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Modeling Susceptible Districts in GIS for Managing the Repair and Maintenance of Ancient Monuments

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ABSTARCT

Iran has many significant signs of historical urbanization. These signs include historical monuments and ancient buildings. It is imperative to protect these signs, for they are always susceptible to natural disasters and human interference. Thus, there has been an increasing need for an all-embracing approach to natural disasters and their consequences. The historical city of Tabriz is considered as one of the earthquake zones of Iran due to its vicinity to active dextral faults. Meanwhile, the municipality of District 8 of Tabriz, which is known as the historical and cultural municipality in Tabriz, has priceless historical places, a rusty fabric, and heavy traffic and the historical buildings of the city are always threatened by natural and unnatural disasters. In the present research, weighted index overlay analysis (WIOA) was used in GIS to distinguish the susceptible areas of the region. The layers used in this model include distance from the fault, the quality of the structures, vicinity to roads, vicinity to open spaces, fire station, gas station, and the topography of the studied region. The results showed that only 13.94% of the studied region is in a favorable or very favorable condition in terms of susceptibility during crisis. 47.37% of the region is in an average condition. Finally, 38.69% of the region is in unfavorable or very unfavorable condition in this regard. This necessitates precise, systematic planning before, during, and after crisis for protection, repair, and maintenance of the ancient monuments of the region.

Keywords: historical monuments, Bazaar of Tabriz, District 8, WIOA

INTRODUCTION

Our historical cities are disappearing and during the past two decades there has been an increasing formation of vast, modern urban fabric around the historical fabric. The excessive expansion of cities, natural disasters, and unscientific human interferences (e.g. roads, passages, and bridges that run through historical structures) has led to irreversible damages to the historical fabric [1]. Due to the unpredictable nature of most natural disasters and the necessity to make quick decisions and take prompt action, a new branch of knowledge has emerged which is known as management and maintenance of historical monuments. Tabriz City, with its dense population and priceless historic structures, is always threated by these hazards. Under these conditions, any natural or unnatural crisis will cause irremediable damages and obviously correct management is the only way to prevent such events [2,3].

Region 8 of Tabriz is of utmost importance due to its historical fabric and its dense population. Natural disasters and lack of proper management has caused much destruction in the historical monuments of the region. It is thus imperative to distinguish different areas of the district in terms of their susceptibility [4]. This district is located at the center of the city and attracts a large population on a daily basis. Hence, there is always much traffic in the streets and thoroughfares that puts much pressure on the historical fabric of the district. Due to the rusty fabric and dense population, any crisis in the district will clearly lead to considerable casualties and historical damage. Thus, an

attempt was made in the present research to distinguish the susceptible areas of District 8 of Tabriz using GIS [5]. Pourmohammadi et al. (2006) carried out a research on the role and application of GIS in controlling and rescuing the urban and rural residents of Tabriz. They studied the role of GIS in crisis management and rescue process before, during, and after crisis in Tabriz [6]. Asgari and Parhizcar (2006) studied the strategies for dealing with earthquakes and reducing the resulting damages in District 17 of Tehran. They introduced GIS as a helpful tool for crisis management by urban planners [7]. Adhami and Maleki (2009) examined the role of GIS in crisis prevention and management. They believe that GIS data and efficiently trained personnel can increase the efficiency of crisis response systems [2]. Asgari and colleagues (cited in Nesyani, 2010) studied the role of urban services in managing crises and accidents with an approach to GIS. Nesyani (2010) also applied SDSS in GIS for crisis management to analyze District 8 of Tabriz in terms of its susceptibility to earthquakes [8].

The Studied Region

Tabriz is one of the historical cities of Iran with an area of 140 km^2 located at 38°04′N 46°18′E. The mean altitude is about 1340 meters. The historical, geographical, cultural, economic position of Tabriz has given it a special place in the country. Meanwhile, District 8 of Tabriz, with an area of 260 hectares, constitutes the major rustic and historical fabric of the city.

Susceptibility of Tabriz to natural disasters

The Iranian plateau is a disaster-prone area and Tabriz City is highly susceptible to natural disasters due to its geographical structure and its special topography. Earthquake and flood are the major natural disasters that have accompanied this ancient city throughout history, imposing much casualties and costs on the region. The historical and ancient monuments of the city have suffered the greatest damage from such destructive earthquakes.

The natural disasters that threaten the historical monuments of cities

1. Flood

According to hydrological and meteorological studies of Tabriz, February, March, and April are the rainiest months of the year (ZISTA Architecture & Urban Planning Consulting, 1999).

Table 1 – The flood-based disasters in Tabriz in a five-year period

City	Region	Date	Damage (million rial)
Tabriz	Central part	1998	79
	Villages of the central part	1994	1620
	Villages of the central part	1996	501
	Entire city	1996	501
	Subsidiary parts	1997	12900

Source: ZISTA (1999)

2. Earthquake

Tabriz is one of the earthquake-prone regions of the country, such that earthquakes have destroyed the city several times throughout history and have caused many casualties and many costs. One of the most destructive of earthquakes occurred in 1721 BC in Tabriz where 250 thousand people were killed (Table 2). Considering the multi-million population of Tabriz, any earthquake can cause dreadful casualties.

Table 2 – Destructive earthquakes in Tabriz

Year	Severity of destruction	Casualties
858 BC	Destruction of the entire city	-
1041 BC	Severe earthquake	50000
1042 BC	Severe earthquake	40000
1527 BC	Severe earthquake	40000
1721 BC	Very severe earthquake	250000
1779 BC	Severe earthquake	100000
1780 BC	Severe earthquake	40000

Source: Shafi'i (2005)

The historical value of the region

There are many historical monuments that have survived from different period and are scattered around the region, including Bazaar of Tabriz, Arg (castle) of Tabriz, Congregational Mosque of Tabriz, Saheb-ol-Amr Mosque, Blue Mosque, Maqbaratoshoara, Tabriz Museum, etc.

MATERIALS AND METHODS

In the present research, library studies were carried out to identify the driving factors in locating the regions susceptible to natural disasters. The collected parameters are as follows:

- Distance from dangerous areas such as gas stations, power lines such as water and gas, etc.
- Distance from roads and thoroughfares (minor arterial roads and local roads)
- Access to open spaces (the more the access, the less the susceptibility)
- Topography (slopes are positively associated with susceptibility)
- Distance from faults (negatively associated with susceptibility)
- Quality of the structures
- Distance from fire stations

Creating the information layers

Considering the mentioned parameters, there was a need for a land use map for the management of the historical fabric and reduction of damages at the time of disasters. Thus, the land use map of Tabriz was acquired from the Department of Housing and Urban Development. Then, different areas designated for specific purposes of land use were marked out and used for extracting the required layers (figure 2). It must be noted that a map related to the faults as well as the topography of the region were also obtained from the Department of Natural Resources.

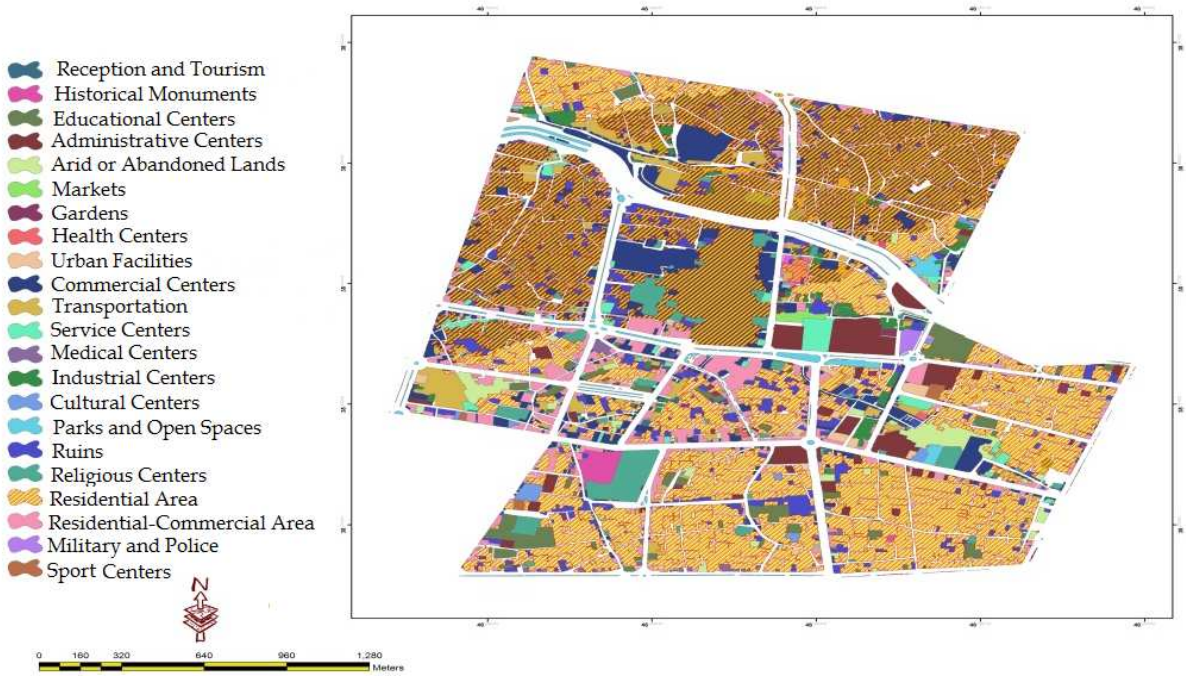

Figure 1 – The land use map of Region 8 of Tabriz

Standardization of the information layers

The first step in managing the maintenance of historical monuments at the time of crisis is to extract the required information layers. Most of the layers of the required criteria and sub-criteria for identification of susceptible regions are separated and valuated by creating a buffer or, in some cases, by means of Query Builder. The different layers are drawn on the surface of the studied region and are stored in the database in the form of raster layers (which are able to reclassify). The layers are prioritized and standardized into 3 to 6 categories based on the created buffer or the existing applications and the final layers are as follows:

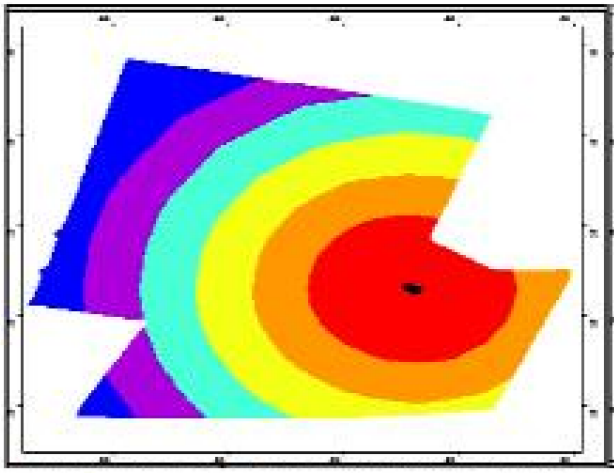

Figure 2 - Standard map of distance from fire

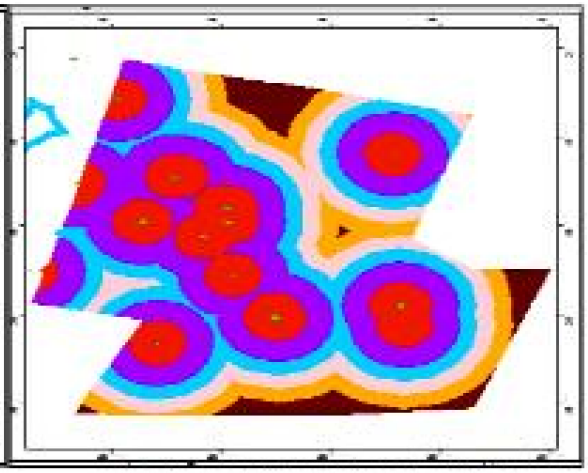

Figure 3 - Standard map of distance from health

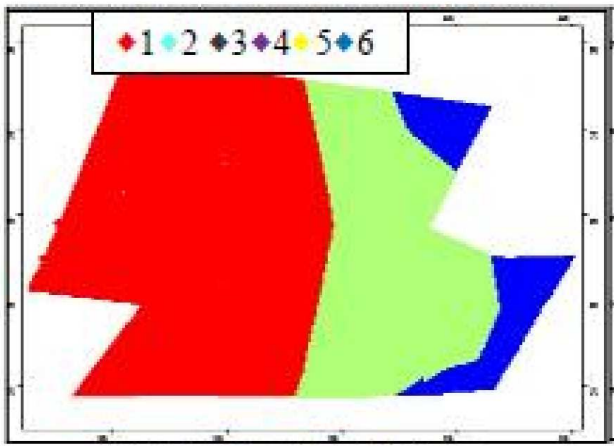

Figure 4 - Standard map of altitude

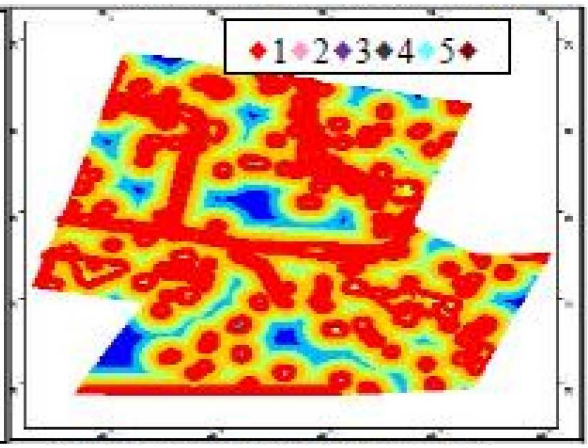

Figure 5 - Standard map of vicinity to open spaces

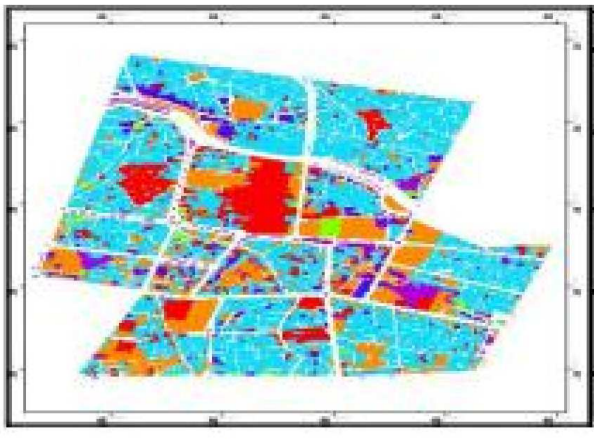

Figure 6 - Standard map of structure quality

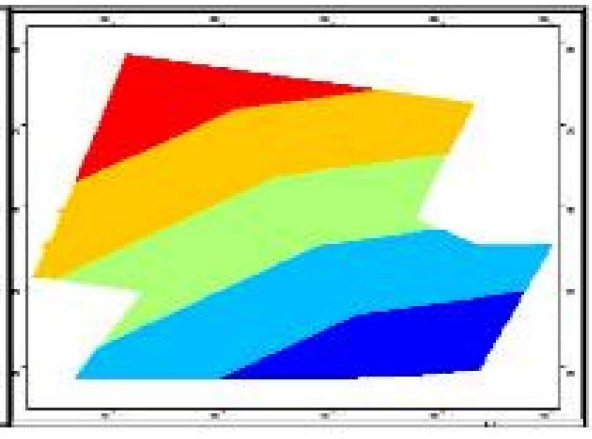

Figure 7 - Standard map of distance from faults

RESULTS

Weighted index overlay analysis

Spatial analysis is done to identify the potential regions that are extracted from the values of each pixel of the raster map based on some criteria. The weighted index overlay model enables us to combine different maps. In the present research the multi-criteria method is used and the model is defined as (Murray, 2003): [9].

$$S = \sum_{i}^{n} \frac{S_{ij} W_i}{W_i}$$

where S is the score assigned to each cell, W_i is the weight of the ith information layer, and S_{ij} is the score of the jth class from the ith map. In this model, each class of different layers can be assigned a particular weight and considering the importance of each layer compared to other layers, we can assign a weight to each layer based on its importance. This is one of the characteristics of this model in combining layers [10, 11]. To obtain the output map for the susceptible areas of Region 8 of Tabriz, the maps were classified and the potential of each of the parameters was evaluated by the authors (table 4).

Table 3 – The weights of the evaluated criteria in the index overlay method

	Priority	Importance
Localization Criteria	Distance from faults	19%
	Quality of structures	20%
	Vicinity to roads	18%
	Vicinity to open spaces	11%
	Distance from fire station	12%
	Distance from gas station	8%
	Altitude	12%

After standardization, the layers were imported in Weighted Overly environment in ARC GIS 9/2. After modeling (figure 8).

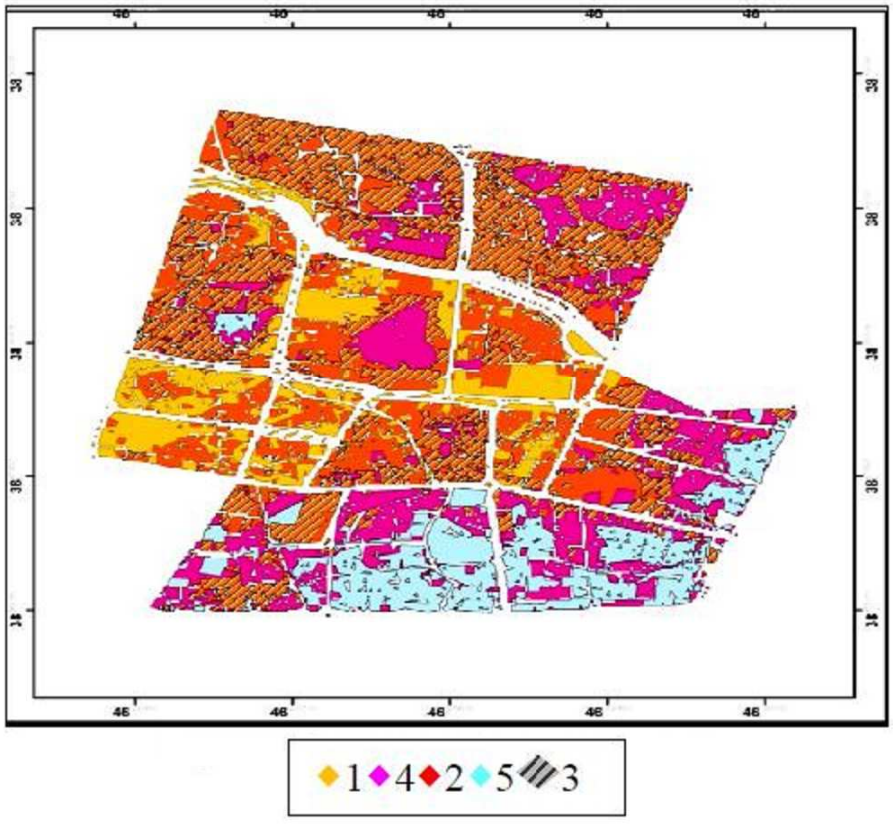

Figure 8 – The final map obtained from WIOA

DISCUSSION AND CONCLUSION

Protection of historical monuments against natural disasters has received increasing attention over the last few decades. Especially after recent earthquakes and other devastating natural disasters that led to destruction of priceless historical monuments around the world, this issue has turned into a recognized and common issue. In countries where managers of service organizations had no idea of managing the maintenance of historical monuments for prevention, readiness, and confrontation plans, coordination between different sectors, public training, etc., we have witnessed an increasing awareness among the people of the society in this regard. Now the responsibility of preparing the society falls on the shoulders of administrators, planners, and experts. Tabriz is susceptible to various hazards due to its special geographical and climatic condition and its natural structure and most of the known natural disasters of the world have occurred in this city. Considering the history of the city with its hundreds of priceless historical monuments, there is a greater chance of damage and costs due to hazards. Thus, the bitter experiences of the past on the one hand and the necessity for a prompt response to different disasters that threaten the historical fabric of the city on the other hand entails creating a system for confronting these destructive crises.

One of the most critical regions of Tabriz, i.e. Region 8, was studied in the present research. The factors that distinguish this region from others are as follows: the ancient monuments that has survived different historical periods are scattered around the city, including Bazaar of Tabriz, Arg (castle) of Tabriz, Congregational Mosque of Tabriz, Saheb-ol-Amr Mosque, Blue Mosque, Maqbaratoshoara, Tabriz Museum, etc. Another important characteristic of the region is the presence of old residential areas. The disastrous record of this city necessitated the adoption of strategies for classifying the susceptible parts of the region. This would enable us to take necessary actions for preventing possible damage to the rustic and historical fabric of the city before, during, and after crisis. Thus, the susceptibility map of the region was created using weighted index overlay method (figure 8). The results of the output of the model indicate that only 13.94% of the studied region is in a favorable or very favorable condition. 47.37% of the area is in an average condition in terms of susceptibility during crises. 38.69% of the area is in an unfavorable or very unfavorable condition. Considering the studies carried out and the results related to the layer of fire station, it must be noted that the radius of action of the closest station is between 1250-1650 meters, we have an area in the northwest of the region that is not covered by the firefighting services. It is thus recommended that another fire station be established in that area. It is also recommended that the instable non-historical regions be converted to open spaces to reduce the pressure on the historical fabric and enable its repair and maintenance.

In general, since a large part of Region 8 of Tabriz lies within the average to very unfavorable spectrum, it is necessary for the officials to implement the best strategy for protection of the historical monuments of the region and conversion of the old, non-historical areas to open spaces as specified by the overlay map (figure 8) and thus reduce the destructive physical pressures caused by traffic. The recommended strategies and others can prevent the destruction of the historical fabric and the rustic residential areas of the region and therefore maintain the historical identity of the city.

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