Tarbiat Modares University

The International Journal of Humanities

[DOR: 20.1001.1.25382640.2022.29.2.2.4]

[DOI: 10.52547/eijh.29.2.81]

RESEARCH ARTICLE

Received: 4 October 2020
Accepted: 24 July 2021
Published: 1 April 2022

[1] GIS, Geography faculty, University of Tehran, Tehran, Iran
E-mail: mehdi.farokhanari@ut.ac.ir

How to cite this article: Farokh Anari, Mehdi (2022). Vulnerability Study of Ancient Monuments in Lorestan's Khorramabad Using GIS and Fuzzy Logic Method, *The International Journal of Humanities* (2022) Vol. 29 (2): (81-94).

Vulnerability Study of Ancient Monuments in Lorestan's Khorramabad Using GIS and Fuzzy Logic Method

Mehdi Farokh Anari[1]

Abstract: Natural and human factors are always a threat to the destruction and damage of ancient monuments, and depending on the type of area, each of these factors can be damaging; many historical sites have been destroyed or seriously damaged as a result of these circumstances. Using GIS, the threatened regions of historical sites in Lorestan's Khorramabad region were identified to take action to preserve them. Shapur Khast Fortress (Falakol aflak), Broken Bridge, Safavid Bridge (Gap Bridge), brick minaret, Khorramabad inscription, and Gerdab Sangi are among the region's known ancient sites. Effective factors in the destruction of ancient monuments are five criteria defined by professionals in the field, which include the distance from the waterway, distance from the streets, slope, height, and slope orientation, all of which are depicted on a geographical map. The model is next assessed utilizing modeling by fuzzy logic operators approach and identifying the effect of each criterion. The final result includes five vulnerability classes: very high, high, medium, low, and very low. In this study, the AND operator provides the optimal risk-adjusted state, which has been proven by empirical verification and historical sources.

Keywords: Fuzzy Logic; GIS; Archeology; Khorramabad; Environmental Factors.

[DOR: 20.1001.1.25382640.2022.29.2.2.4]

[DOI: 10.52547/eijh.29.2.81]

Introduction

Archaeologists and other scientists have researched the vulnerability of ancient cities and ancient monuments in different historical periods using diverse methods to environmental factors. Vulnerability is defined as an incident that can occur gradually or unexpectedly, in which a community, structure, service, or geographic region is destroyed or disturbed by its nature or location as a result of the effect of a specific natural or human danger. Environmental circumstances and variables in each location have a significant impact on the emergence of human settlements and the construction of units within them (Zaheri, 2009). It is evident and analyzed in the form of different patterns. These patterns are the product of structured cultural linkages with natural and environmental resources (Anschuetz et al, 2001: 159). Because of their favorable environmental conditions, alluvial zones such as plains and alluvial fans are desirable for the people. Humans have inhabited these zones since the Quaternary period and continue to do so now (Motamed, 2003: 192). Human vulnerability to the natural environment demonstrates how the Jajroud alluvial fan in Tehran's Varamin plain and Qazvin's Haji Arab plain has played an important role in the establishment of ancient settlements in these areas (Maghsoudi et al., 2012).

The ancient city of Shapur Khast was located on the old routes from Hamedan to Khuzestan, as well as the road connecting Mesopotamia to the central regions of the Iranian plateau, and was regarded as one of the most significant cities in western Iran throughout the Islamic era. In terms of geography and environment, the Khorramabad valley and its southern sedimentary plains, the most notable of which is the huge plain of Koregah, are in a favorable position. In terms of geography and environment, the Khorramabad valley and its southern sedimentary plains, the most notable of which is the vast plain of Koregah, are in a favorable position. Adequate geographical circumstances, the heights around this valley, and notably the connecting routes have given this valley a privileged location (Abdoli Fard, 2004: 600; Najm al-Mulk, 1963: 600; Najm al-Mulk, 1963: 18 and Bishop, 1996: 67).

[DOR: 20.1001.1.25382640.2022.29.2.2.4]

[DOI: 10.52547/eijh.29.2.81]

The current city of Khorramabad's primary center is formed to the west and northwest of the Falakalaflak Fortress. Before the modern city of Khorramabad was founded, a city called Shapurkhast existed in its site, dating back to the Sassanid dynasty. Numerous factors have been effective in the formation of Shapur Khast city, including favorable environmental conditions, sitting in the route of communication arteries, and the presence of a fort that could offer protection (Falakolaflak Fortress), whereby these variables can also be effective in the formation of Khorramabad, a new city in its northwest. Falakol Aflak fortress, particularly in terms of military and defensive stance, was a key factor in the construction of Shapur Khast city and today's Khorramabad. Throughout history, this fort, together with the market and the old districts of Khorramabad, located to the west of the stronghold, has functioned as an administrative and governmental center. Because of the significance of this fortress regarding the city of Shapur Khast and the present city of Khorramabad, as well as its historical and architectural importance, it needs to be renovated and restored (Hajizadeh et al., 2015: 1). Environmental factors have a greater impact on the formation or destruction of ancient settlements than any other factor, and it is impossible to reconstruct many biological and livelihood dimensions of early humans due to their reliance on environmental factors without first recognizing environmental elements (Ramesht, 2009: 111). Identifying the present appearance and developing connection and interaction with the ancient aspect can help to prevent further environmental damage (Alavipanah, 2007: 598). Maghsoudi et al. used fuzzy logic to examine the role of environmental factors in locating prehistoric settlements in the Varamin plain in a study (Maghsoudi et al., 2015). In 2018, Behzad et al. addressed the impact of environmental factors in the destruction of historic monuments (Behzad et al., 2018). Davarpanah et al. utilized ANP-OWA spatial data analysis to estimate the vulnerability of sites and monuments in flood risk (Davarpanah et al., 2016).

The current study is an attempt to investigate the vulnerability of the historical sites of Shapur Khast (Khorramabad) as one of the towns of the early Islamic era, the founding

[DOR: 20.1001.1.25382640.2022.29.2.2.4]

[DOI: 10.52547/eijh.29.2.81]

of which dates back before the Islamic era and maybe before the Sassanid period. The overall aim of this study is to create a map of high-risk areas in this city. Finding effective geographical factors in the destruction of ancient monuments is one of the applications of remote sensing science and geographic information systems that allows us to observe and analyze influential factors on a map, which has a significant impact on management and decision-making to preserve ancient monuments. Satellites and contemporary data processing technologies can limit the number of archaeological excavations that result in changes in land formation, irrigation systems, and vegetation. (Alavipanah, 2007: 598). Remote sensing and geographic information systems (GIS) are more dependent on location than anything else, and because geographical locations are one of the most essential requirements in the development of cultures and civilizations, and since man has left relics of these cultures and civilizations, we may utilize this knowledge to preserve precious historical monuments.

This article proposes a strategy to deal with environmental dangers and human impacts in the preservation of historical monuments. It makes use of current satellite images captured by geological satellites, as well as aerial imagery, which is a valuable source for identifying changes over time. Modeling is used to simulate the processes that cause historic monuments to be destroyed. Fuzzy modeling is utilized to create risk maps for the region in this research.

Geographical Location of the Study Area

Khorramabad is the provincial capital of Lorestan province. This city is limited to Selseleh city from the north, Boroujerd city from the northeast, Doroud and Aligudarz cities from the east, Andimeshk city from the south, and Dowreh and Pol Dokhtar cities from the west and southwest. Khorramabad is located at 33.48 degrees north latitude and 48.35 degrees east longitude and an elevation of 11.478 meters above sea level (Figure 1) (Dalvand, 2009: 14). In Konji Cave in Lorestan, Henry Field performed the first archaeological study and Paleolithic excavations (Vahdatinasab and Aryamanesh, 2015: 70) then, in 1964, Frank Hole and Kent Flannery proceeded to the Konji cave to

investigate experimental doubts. They next explored the Ghararzhaneh rock shelter, the Yafteh cave, the Ghamari cave, and the Pasangar rock shelter (Vahdatinasab and Aryamanesh, 2015: 77).

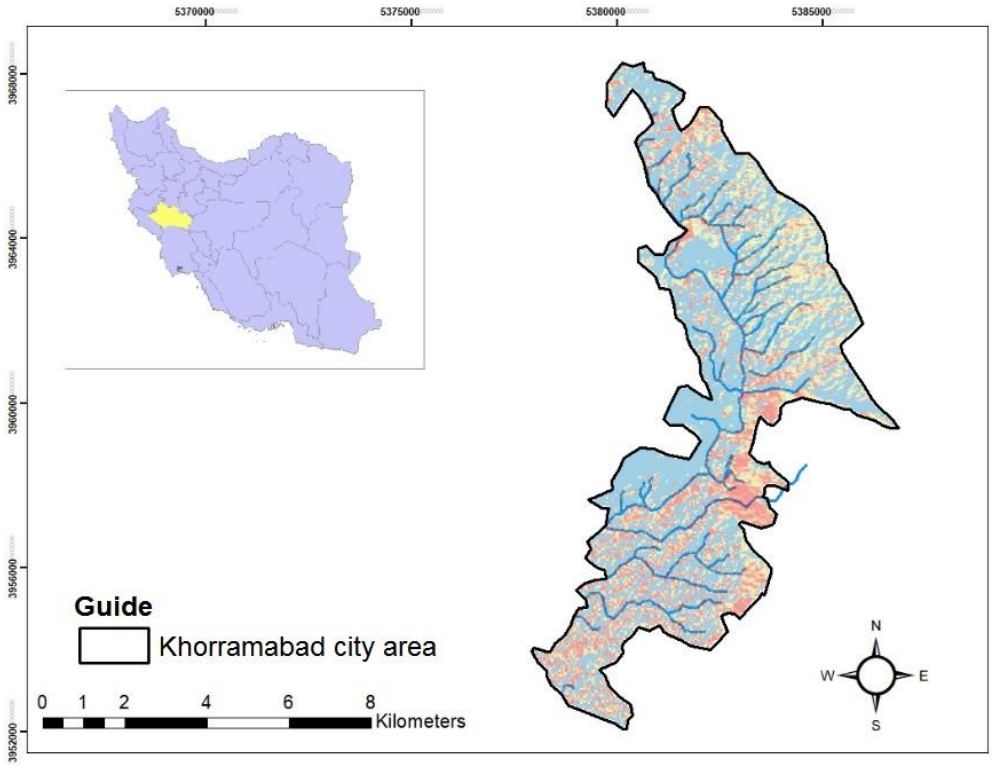


Fig. 1. City of Khorramabad

Archaeological Data and Monuments

The location of the area was initially determined using topographic maps and Google Earth to conduct this research. The ancient sites of this region were then recognized and depicted on the map. Natural forces had destroyed a total of 7 ancient sites in recent years, according to this analysis. Shapur Khast Fortress (Falakol Aflak), Broken Bridge, Safavid Bridge (Gap Bridge), brick minaret, Khorramabad inscription, and Gerdabe Sangi are among these historical sites. Falakol Aflak, a historical fortress, is situated on an ancient hill in the heart of Khorramabad, Lorestan province's capital. The Khorramabad River to the east and southwest, Dovazdeh Borji Street to the west, and Falakol Aflak Street to the north limit the solitude of this majestic structure. The western section of the

[DOR: 20.1001.1.25382640.2022.29.2.2.4]
[DOI: 10.52547/eijh.29.2.81]

[DOR: 20.1001.1.25382640.2022.29.2.2.4]

[DOI: 10.52547/eijh.29.2.81]

castle has Khorramabad's original texture and the initial core of the city's foundation. The Safavid Bridge or brick bridge, also known as Gap Bridge among Khorramabad locals, is a historical bridge from the Safavid period. This historical bridge has been added to the National Heritage list. This bridge connects the western and eastern parts of Khorramabad and is located on the Khorram Rud in the city center. This bridge was built in a similar style as Khajoo Bridge, and it featured alcoves that were ruined by floods. During the reign of Shah Sultan Hussein Safavid, this masterpiece was constructed. Broken Bridge, one of the Sassanid period's architectural wonders, is located on the south side of Falakolaflak Castle in Lorestan province's Khorramabad city. The brick minaret, which dates from the fourth century AH, is one of Khorramabad's historical monuments. The inscription, which is carved in Kufic script on a three-and-a-half-meter-high piece of stone, dates from the sixth century AH during the Seljuk period. This inscription was inscribed during the year 513 AH during the reign of Abu Sayeed Barsaq Kabir, one of Mahmud I of Seljuk's governors.

Research Method

The research method is based on the fact that the effective criteria in the destruction of antiquities are first identified and extracted, then their maps are drawn, and finally, the information layers of the mentioned criteria are prepared from satellite images and applied to maps using the GIS distance analysis function. Despite the fact that the GIS was not created with archeology in mind, it has evolved into one of the most important and powerful tools in the field, and it is utilized in a variety of ways (Siart, et al, 2008: 2918)

The ratio of the frequency of vulnerable locations in each of the classes of factors causing slip has been determined to zoning, revealing vulnerable areas using fuzzy operators. The maps of the various factors were transformed into fuzzy maps based on the obtained frequency ratios and the employment of the fuzzy Gaussian basis functions, and all the factors were overlapped using the fuzzy maps of the sum and operators. Figure 2 depicts the steps taken in this research.

[DOR: 20.1001.1.25382640.2022.29.2.2.4]

[DOI: 10.52547/eijh.29.2.81]

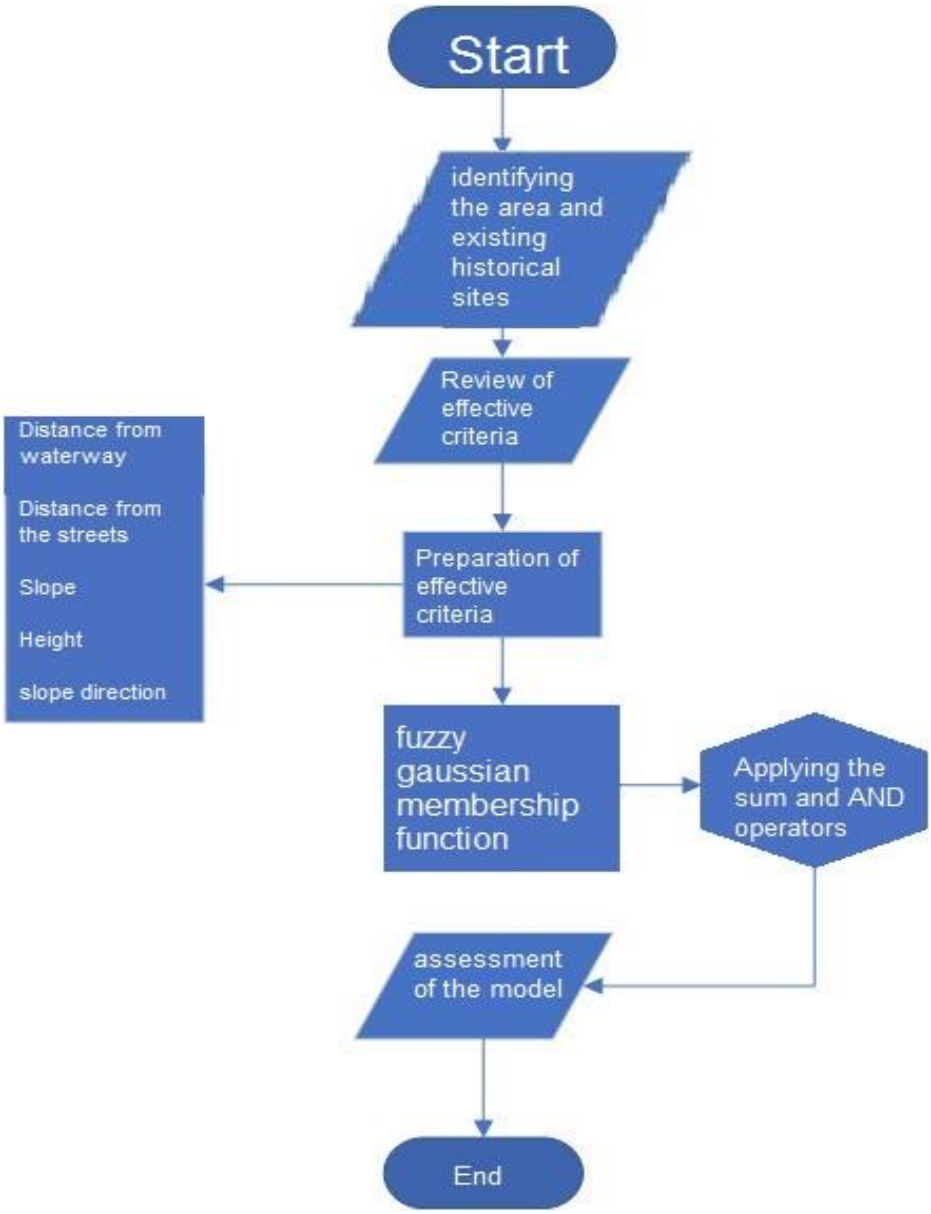


Fig. 2. View the steps

Review Criteria

Archeological and GIS criteria were employed in this study, which are covered in the following order.

A. Distance from waterway: This is one of the factors that contribute to landslides by causing erosion along the river and disrupting the slope's stability. Different methods are

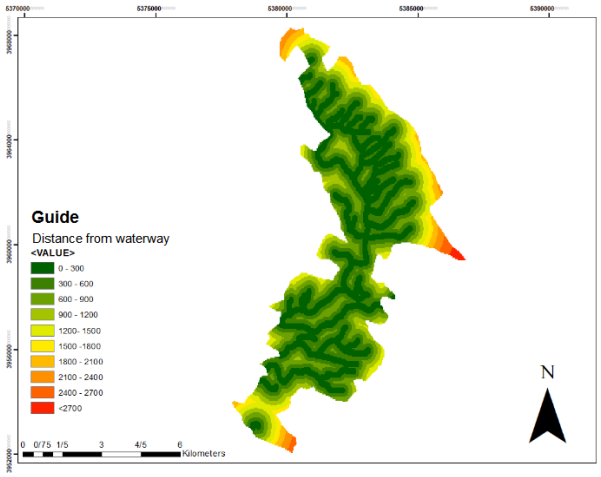
used to consider this factor in the vulnerability of historical monuments. The distance from the waterway and the waterway network were estimated and generated using the imagery of Aster satellites with a 30-meter precision to prepare the map.

B. Slope direction: Due to its influence on weathering and humidity in the slope, the direction of the slope is generally of significant relevance in the occurrence of landslides, which is a factor in the destruction of ancient monuments.

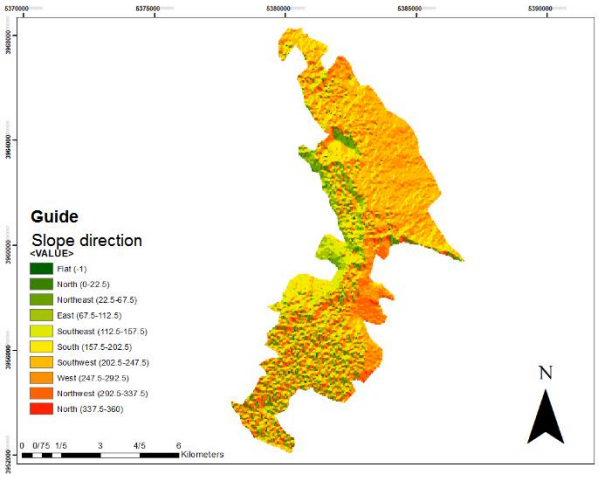
C. elevation classes or heights: Many elements that degrade historical monuments are indirectly influenced by this factor, including annual rainfall, heavy rainfall, type of rainfall, temperature changes, frost, physical destruction, and chemical weathering. The map classification of the digital elevation model DEM of Aster stereo pair images was used to create a map of its elevation classes.

D. Distance from streets: The streets are a human factor that has been constructed in such a style that only the feature of traffic is taken into account, regardless of historical monuments. This factor can be effective.

And. Degree of the foot slope: The mechanism of many displacements related to surface materials and movement processes is a function of slope, and the slope is a functioning component in landslides, thus investigating slope status is critical. The slope is regarded as one of the factors since the region has been exposed to this risk in recent years. The DEM 30-meter Aster sensor was utilized to create the slope map (Fig. 3).

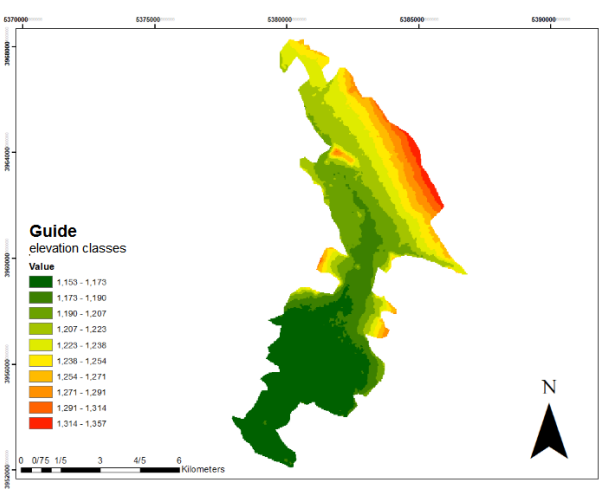


A. Distance from Khorramabad watershed

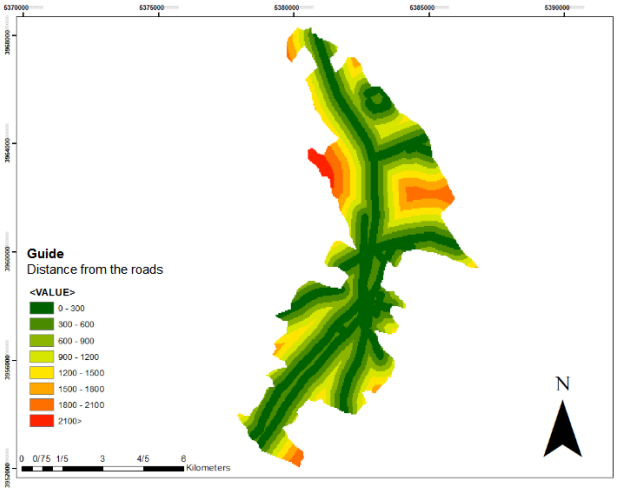


B. Khorramabad slope orientation

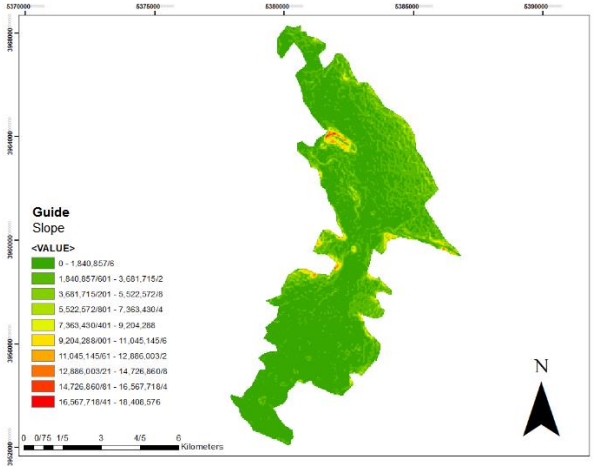
[DOR: 20.1001.1.25382640.2022.29.2.2.4]
[DOI: 10.52547/eijh.29.2.81]



C. Height classes of Khorramabad



D. Distance from streets in Khorramabad



And. Slope of Khorramabad

Fig. 3. Studied criteria

Zoning the Risk of Destruction of Historical Monuments using Fuzzy Logic

One of the areas that lead to effective and efficient management is decision-making, which is rapidly expanding. Multi-criteria decision-making is one of the most significant branches of decision theory. Fuzzy logic, one of the multi-criteria decision models, can mathematically transform many concepts, variables, and systems that are inaccurate and ambiguous, and provide the basis for reasoning, control, and decision-making in conditions of uncertainty. When our criteria and variables are not specific and exact, we switch to the fuzzy method. Although there is no precise method for obtaining the membership function, experience, ingenuity, and the involvement of experts in the

[DOR: 20.1001.1.25382640.2022.29.2.2.4]
[DOI: 10.52547/eijh.29.2.81]

construction and formulation of the membership function can be beneficial. The prepared fuzzy maps were overlapped and the hazard points map for Khorramabad historical monuments is prepared using these operators after establishing the membership function using the sum and AND operators. The fuzzy algebraic sum operator of this operator is a complement of fuzzy algebra multiplication and the AND operator is a complement of fuzzy algebraic sum (Ashqali Farahani, 2001).

The frequency ratio in each of the classes of factors affecting slip has been determined to display the vulnerable areas using fuzzy operators. The maps of the various factors are transformed into fuzzy maps based on the obtained frequency ratios and the utilization of the Fuzzy Gaussian membership function, and all the factors are overlapped using the sum and AND operators of the fuzzy maps, and the vulnerability map is based on each of them. The operators are classified into five risk categories: very low, low, medium, high, and very high risk (Figures 4 and 5).

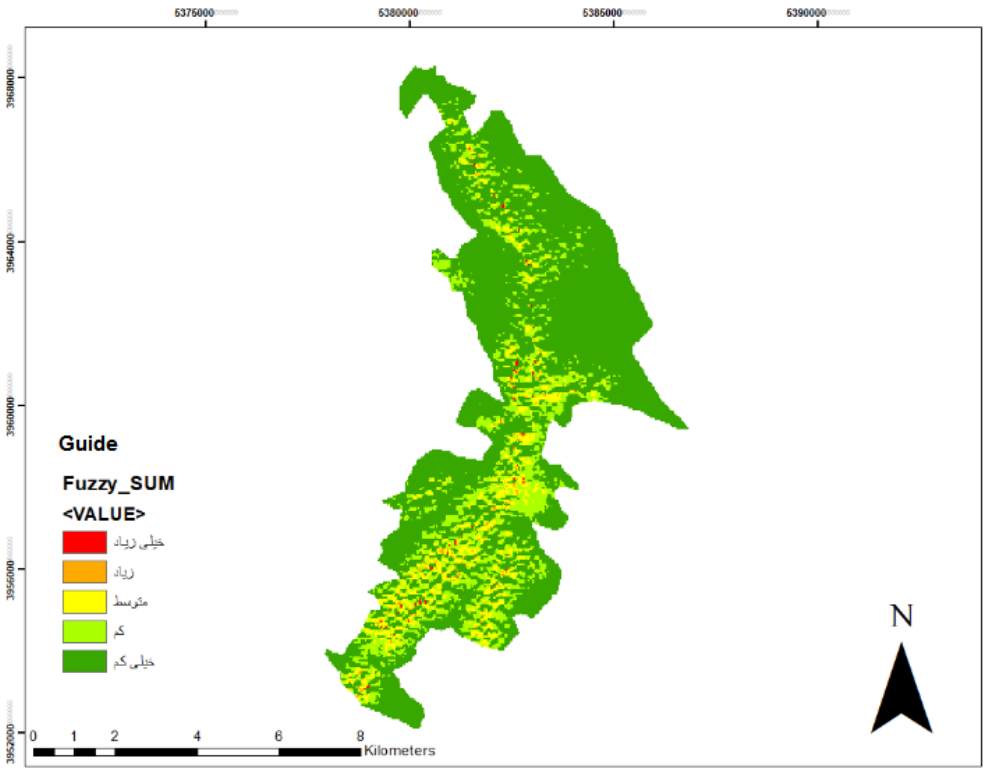


Fig. 4 Map of vulnerability areas of Khorramabad historical monuments using fuzzy sum operator

[DOR: 20.1001.1.25382640.2022.29.2.2.4]
[DOI: 10.52547/eijh.29.2.81]

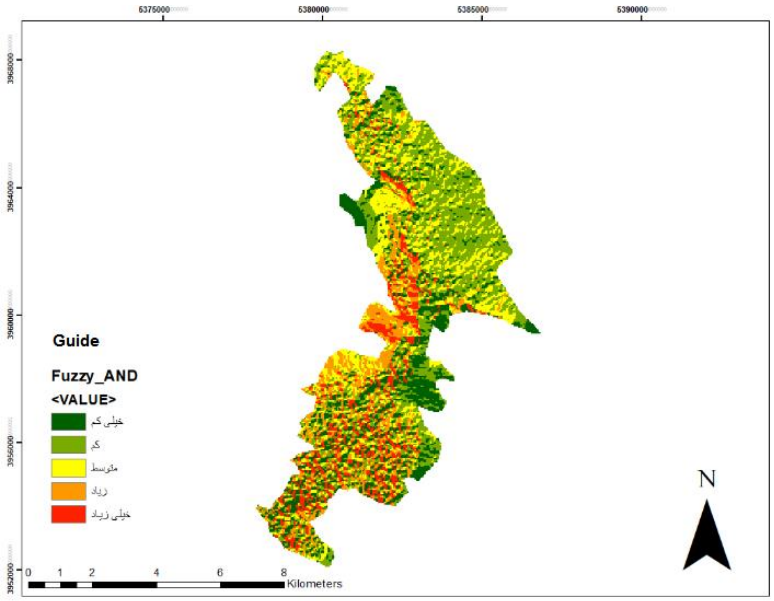


Fig. 5 Map of vulnerability areas of Khorramabad historical monuments using fuzzy AND o**perator**

Accuracy of Output Model

Various methods for analyzing natural and human hazard risk zoning models on historical sites are presented by researchers. The majority of assessment techniques are based on field and experimental data, and there is no model for evaluating them. Because historical sites were considered in this study, the assessment was conducted in the form of observations and library and historical resources, indicating that the observations were consistent with the fuzzy AND operator. The images depict the recent damage of historical monuments in the Khorramabad region due to floods, as well as other factors such as the development of roadways surrounding historical sites.

Discussions and Conclusion

Natural and human factors have always posed a hazard to historical monuments, and depending on the type of area, each of these variables can be vulnerable in various manners. This study attempted to identify the endangered locations of historical sites in Lorestan's Khorramabad region using GIS technology to take steps toward their preservation. Shapurkhast Fortress (Falakol Aflak), Broken Bridge, Safavid Bridge (Gap Bridge), brick minaret, Khorramabad

[DOR: 20.1001.1.25382640.2022.29.2.2.4]
[DOI: 10.52547/eijh.29.2.81]

[DOR: 20.1001.1.25382640.2022.29.2.2.4]

[DOI: 10.52547/eijh.29.2.81]

inscription, and Gerdabe Sangi are among the region's historical monuments. Criteria for the demolition of historical monuments that are effective the distance from the canal, the distance from the streets, the slope, the height, and the orientation of the slope are the five requirements. The final output contains five vulnerability classes: very high, high, medium, low, and very low. In this study, the AND operator provides the optimum risk-adjusted situation, as established by empirical validation and historical data. The results demonstrate that few historical sites, such as Shapurkhast Fortress, have been destroyed at various periods due to natural and human factors, such as floods, but others are stable due to the strength of the structure. In this regard, efforts should be undertaken to minimize the destruction of historical monuments by establishing a study platform. It is feasible to develop geographic information systems to monitor historical sites for administration and management, as well as to safeguard historical monuments from natural and human threats.

References

[1] Abdoli Fard, Fereydon, (2004). *The chapar Khanahs and chapar roads in Iran.* Tehran: Hirmand (In Persian).

[2] Alavipanah, Seyed Kazem, (2007). Fundamental of modern Remote Sensing and interpretation of satellite imagery and aerial photos. Tehran: University of Tehran (In Persian).

[3] Anschuetz, Kurt F., Richard H. Wilshusen, and Cherie L. Scheick, (2001). An archaeology of landscapes: perspectives and directions, *Journal of Archaeological Research* 9(2):157-211.

[4] Anschuetz, Kurt F., Richard H. Wilshusen, and Cherie L. Scheick, (2001). An archaeology of landscapes: perspectives and directions, *Journal of Archaeological Research* 9(2):157-211.

[5] Ashqali Farahani, Aqeel, (2001). *Assessing the risk of instability of natural slopes in Rudbar region using fuzzy theory.* Master Thesis in Engineering Geology, Tarbiat Moallem University (unpublished) (In Persian).

[6] Behzad, Ardavan, Bezad Fozoni, Ezatollah Mirzaei, (2018). The role of environmental factors on the destruction of ancient sites (Case study of ancient sites in Sar Firoozabad district of Kermanshah province*), Quarterly of New Attitudes in Human Geography*, Vol. 10, No. 3: 19-32 (In Persian).

[۷]Bishop, Isabella Lucy Bird, (1996). *Journeys in Persia and Kurdistan Including a Summer in the Upper Karun Region and a Visit to the Nestorian Rayahs*,

Persian translation by Mehrab Amiri, Tehran: Sahand and Anzan.

[8] Dalvad, Hamidreza, (2009). History and architecture of Shapurkhast fortress (Falakol Aflak), Tehran: Richt (In Persian).

[9] Hajizadeh, Karm, Mahtab Islami Nasab, Majid Mohammad Yarloo, Soveil Amani, (2015). *Improvement and protection of the historical monument of Falakalaflak Castle in Khorramabad*, International Conference on Civil Engineering, Architecture and Urban Infrastructure (In Persian).

[10] Maghsoudi M, Zamanzadeh S M, Ehdaei A, Yousefi Zoshk R, Yamani M., (2015). Analysis of the role of environmental factors in site selecting of prehistoric settlements in Varamin Plain with usage fuzzy logic. *The Journal of Spatial Planning*. 2015; 19 (3) :263-261 (In Persian).

[11] Maghsoudi, M., H. Fazeli Nashli. Azizi, Qasem. Gillmore, G.K., Eshmit, Armin, (2012). The role of Alluvial Fan in distributing prehistoric settlements from the perspective of archaeological land (Case Study: Jajrud and Haji Arab Alluvial fan) Natural geography research, Vol. 44, No.4, pp.1- 22. [in Persian]

[12] Maghsoudi, M., H. Fazeli Nashli. Azizi, Qasem. Gillmore, G.K., Eshmit, Armin, (2012). The role of Alluvial Fan in distributing prehistoric settlements from the perspective of archaeological land (Case Study: Jajrud and Haji Arab Alluvial fan) Natural geography research, Vol. 44, No.4, pp.1- 22 (In Persian).

[13] Malian A, Davarpanah M, Sheikhmohammadzadeh A., (2016). Assessment of Vulnerability of Flood Prone Historical Monuments and Sites Using ANP-OWA Spatial Multi Criteria Analysis. *Geospatial Engineering Journal*. 2016; 7 (3) :25-37 (In Persian).

[14] Motamed, Ahmad, (2003). *Quaternary Geography*, Tehran: The Organization for Researching and Composing University Textbooks in the Islamic and Human Sciences (In Persian).

[15] Najm al-Mulk, Abdolghafar ibn Ali Mohammad, (1963). Travelogue of Khuzestan, by the effort of: Mohammad Dabir Siyaghi, Tehran: Ali Akbar Elmi.

[16] Ramesht, Mohammad Hossein, (2009). Space in Geomorphology, *The Journal of Spatial Planning*, Vol. 14, No. 4, Pp. 111 -136 (In Persian).

[17] Siart, Christoph, Bernhard Eitel, Diamantis Panagiotopoulos, (2008). Investigation of past archaeological landscapes using remote sensing and GIS: a multi-methodical case study from Mount Ida, Crete, *Journal of Archaeological Science, Vol. 35*, Pp: 2918-2926.

[18] Vahdati Nasab, Hamed, Shahin Aryamanesh, (2015). *Paleolithic Archaeology of Iran (From Beginning to the Dawn of Early Villages)*, Tehran: Richt (In Persian).

[19] Zaheri, Mohammad, (2009). The Analysis of Correlation between Environmental Factors and Desirability of Physical Structure of Rural Houses (Case study: The residential units of 15 villages of East-Azerbaijan), *Journal of Geography and Planning*, Vol.14 No: 29: 163-189 (In Persian).

[DOR: 20.1001.1.25382640.2022.29.2.2.4]

[DOI: 10.52547/eijh.29.2.81]

The International Journal of Humanities (2022) Vol. 29 (2): (81-94)

The International Journal of Humanities

بررسی آسیب‌پذیری آثار باستانی خرم‌آبادِ لرستان با استفاده از GIS و روش منطق فازی

مهدی فرخ اناری[1]

تاریخ دریافت: ۱۳۹۹/۷/۱۳
تاریخ پذیرش: ۱۴۰۰/۵/۲
تاریخ انتشار: ۱۴۰۱/۱/۱۲

[1] گروه سنجش از دور و سیستم اطلاعات جغرافیایی گرایش سیستم اطلاعات جغرافیایی، دانشکده جغرافیا، دانشگاه تهران، تهران، ایران.

E-mail: mailto:mehdi.farokhanari@ut.ac.ir

چکیده: عوامل طبیعی و انسانی همواره تهدیدی برای از بین رفتن و آسیب دیدن آثار باستانی است و بسته به نوع منطقه هر کدام از این عوامل می‌تواند زیان‌بار باشد که تاکنون آثار باستانی بسیاری بر اثر این عوامل یا از بین رفته‌اند یا به‌شدت آسیب دیده‌اند. در این پژوهش سعی شده است با استفاده از GIS مناطق خطرپذیر آثار باستانی منطقه خرم‌آباد لرستان شناسایی شود تا در جهت حفظ آثار باستانی قدمی برداشته شود. آثار باستانی شناسایی شدهٔ منطقه شامل دژ شاپورخواست (فلک‌الافلاک)، پل شکسته، پل صفوی (پل گپ)، مناره آجری، سنگ‌نوشته خرم‌آباد و گرداب سنگی است. معیارهای مؤثر در تخریب آثار باستانی ۵ معیار است که کارشناسان در منطقه شناسایی کرده‌اند و شامل فاصله از آبراهه، فاصله از خیابان‌ها، شیب، ارتفاع، جهت شیب است که نقشه جغرافیایی آنها ترسیم شده است. پس از آن با استفاده از مدل‌سازی به روش عملگرهای منطق فازی و تعیین عضویت هر کدام از معیارها برای مدل مورد تحلیل قرار گرفته است. خروجی نهایی نشان دهنده ۵ کلاس آسیب‌پذیری شامل خیلی زیاد، زیاد، متوسط، کم و خیلی کم است. در این پژوهش عملگر AND بهترین وضعیت از لحاظ خطرپذیری را نشان می‌دهد که با توجه به صحت‌سنجی تجربی و منابع تاریخی مورد تأیید قرار گرفته است.

واژه‌های کلیدی: منطق فازی، GIS، باستان‌شناسی، خرم‌آباد، عوامل محیطی.

[DOR: 20.1001.1.25382640.2022.29.2.2.4]
[DOI: 10.52547/eijh.29.2.81]