

## **Analyzing and Determining the Vulnerability of Urban Facilities with Passive Defense Approach Using GIS (Case Study: Gorgan City)**

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### **Abstract**

*Cities are a gathering place for human resources and the centers of political decision-making, administrative, military, and financial and intellectual capital are based in cities; for this reason, cities are responsible for a very important role in managing wars due to facilities and welfare services. In addition, urban planning has huge problems in some cities, so that these cities will suffer from disruptions in water supply systems, power distribution and city gas in the event of crisis and rocket attacks. In the meantime, planning on the basis of passive defense approach can to a large extent compensate the shortcomings resulting from the incorrect planning. The aim of this study was to assess the vulnerability of urban infrastructure in Gorgan city. To this end, descriptive - analytical method, field studies and subsequently, zoning and overlay information layers (Index Overlay) have been used in GIS spatial analysis software. Using two criteria including building density and spatial distribution of critical and sensitive facilities in Gorgan city and their zoning and finally using prepared overlapping layers, it was found that the northwestern of Gorgan city is more vulnerable due to high concentration of vital facilities such as electricity Distribution Company, National Petroleum Products Distribution Company and regional water companies which requires more planned measures in the framework of passive defense.*

**Keywords:** urban facilities, passive defense, vulnerability, Gorgan city.

## **1. Introduction**

Cities are a gathering place for human resources and the centers of political decision-making, administrative, military, and financial and intellectual capital are based in cities; for this reason, cities are responsible for a very important role in managing wars due to facilities and welfare services (Kamran, 2011: 5), which human beings built their cities through technological conditions (Ziyari, 2009: 6). In fact, cities are highly sensitive because of the conditions mentioned in wartime and pay attention to the essential principles of passive defense seems necessary in order to reduce the damages (Khamr, 2013: 21).

Urban passive defense is a branch of civil crisis management and its type of crisis is associated with war (Hosseini Amini, 2011: 22). Since the end of World War II, modern passive defense been considered as an unarmed solution in order to reduce vulnerability of urban facilities, infrastructure and human resources in many countries of the world (Kamran, 2012: 217). Urban facilities and equipment has two parts, which the critical infrastructure of the country is one of them and the other part is the centers for production, distribution and delivery of municipal services, such as: Land use, water resources, power facilities, telecommunication center, urban gas facilities, emergency, fire departments, governors, mayors, subway and transport routes, hospitals and the like are the public and strategic services areas in the city that their locating should be consistent with the natural and geological conditions (Banergeet, 1998: 37). In the meantime, the main discussion regarding passive defense in urban planning is to strengthen urban infrastructure, build way to escape danger, improve the services that will be necessary in defense, which seeks to reduce vulnerability and loss of life and property in cities (Ayat Ullah, 2008: 87). The aim of this study was to assess the vulnerability of urban infrastructure in Gorgan city. To this end, descriptive - analytical method, field studies and subsequently, zoning and overlay information layers (Index Overlay) have been used in GIS spatial analysis software.

## **2. Theoretical Foundations**

Passive Defense is one of the most important approaches and strategies in the field of urban crisis management. Safety and security from time immemorial have been considered in the planning and management of urban settlements. According to the structure, the political space and military paradigms in urban areas, we realize that the passive defense system should be considered in order to increase military authority and reduce vulnerabilities (Akhbari, 2014: 36). The passive defense is a set of measures that does not require certain weapons (Zarepour, 2011: 8) and is meant to save lives, ensure safety of people and preservation of territorial integrity and national sovereignty (Ahamarlouei, 2010: 13 ). The passive defense is one of the branches of crisis management and it is focused on management; in fact, it can be defined by every unarmed action that reduces vulnerability of human resources, buildings, facilities and equipment (Parizadi, 2010: 45) order to reduce vulnerability and increase national resistance (Fardrou, 2010: 121).

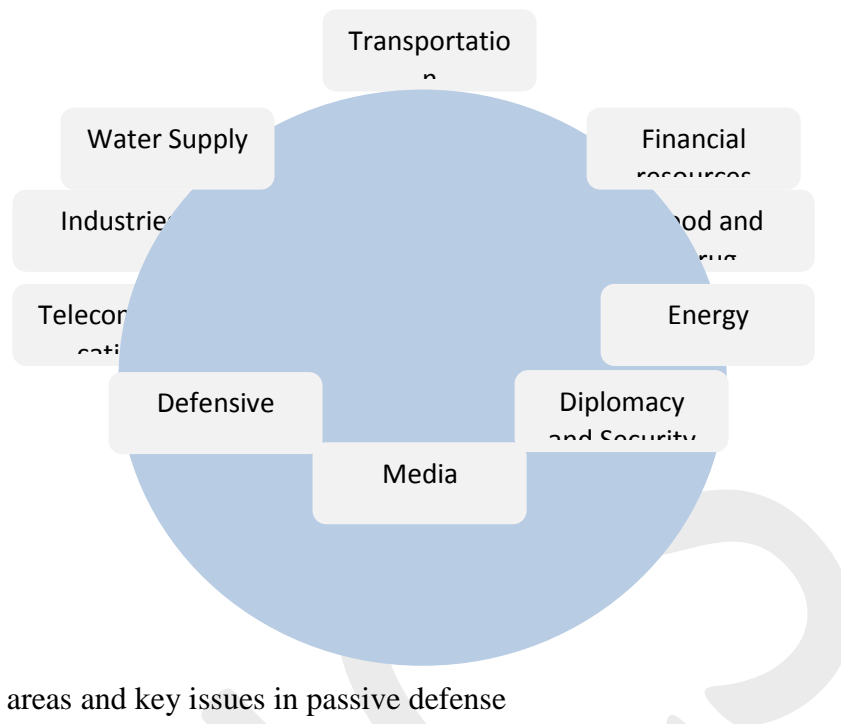


Figure 1: areas and key issues in passive defense

Discussion of passive defense, especially its application in urban planning has a long history. The validity of this claim can be found in the wars of early Islam and defensive measures such as digging ditch, but due to advances in technology and changes in the nature of the weapons, use of passive defense in reducing casualties of wars is felt more than ever before (Kamran, 2012: 215) and another of its manifestations can be seen in the construction of castles in ancient Persia (Majidi, 2011: 37).

### **2.1 Vulnerability assessment of the city**

Each city is influenced by the type and amount of relationship with the surrounding natural or artificial environment outside the urban zone. In fact, in the city, there is a network or a hierarchy of spatial and functional relationships with surrounding environment and any defense, political, economic and social review will become meaningful in relation to the area (Akhbari, 2014: 38). Healthy city structure is in such a way that the two dimensions of form and function sought to limit the damages caused by war (Lacina, 2006: 276). In general, vulnerability of the city against enemy aggressions depends on several factors, including building density, shape and form, urban texture and the like.

### **2.2 Vulnerability Assessment of the city based on building density**

The most important factors associated with building density in relation to the vulnerability are as follows:

#### **- Urban texture**

Urban texture, shape, size and how to combine the smallest components will be effective against military aggression and other urban disasters (Abolhasani, 2005: 60). The urban texture can be studied on the basis of various indicators and of which, we can pointed out to regular or irregular texture, dense and scattered texture, fine-grained and coarse-

grained texture and blank spaces. Amount of density indicates the location and nature of a place. This set is converted to an index by dense and intensive texture (Farazam Shad, 2009) that this factor leads to more vulnerability. In fine-grained components, after the incident, human casualties would rise due to lack of open and safe space to run away and take shelter. In conjunction with regular and irregular texture, it must be acknowledged that at the time of invasion and incidence of crisis, regular texture has better conditions to run away and take shelter and relief work is also easier.

Table 1. The relationship between size of components and surface with respect to the level of vulnerability

No.	Ratio of surface area to total area (Percent)	Component Size (m <sup>2</sup> )	Vulnerability
1	$60 < A < 100$	$s \leq 200$ small size	much
2	$30 < A < 60$	$250 < s < 500$ Average size	Average
3	$A < 30$	$s \geq 500$ Large size	Low

(Source: Abolhasani, 2005)

The area where the ratio of surface built to total open area is average or low, are less vulnerable, because the conditions are right for escape and take shelter after the destruction and disaster and relief work would also be easier.

### - Structure of City

Distribution of elements, combining elements and functions that make up the structure of the city, have a main role in the vulnerability of the city against various events, especially military attacks. Physical division of the city, such as alley, neighborhood, district, and regional districts, single-center or multi-center, and the like are another face of the structure of the city and each has a special talent in terms of combating disasters (Abolhasani, 2005: 59). In other words, the combination of design and structure of the city in times of crisis and war, should be such that the sustainability of the city and its defensive scheme can be preserved and remained intact (Zargar, 2008: 9).

### 2.3 Vulnerability Assessment of the city based on major urban centers

In relation to major urban centers, 3 types of these centers are listed, which are as follows:

- **Vital centers:** it is the primary requirement for any city and the life cycle is built based on this concept (Dalir, 2012: 4) And in the event of destruction or part thereof causes of the crisis, suffer serious harm and risky in the political system, direct, command and control, production and economy support, communication and transportation, social, defensive with an effective level. The center will include governors, hospitals, telecommunications, police (Amini, 2010: 140).

- **Sensitive centers:** these center is a king of center which in case of their total or partial destruction, it causes considerable damage to the political, economic and defensive systems with the influential regional level (Maleki, 2012: 12). These center include petrol stations, water and gas transmission networks and bridges.

- **Major centers:** In case of total or partial destruction of these centers, the systems of political, governing, command and control, production and economy support, communication

and transportation, social and defensive will have serious and risky harm which is at the neighborhood level (Movahednia, 2007: 29). These centers include CNG station, market and prison.

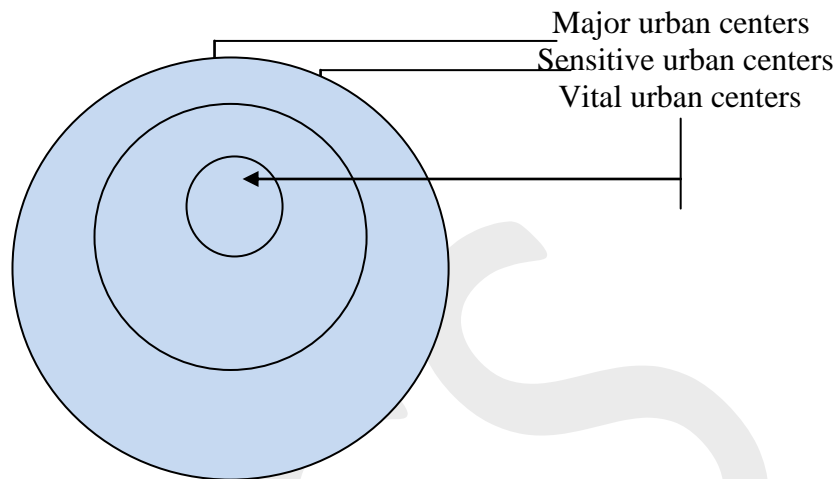


Figure 2: Classification of important urban centers.

### 3. Methodology

For this study, by using descriptive - analytic method and library studies, these concepts were evaluated and some fundamental definitions were developed for passive defense; then, informational layer related to the distribution and dispersion of urban facilities across the city were collected through urban organizations (especially municipal and master plan of Gorgan city) and operations were carried out in GIS software environment. These layers include zoning based on building density and zoning in vulnerable areas based on building facilities. Then, using a combination of hierarchical analysis (AHP) and the logic of valuation layers (IndexOverlay), a model is provided for zoning in vulnerable areas in Gorgan city by using the Geographic Information System (GIS).

### 4. Introduce the area under study

Gorgan city is located in Golestan province and geographically bounded by 54°25' in latitude and 50°36' in longitude. Gorgan has mild climate and according to the 2011 census, its population is equal to 320,536 people. The city has two districts of municipal administration. The city was chosen as the center of Golestan province in 1997. Before that time, Golestan province was a part of Mazandaran province. After being elected as the provincial capital, many managerial and administrative centers and vital and critical centers have been moved to Gorgan city (see Table 1).

Table 1: critical elements of Gorgan city

Category	Elements	Category	Elements	Category	Elements	Category	Elements
Vital installations	Water transmission network Water reservoir Electrical	Administrative and	Governorship Governorate	Support Center	Fire Stations Radio and	Urban equipment	Airport Passenger termin

	Distribution Network Gas distribution network fuel tanks Telecommunications	military centers	Departments Barracks Prison Police station		Television Universities Food reserves		hospitals
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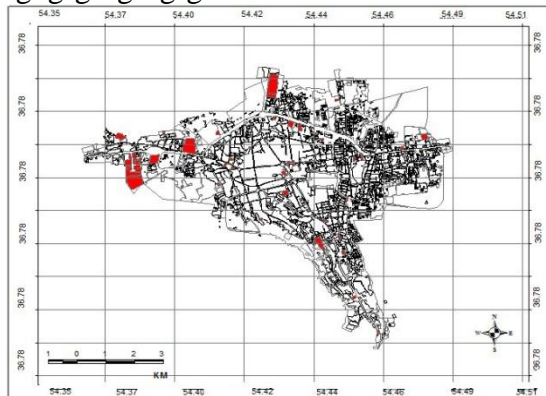


Figure 3: Spatial distribution of facilities in Gorgan city

## 5. Research Findings

To assess the vulnerability of facilities in Gorgan, the zoning of building density and vulnerability mapping based on urban facilities were evaluated using the AHP valuation method and GIS software interpolation and then by use of overlapping layers (Index Overlay), we prepared the vulnerability mapping of facilities in Gorgan city with passive defense approach.

### 5.1 Vulnerability of the city based on the structural elements

Figure 4 shows the zoning of Gorgan based on building density (texture, microlithic, empty spaces, etc.) that is displayed in 5 ranges from very high density (with small parts) to very low density (larger parts). According to the information contained in this Figure, the central part of the city has a very high density due to the fine-grained parts and this factor leads to greater vulnerability during the crisis. In contrast, the northern and western areas of Gorgan city are less vulnerable in times of crisis because of large parts and components.

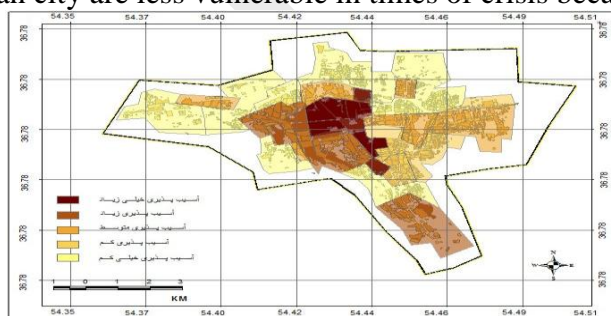


Figure 4. Gorgan city's vulnerability mapping based on physical indicators

### 2.5. The vulnerability of the city based on density of vulnerable elements

Figure 5 shows the vulnerability mapping of Gorgan city based on distribution of vulnerable elements in the city. As can be seen, many vulnerable elements have been distributed in the northwest of Gorgan city. The northwest part of Gorgan city is very important due to deployment of urban installations and critical facilities are located in this area including electricity Distribution Company in the province, the national petroleum products distribution company, regional water companies, water management and sanitation, the center of Iranian Revolutionary Guards and Veterinary Office which makes this area a very important matter terms of passive defense. In addition to this, important centers such as the Department of Transportation, Justice and the departments are located in north eastern and they are secondary in importance.

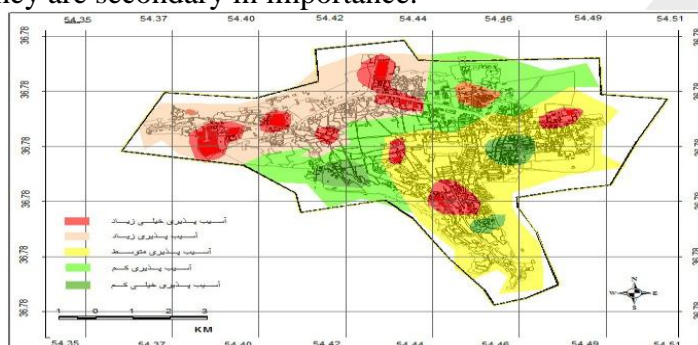


Figure 5. Vulnerability mapping in Gorgan city based on vulnerable elements

### 3.5. Zoning based on the vulnerability in the framework of passive defense

Finally, after the zoning of Gorgan city in terms of building density and distribution of urban facilities, this zoning should be integrated and combined and as a result, with overlapping layers of information, the zoning of Gorgan city is presented in terms of the vulnerability of urban installations with passive defense approach. According to the information contained in Table 6, the central and north-western areas because of high building density and centralized distribution of critical facilities have more vulnerability compared to other urban areas.

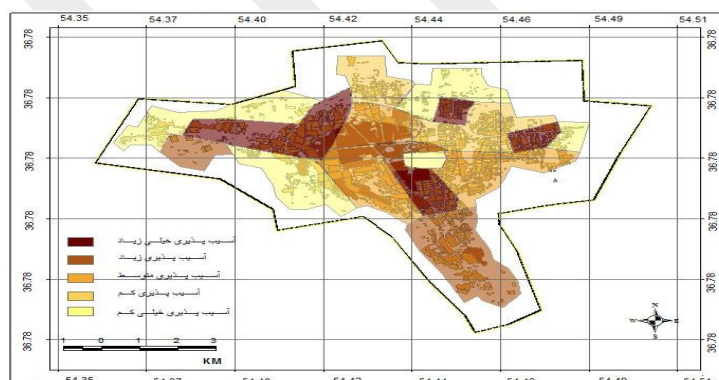


Figure 6. Vulnerability mapping of Gorgan city with passive defense approach

### Conclusion

Urban planning has huge problems in some cities, so that these cities will suffer from disruptions in water supply systems, power distribution and city gas in the event of crisis and rocket attacks and as a result, people will face with severe shortage of food and vital

communications will be interrupted. The passive defense is a set of measures that does not require certain weapons and is meant to save lives, ensure safety of people and preservation of territorial integrity and national sovereignty.

In this study, at first, the list of sensitive areas in Gorgan city was prepared. Then, the zoning of Gorgan city was investigated based on building density and zoning of installation elements with passive defense approach. According to the zoning map of building density, the center of Gorgan city because of smaller parts and components is more vulnerable during crisis and a huge number of vulnerable facilities are located in the North West of the city. Finally, with overlapping layers of information, it became clear that the North and North West of Gorgan due to the sensitive centers such as electricity distribution companies in the province, the national petroleum products distribution company, regional water companies, water directorate is more vulnerable compared to other areas.



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