard of infrastructure.

### 5.2. The vulnerability of Khorasan Razavi province infrastructures

#### 5.2.1. Determining the gravity levels of the study area

Gravity levels (importance level) are classified into four levels of vital, sensitive, important, and protectable in the scale of regional infrastructures. Since the number of gravity centers in the provinces is very wide, it is necessary to pay attention to the macro position of these centers primarily in the Province, and then consider whether they are effective on the country scale. Therefore, the importance of these centers should be evaluated in the province level. For this purpose, twelve criteria including the role and function in managing the country affairs, the scope of influence, the depth of impact, the role in creating economic

prosperity, role-playing in increasing safety, security and health, role-playing in scientific-technological development, uniqueness, the possibility of replacement, consequences of damage, and capital value, were investigated according to the existing standards and evaluated on the scale of Khorasan Razavi province. According to Figure 1, the main infrastructures of the province were evaluated, based on which the gravity level of each main infrastructure was calculated in the study area as the result of gravity.

According to the obtained rates of Figure 1, and the survey of interviews and questionnaires on the gravity points of the study area, 1 infrastructure was recognized as vital, and 13 main infrastructures were identified as sensitive infrastructures. In between, 7 infrastructures were recognized as the most important, and other infrastructures were defined as protectable centers, respectively.

### 5.2.2. Calculation of spatial vulnerability of infrastructures in the study area

Raster calculator is a powerful tool with multiple capabilities. It is possible to apply this tool and perform the mathematical functions, data selection, and algebraic calculation appropriately. Thus, the entry can be defined as data, raster layers, shapefiles, tables, and numbers. In the present study, raster calculator was used to measure the cell value of each class in the different layers. This calculator is located in the Toolbox section of Arc map software, and it seems possible to provide a detailed analysis of the vulnerability of the region's infrastructures in Khorasan Razavi province using Spatial Analysis and its other tools.

**5.2.2.1. Vulnerability analysis of regional infrastructures based on natural indicators.** Considering the spatial and natural diversity of Khorasan Razavi province and the variety of Natural complications, it is very important to pay attention to the vulnerability index in the regional distribution of infrastructures. Hence, the analytical network process (ANP) was used to score the indicators, and each index was divided into the different classes that were calculated in the GIS software. According to the results, more than 80% of the basic infrastructures were exposed to serious landslides with increasing the slope in the study area. Also, the majority of suitable located centers around the existing slope are related to the major cities of the province such as Mashhad, Neyshabur, and Torbat Heydariyeh. Therefore, the established infrastructures in the second- and third-level cities of the province and most rural areas were not desirable. The cities of the province were investigated as zones with very low to too much vulnerability in the face of earthquakes to analyze the vulnerability of the Khorasan Razavi province infrastructures in terms of earthquake zones.

Accordingly, the cities of Gonabad, Bajestan, Roshtkhar were in an area with very high vulnerability, Khalilabad, Davarzan, Khoshab, Jovin, Sabzevar, Torbat Heydariyeh in the high vulnerability zone, Sarakhs, Kalat, Kashmar, Bardaskan, Rashtkhar, Mahvelat in a moderately vulnerable area, and other cities were in areas with the low to very low vulnerability. Figure 5 shows counties with very high vulnerabilities in red and counties with very low vulnerabilities in bold blue. Therefore, Bardaskan, Dargaz, northern half of Quchan, Bajestan, Gonabad, northwest of Kalat, Sarakhs and Mashhad, northern areas of Torbat-e-Jam, central areas of Neyshabur were the most vulnerable areas in terms of natural indicators. Therefore, it can be said that the northern, northwestern, southern, and southwestern regions of the province had the most vulnerability in the natural indicators and the southeastern regions and parts of the northwest of the province such as Joghtay, Jovian, Sabzevar, Khalilabad, Mahvelat, Rashtkhar, Kashmar, etc. had the least vulnerability.

**5.2.2.2. Infrastructures of Khorasan Razavi province based on biological indicators.** Nowadays, paying attention to biological indicators is very important in the discussion of the vulnerability of the province infrastructures and the identification of vulnerable zones at different

geographical levels. For this purpose, six main sub-indices including waterway, land use, protected areas, urban areas, water dams, and wetlands were investigated in this part of the study. In the meantime, the closeness and distance from biological indices can indicate the vulnerability of the geographical area. Therefore, the indexes were valued by elites and experts after preparing the required layers, the results of which are shown in Table 2.

Scoring the seven main layers of biological indicators by network analysis method shows that urban areas or the major areas of life with a score of 0.302 and land use with a score of 0.074 had the highest and the lowest importance, respectively. Therefore, the cities with highly vulnerable infrastructures included Chenaran, Sarakhs, Jowayin, Joghtay, Davarzan, Binalood, the north and east part of Fariman, the eastern half and northwest of Mashhad, northeast of Neyshabur. Also, cities with very low vulnerabilities consisted of Bajestan, Gonabad, and other cities of Khorasan Razavi province were in the areas with low to high vulnerability.

### 5.2.2.3. Infrastructures of the study area based on access and communication Indicators.

Ease of access to infrastructure is one of the most significant indicators of infrastructure vulnerability assessment. To apply this index, 5 sub-criteria including the communication path (road), railway, tunnel and bridge, international border, energy transmission lines, and air corridor routes were used for evaluation and identification of vulnerable areas in Khorasan Razavi province. Scoring the five main layers of access index by network analysis method shows that international boundaries with a score of 0.468 and railways, tunnels, and bridges with a score of 0.05 had the highest and lowest importance, respectively.

Based on Figure 8, it can be said that all counties of the study area were in a vulnerable situation without exception in terms of access indicators. According to this figure, the extent of red zones with a very high vulnerability is more than that of blue zones with a very low vulnerability. Therefore, parts of each urban infrastructure are supposed to face very high vulnerability, while some others are subject to a very low vulnerability.

### 5.2.2.4. Vulnerability analysis of infrastructures in Khorasan Razavi province based on distance from infrastructure index.

Power plants, oil and gas industries, petrochemicals, and electricity and energy transmission are vulnerable to enemy attacks and natural and abnormal accidents because they are the main sources of income of the country, and also sensitive to and capable of ignition and explosion; thus, they require a comprehensive and codified program in the field of passive defense. In today's wars and control and command systems, a new method of war has developed with a focus on identifying the most important centers and economic bases, military, and industrial infrastructures of the enemy using new intelligence technologies. Such technologies help obtain information from the enemy, drain the information of those arrested, and destroy the most vital regional infrastructure of enemies. For this purpose, 25 infrastructures of the province were classified into 6 groups, for each of which the distance intervals and related points were considered to evaluating the safety of regional infrastructures. These sub-facilities include industries and mines, airports and fuel distribution centers, medical centers, military centers, IRIB, and shelters and warehouses. The groups were merged, and scoring was performed by network analysis according to the standards and experts' opinions to apply this index in the GIS environment.

Scoring six main layers of distance from infrastructure index by network analysis method shows that military centers with a score of 0.454 and IRIB with a score of 0.05 had the highest and lowest importance, respectively. According to this form, counties with very high vulnerabilities were in the province zones with red color, and cities with very low vulnerability were in zones with green color.

5.3. Spatial dispersion of infrastructure based on standard deviation ellipse

The standard deviation test method was used to investigate the spatial dispersion levels of the province infrastructures. The steps to determine the standard deviation test are as follows:

- 1) Calculate the average center coordinates (Xmc and Ymc).
- 2) For each point of Pi in distribution, transfer coordinates as follows:  
 $X_i = X_i - X_{mc}$   
 $Y_i = Y_i - Y_{mc}$
- 3) Calculate the angle of Q rotation according to the following relationship:

Eq. (1):

$$\tan \theta = \frac{(\sum_{i=1}^n X_i'^2 - \sum_{i=1}^n Y_i'^2) + 4\sqrt{(\sum_{i=1}^n X_i'^2 - \sum_{i=1}^n Y_i'^2)^2 + 4(\sum_{i=1}^n X_i' - \sum_{i=1}^n Y_i')^2}}{2\sum_{i=1}^n X_i' \sum_{i=1}^n Y_i'} \tag{1}$$

- 4) According to the angle of rotation calculated in the previous step, determine the deviation along the x and y axes as follows.

Eq. (2):

$$\delta x = \sqrt{\frac{\sum_{i=1}^n (x'_i \cos \theta - y'_i \sin \theta)^2}{n}} \tag{2}$$

$$\delta y = \sqrt{\frac{\sum_{i=1}^n (x'_i \sin \theta + y'_i \cos \theta)^2}{n}}$$

- 5) Based on the calculations, this direction is in the northeast to southwest of the region with an angle of 55° deviation from the north.

5.4. Calculation of the spatial dispersion of infrastructures in Khorasan Razavi province Based on the nearest neighbor index

Spatial statistics analysis sets offer many tools to analyze the patterns. One of these tools is the calculation of spatial dispersion. This instrument calculates the average of the nearest spacing of the same infrastructures. At first, the distance between the center points of each complication, and the center point of its closest neighbor are measured, and then the average of all these closest neighbors is calculated. If the calculated mean distance is less than the average of the hypothetical random distribution, it indicates that the distribution of phenomena in space is clustered. However, if the calculated mean distance is greater than the average of the hypothetical random distribution, it indicates that the complications are distributed sporadically in geographical space. Analysis of the infrastructure of Khorasan Razavi shows that their spatial distribution pattern was clustered. Also, this distribution pattern indicates a wide-spread unjustness in the spatial scale in the study area. Thus, the main distribution of infrastructures on the regional scale has been around the big and known cities, and the share of small-scale cities of these distributions has not been significant and tangible.

The G general statistics, which analyze the clustering (high and low) of data in geographic space, are calculated as follows:

$$G = \frac{\sum_{i=1}^n \sum_{j=1}^n W_{ij} x_i x_j}{\sum_{i=1}^n \sum_{j=1}^n x_i x_j}, \forall j \neq i \tag{3}$$

In this formula,  $x_i$  and  $x_j$  are the characteristics of geographical I and J

complications and  $W_{ij}$  is the desired geographical weight between phenomenon i and j. Also, the standardized G rating is measured as follows:

$$ZG = \frac{G - E[G]}{\sqrt{V[G]}} \tag{4}$$

where:

$$E[G] = \frac{\sum_{i=1}^n \sum_{j=1}^n W_{ij}}{n(n-1)}, \forall j \neq i \tag{5}$$

$$V[G] = E[G^2] - E[G]^2 \tag{6}$$

The  $G_i$  statistic calculated for each complication in the data is a type of Z rating. For positive and statistically significant Z score, the larger the Z

score, the higher the amounts clustered and the hot spot formed. For a negative and statistically significant Z score, the smaller the Z score, the more intense the clustering of low values, and these show cold spots. As can be seen in Figure 11, the cities marked in red formed hot spots due to the spatial concentration of critical infrastructures in Khorasan Razavi province. In fact, the cities of Mashhad, Sarakhs, Fariman, Binalood, Chenaran, and Kalat were highly sensitive due to the existence of infrastructures and also proximity to the border, which has turned the mentioned cities into hot spots of critical infrastructure in Khorasan Razavi province. The cities marked with blue, such as Bakharz, Roshtkhar, Mah-Velat, Khalilabad, Bajestan, and Gonabad, were identified as the cold spots of critical infrastructures in Khorasan Razavi province due to the limited concentration of basic infrastructures in Khorasan Razavi province. These counties are less important than hot spots in terms of the concentration of critical infrastructure. Analysis of the hot spots of Khorasan Razavi province critical infrastructures can be considered in planning and decision-making on the equitable distribution of infrastructures and passive defense of the study area.

5.5. Key affecting driving forces on the spatial distribution of infrastructures in the study area

To identify the key influencing drivers on the spatial analysis of the Khorasan Razavi province infrastructures, a list of variables affecting the subject was prepared according to the documents and elite interviews. Then, as shown in Table 3, a list of primary variables was obtained in the form of an N\*N matrix with 20 × 20 dimensions after further studies. After entering the variables into Mic Mac software according to Table 4, in the framework of the Cross Impact Analysis Matrix, the statistical sample was asked to score variables from 0 to 3 and P based on the importance and influence, influence and dependence of the elements together.

In this regard, numbers zero, one, two, and three showed the null, weak, average, and high impact, respectively, and P meant direct and indirect effect potentially. Finally, it can be found that the obtained fill index for variables with two repetitions of data iterations shows 95%, which indicates the high coefficient of influence of selected variables and factors on each other. This situation indicates the efficiency of the research tool and confirms the information collected at a very desirable level, and also the accuracy of the obtained data. Also, based on the findings of Table 4, it should be said that based on 380 values calculated in the primary matrix of crossover effects by elites, 219 cases with the highest statistical volume had a moderate impact. Also, 123, 38, and 20



cases had a high, low, and null impact, respectively, while P-value (potential direct effect) was zero. According to the overall analysis of the research, it is necessary to consider the ranking of direct, indirect, and potential effects of variables according to the possible displacement of the indicators in the system in this section. The aim is to prepare the ground to identify the key driving forces in the spatial analysis system of the Khorasan Razavi province infrastructures. Accordingly, the direct, indirect, and potential impact and dependence of the research variables were analyzed in the framework of Tables 5 and 6.

This section may be divided by subheadings. It should provide a concise and precise description of the experimental results, their interpretation, as well as the experimental conclusions that can be drawn. Relying on the findings of Tables 1, 2, 3, 4, 5 and 6 and Figures 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, and 12, and considering the necessity of identifying the key and influential drivers of the research to form the research scenarios, it should be noted that from the sum of 120 Classifications composed of research variables in a matrix framework with dimensions of  $20 \times 20$ , 10 key drivers were identified and separated after entering the variables into The Mic Mac software and calculation of numerical values related to each of them in the framework of scoring system 0 Up to 3 and the cross effects analysis matrix to explain the research variables in a strategic format as Table 6. Accordingly, these 10 key factors were repeated in different priorities in the field of expressing research priorities in both direct and indirect conditions (Table 7) (see Table 8).

According to the identified key driving forces, the most important scenarios in the spatial analysis of the infrastructures of Khorasan Razavi province can be presented in Table 7. The prerequisites of the green scenario are the realization of all elements related to this scenario. Otherwise, the chances of yellow or red scenarios occurring according to the conditions of the infrastructure system will be very likely. It is noteworthy that the prerequisites for the presented scenarios in all the process of the present study have been explained in general. Besides we can understand the case accurately by studying the different sections and analyses obtained in Tables 1, 2, 3, 4, 5, 6 and 7 and Figures 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, and 12. Also, the assumptions of each scenario are in the form of elements that form each scenario, which is presented in the form of sub-elements of each scenario and can be discussed in the form of several types of studies.

## 6. Conclusion and suggestions

The best predictable situation in the framework of the applied approaches in this study is in the first and second scenarios with a high degree of compatibility, believability, and acceptability. In this situation, elements have a uniform and convergent distribution in the scenario diagram page while achieving the highest score of matrices and software analysis. According to the total analysis of the present study, it can be found that there are several threats in the province's infrastructure areas in the different aspects of economic, social-cultural, terrorist, security-political, geographical, biological, new threats, etc., which will cause serious challenges and damages to the infrastructure and related functions of the study area in the event of a crisis. In the meantime, the new and cyber threats such as information attacks, destruction of financial infrastructure, cyberattacks, outbreaks of diseases, biological attacks, changes in climate, social and migration systems can be the dominant threats of Khorasan Razavi province based on library studies, research findings, and elite meetings in line with its dominant religious, tourism, and economic role. It can be said that improving the stability of the spatial distribution system of the infrastructures of Khorasan Razavi province with a passive defense approach, considering the extent of its dimensions, depends on the use of spatial thinking in the form of appropriate systems such as GIS and its combination with strategic approaches that can provide a comprehensive view of its patterns, vulnerabilities, driving forces, and related scenarios. The practice of these perspectives will improve realization to meet the challenges in this field. Therefore, Table 9 presents the following suggestions:

## Declarations

### Author contribution statement

Akbar Heydari: Analyzed and interpreted the data.  
 Hadi Zarghani: Performed the experiments; Wrote the paper.  
 Hadi Azami: Performed the experiments; Analyzed and interpreted the data.  
 Mohsen Janparvar, Fahimeh Jafari: Contributed reagents, materials, analysis tools or data.  
 Hamidreza Rabiei-Dastjerdi: Conceived and designed the experiments.

### Funding statement

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

### Data availability statement

Data will be made available on request.

### Declaration of interests statement

The authors declare no conflict of interest.

### Additional information

No additional information is available for this paper.

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