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استخدام نظم المعلومات الجغرافية لتحديد مواقع الزلازل الخطرة في إيران

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جامعة بغداد – قسم الاعمار والمشاريع

خلاصة :

الهدف من أبحاث التخطيط كافة هو التخطيط لراحة الإنسان وسلامته ، وأحد أهم الأخطار الطبيعية التي يتعرَّض لها الإنسان هو مخاطر الزلازل ؛ لذلك ، يجب توقع مخاطر الزلازل ، ومع تقدم التكنولوجيا العالمية ، من الممكن الحصول على معلومات حول مخاطر الزلازل. تم استعمال نظم المعلومات الجغرافية على نطاق واسع في مجال أبحاث التقييم البيئي نظرًا لإمكانياتها العالية ، ويعدُّ نظام المعلومات الجغرافية تطبيقًا مهمًا في تقييم مخاطر الزلازل. تبحث هذه الورقة في المنهجيات المستعملة في دراسات المخاطر الزلزالية المستندة إلى نظم المعلومات الجغرافية ، وتأثيراتها البيئية الأولية على المناطق الحضرية ، وتعقيد العلاقة بين الأساليب المنهجية المطبقة وتقييمات المخاطر البيئية الناتجة. باستعمال تقنيات التحليل المكاني بناءً على تاريخ الزلازل المكانية وخطوط الصدع والمجمعات السكنية ، توفِّر هذه المقالة خريطة تصور أهم مناطق الخطر الزلزالي في إيران. ويكشف التحليل أن مساحة المنطقة شديدة الخطورة والمعرضة للزلازل بالنسبة للسكنية تساوي (12٪) وتتركَّز في المنطقة الغربية المجاورة للعراق وقريبة من الصفيحة التكتونية. تتركَّز المناطق الخطرة في الجانب الغربي من إيران ، وتمتد من الشمال إلى الجنوب (20٪) وهي نسبة كبيرة نسبيًا أما المنطقة الحرجة بشكل كبير المعرضة للزلازل ، فهي تتركَّز في المناطق الشمالية. (23٪) ، المناطق الحرجة متكررة في الوسط والشمال الشرقي في إيران ، وهي أكبر مساحة (26٪) ، أما بالنسبة للمناطق الأقل تأثراً بخطر الزلزال ، فهي تتركز في الوسطي (17٪) وفيما يتعلق بالمناطق غير المتأثرة بخطر الزلازل ، (1٪).

الكلمة المفتاحية :

نظام معلومات جغرافية ، تحليل مكاني ، زلازل ، صدع ، مقيم

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Using GIS to identify hazardous earthquake locations in Iran

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Abstract :

The objective of all planning research is to plan for human comfort and safety, and one of the most significant natural dangers to which humans are exposed is earthquake risk; therefore, earthquake risks must be anticipated, and with the advancement of global technology, it is possible to obtain information on earthquake hazards. GIS has been utilized extensively in the field of environmental assessment research due to its high potential, and GIS is a crucial application in seismic risk assessment. This paper examines the methodologies used in recent GIS-based seismic risk studies, their primary environmental impacts on urban areas, and the complexity of the relationship between the applied methodological approaches and the resulting environmental risk assessments. Using spatial analysis techniques based on the history of spatial earthquakes, fault lines, and residential complexes. This article provides map which depict the most significant seismic danger zones in Iran. The analysis reveals that the area of very dangerous and earthquake-prone zone is equal to (12%) from the residential areas, it is concentrated in the western region, adjacent to Iraq and close to the tectonic plate. The dangerous areas are concentrated in the western side of Iran, extending from the north to the south (20%), which is a fairly large percentage. As for the critical area by earthquake-prone, they are concentrated in the northern regions (23%), The medium critical areas are frequent in the centre and the north-east in Iran, and it is the largest area (26%), while the areas that less affected by the risk of an earthquake, are concentrated in the middle (17%), As for the areas that are not affected by the risk of earthquakes, (1%).

Keyword :

Geographic Information System, Spatial analysis, Earthquakes, Fault, Resident

Introduction

Disasters occur when risks converge with vulnerability. The possibility of risk turning into a disaster depends mainly on the scientific ability to address risk factors and reduce vulnerability, according to the International Strategy for Disaster Reduction (ISDR) (Zentel, 2013). Human in residential areas by keeping them away from dangerous areas, especially those exposed to earthquake risks, bearing in mind that determining safe and ideal places far from the risk of earthquakes in cities is difficult because the risk of earthquakes is constantly changing, but it is possible to limit and evaluate seismic risks that are closer to reality in order to take appropriate measures in the most dangerous places. Risk assessment and disaster management are requirements (Janik, 2021) because they are essential in mitigating seismic risks. Therefore, extensive studies must be prepared based on the advanced scientific basis for effective geographic information systems and earthquake risk assessment (Cabrera, 2020). Thus, these studies are necessary to reduce the impact of earthquakes on human life and infrastructure. In addition, the research can lead to continuous innovation in this field and the development of better earthquake-resistant structures and early warning systems in the most appropriate and dangerous places.

Land suitability analysis is an effective technique for planning development based on various predetermined criteria (Zheng, 2021). Environmental planners and officers often use multiple methods when analyzing seismic hazards between sites, development, and environmental impact.

GIS technology offers different spatial studies and is often associated with the stratification of seismic hazard zones through the distribution and management of data with an end user identified by a standard identification catalogue or code (Alizadeh, 2018) it is possible to create a sensitive map of earthquake locations, based mainly on geographic information and geological information, and the limitations of this approach depend on the hypothesis to determine the decision judgment and may include some hypothetical acceptance.

Site-specific seismic risk assessment studies are essential in predicting earthquakes and mitigating their potential effects (Weatherill, 2020) It depends on the impact range of the most dangerous areas to determine the frequency of earthquakes in a particular area based on the areas that have been hit by earthquakes of specific strength in the past few decades (Weslati, 2020). The most common cause of earthquakes is the presence of tectonic faults (Church, 2009), The farther cities are from those faults, the safer they are.

One of the most important aspects of spatial analysis is the geographic information system because of its ability to store, manage, process, compare and link many spatial variables and display them (Vahidnia, 2010); Geographic information systems are also adaptable to all areas of science that are related to location, and are capable of analyzing information about multiple risks. Over the past decade, spatial databases have been created, collected, processed, and combined with various satellite images, enabling the development of different types of GIS-based modelling (Jena, 2020) These models have been used to analyze and predict natural disasters to determine the risk of earthquakes.

The essential tools of GIS are spatial analysis and its ability to process and model spatial data using mathematical equations on surfaces (Serbaji, 2023). Spatial data processing is essential for a GIS that distinguishes it from any other database management system, Thus obtaining spatial modelling mathematical (Huang, 2023)and environmental sciences (Skidmore, 2017). Accurately predicts the spatial pattern.

The Islamic Republic of Iran is considered one of the most countries that at the hazard of earthquakes (Farahani, 2023), located in West Asia. It borders Turkey and Iraq to the west, Armenia and Azerbaijan to the northwest, Turkmenistan and the Caspian Sea to the north, Afghanistan and Pakistan to the east, and the Gulf of Oman and the Arabian Gulf to the south. It has a population of 84 million and an area of 1,648,195 square kilometres. (Khoshkam, 2023)

The most significant seismic force to strike Iran is seven on the Richter scale, repeated once every ten years (Yagoub, 2015). Most earthquakes have a

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small focal depth and can be very destructive, as with the 2003 Bam earthquake (Zahraei, 2007), map (1).

The weighted overall combination is founded on a weighted average. Continuous criteria are standardized to a standard joint number range, and then they are combined using a weighted average (Li, 2010). The decision maker gives each attribute map layer a weight based on its relative importance feature map layer is given a weight according to its relative hypotheses. The total score for each pixel is calculated by multiplying the importance weight assigned to each attribute by the scaled real value of the option for that attribute and then adding up all of the features for the map. The method can be used with any GIS system with overlay capabilities (Lee, 2012). It enables the evaluation criterion map layers to be combined to determine the output composite map layer. Both raster and vector GIS environments can use the methods.

Map1: Iran countery

Source: https://www.usgs.gov

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Methodology

This method allows for the result of a geographically referenced database for the entire country of Iran by conducting a typical classification of cities using the data derived from the (usgs.gov/data, 2023) site on the model, engineering, structural and technological basis and visualizing the results in the form of maps in which the regions that express the estimation of risk areas are specified, and accordingly what must be assumed follows:

1-An 20 kilometre buffer zone should be maintained around residential areas.

2-The hazard zone is 14 kilometres broad and surrounds the miner faults.
3-The hazard zone is 20 kilometres broad and surrounds the major faults.
4-The hazard zone is 150 kilometres broad and surrounds the tectonic plates.
5-The risk zone around each earthquake location is about 20 kilometres away.
6- The earthquake layer weight (20%) and major fault layer weight (20%), and sub fault layer weight (15%), and tectonic plat layer weight (25%) as well as the residential layer weight (20%), are removed from the overall weight findings.[1]

These supposed distances were carefully chosen according to previous studies, including the study of (Defining a safe design distance from tectonic structures in urban and regional planning) by Dimitrios Ntokos (Ntokos, 2020).

This means that the weight of earthquake and fault layers, as well as the residential layer, will be a decision that may affect predicting the risk zone around each earthquake location between 1996-2014, as the weight of earthquake and fault layers is significant in determining the risk zone, we can add another data to have accurate data of earthquake and fault layers to ensure that the risk zone is predicted correctly, which can ultimately save lives and prevent damage to infrastructure

[1] These percentages were determined according to the researcher's hypothesis

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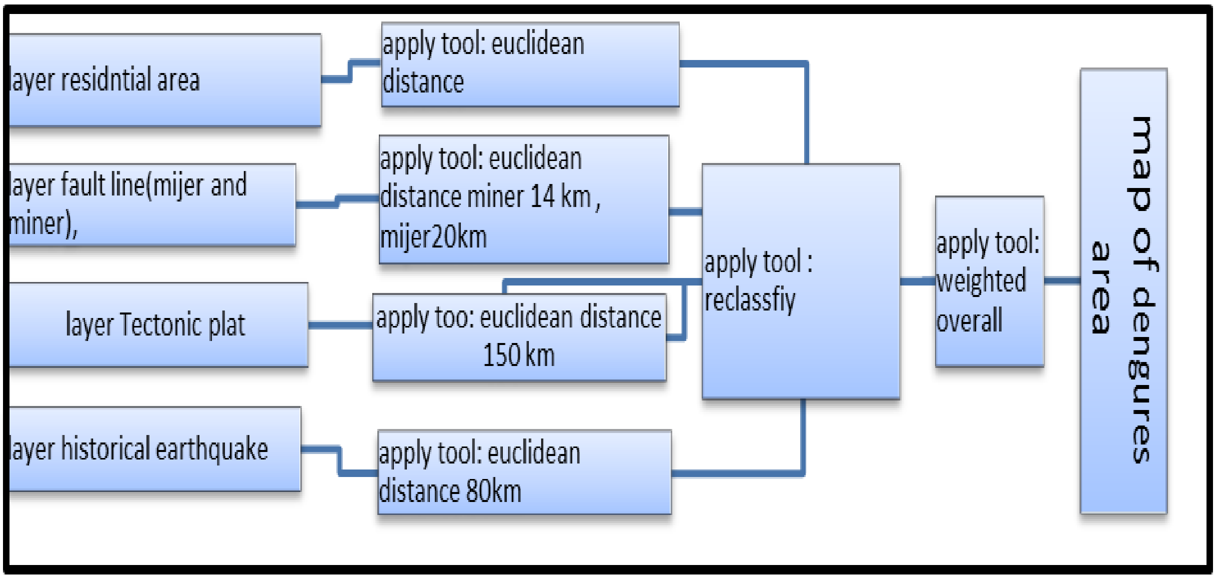

Diagram of the paper's flow

1- Layers

A layer is a piece or coating of the natural world in a particular area. It is similar to a legend on a paper map. For instance, roads, parks, political boundaries, and rivers are distinct layers. (Wade, 2006) , The source information for the residential areas, major and sub fault locations, tectonic plat location and seismic history of the State of Iran was obtained in the form of a ship file by Esri arc GIS map. This allows for a more comprehensive understanding of the geography and can aid in making informed decisions about the area. Additionally, layers can be combined and analysed to reveal patterns and relationships between different aspects of the landscape. Map (2) A,B,C,D,E.

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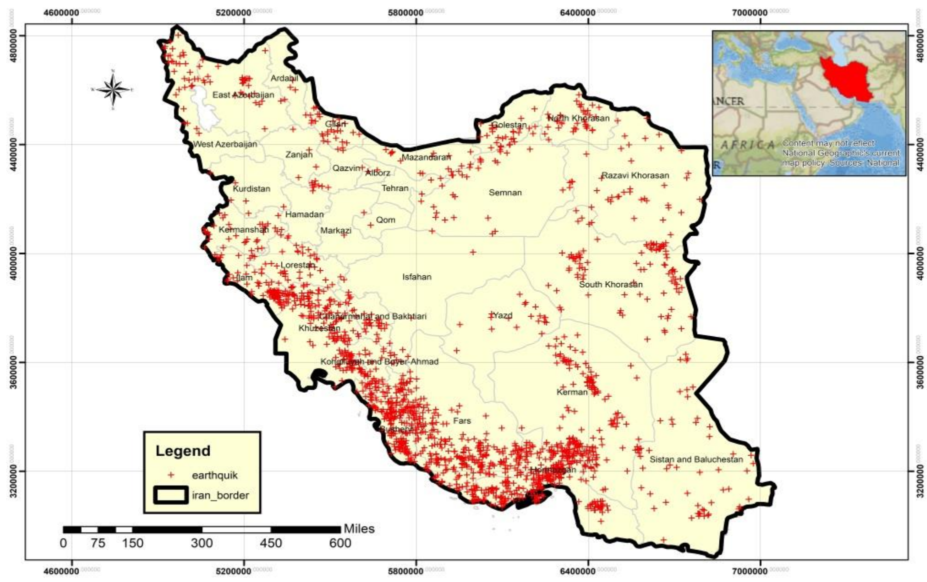
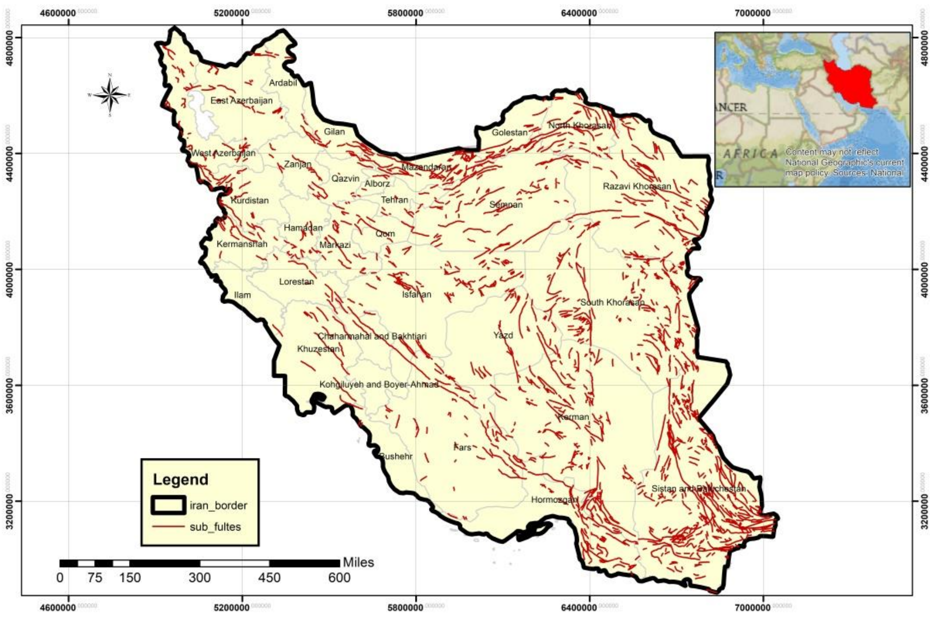
Map 2: the layers in ArcGIS media

Earthquak place in iran



B- Sub Fault in iran



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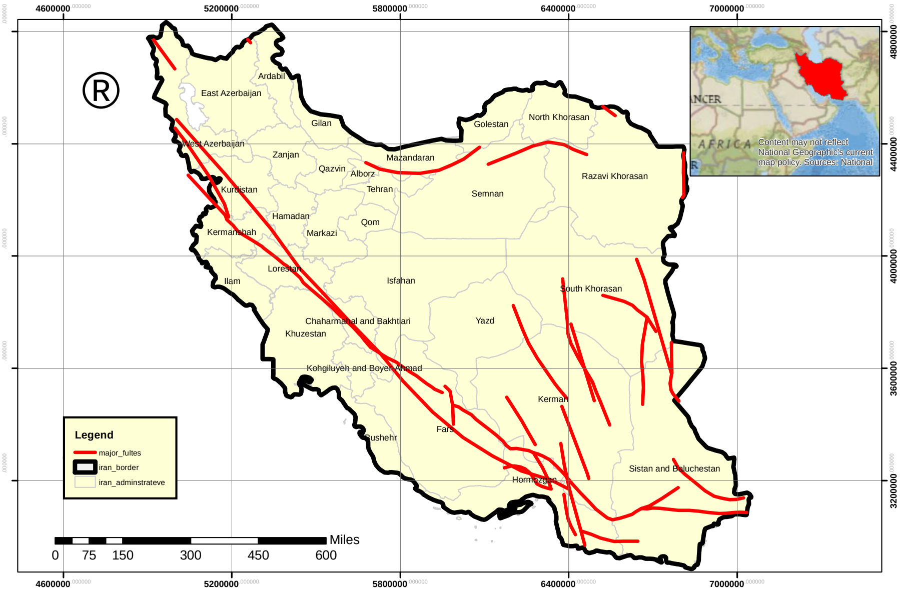
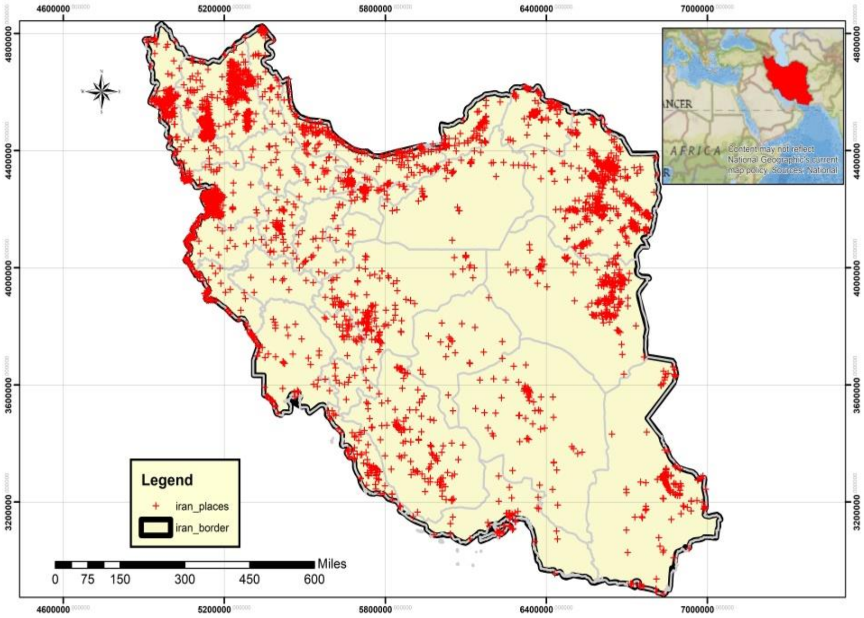
C- major fault in iran



D- Residentiall place in iran



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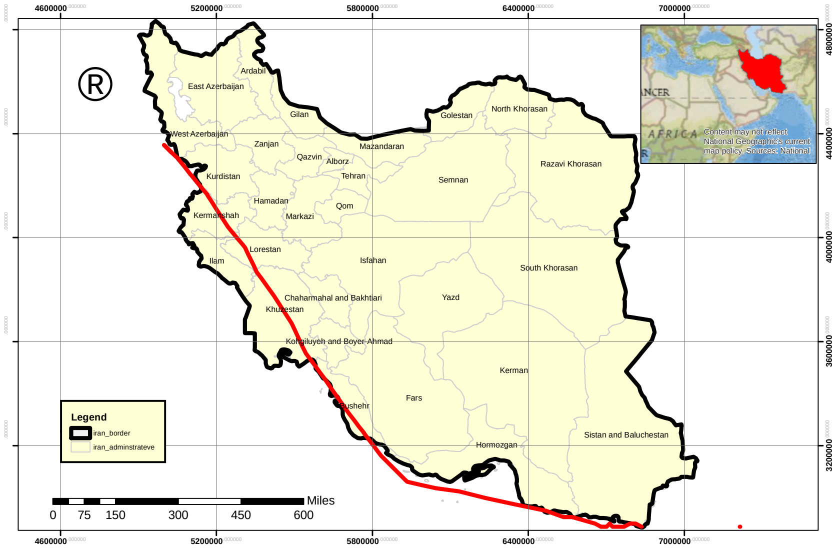
E- Tectonic plate in iran



2- Euclidean distance

In response to the requirements of the hypothesis, the Euclidean distance tools describe each cell's relationship to a source or set of sources based on the straight-line distance. Where:

1- A safe distance of 80 kilometers should be maintained around the residential layer.

2 - The danger zone is 14 Km^2 around the miner fault layer.

3 - The danger zone is 20 Km^2 around the miner fault layer.

4 - The danger zone is 150 Km^2 around the miner fault layer.

5- The danger zone is 80 Km^2 away from each earthquake layer.

The results of applying this hypothesis are depicted on the noting that the result appeared in raster image format

Reclassify

Reclassifies (or modifies) the values in a raster; each cell in the image is assigned a weighted value, and the image is divided into 10 weighted levels, Important reclassification of Euclidean distance.

Map (4):

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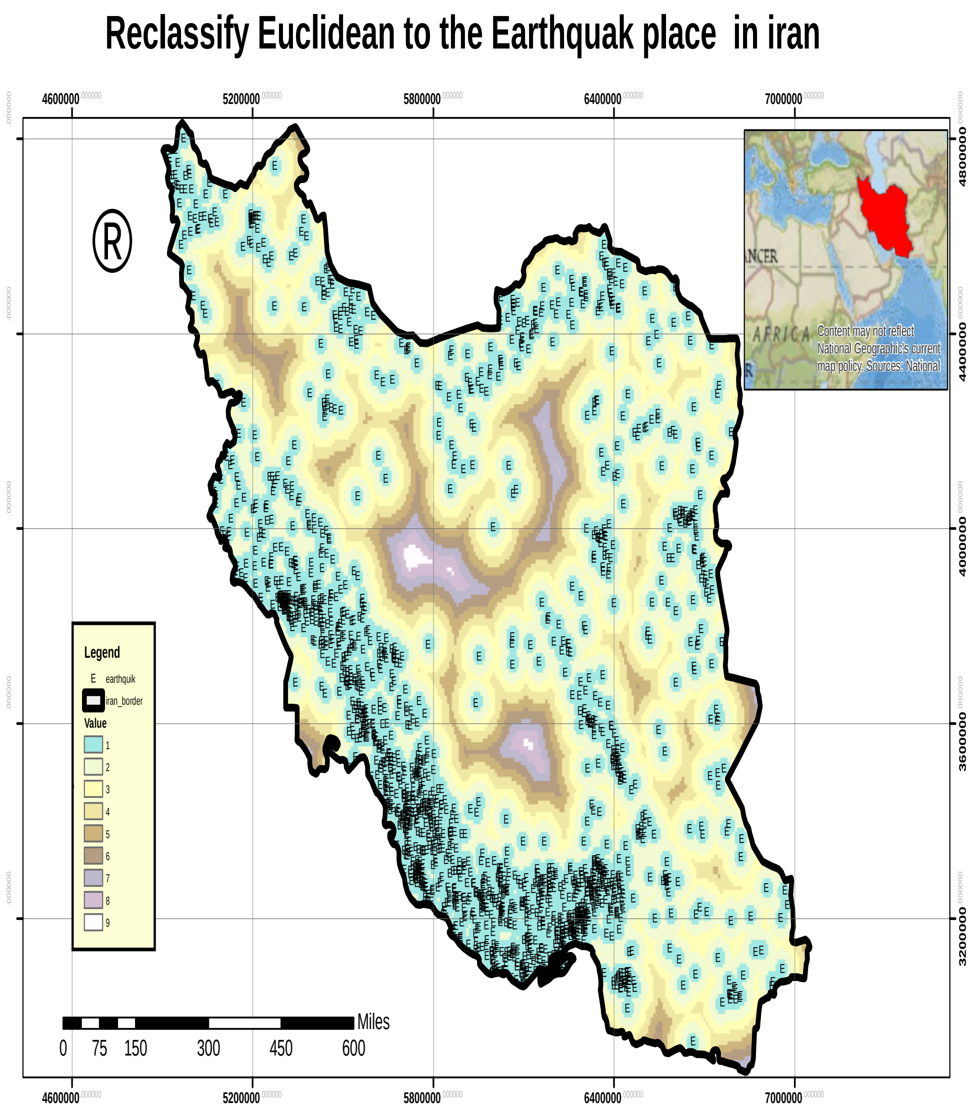

Source: researcher

We notice in Map No. 4 that the historical earthquakes left Iran in the region of southern, which is close to the tectonic plate and adjacent to the Arabian Gulf and Iraq.

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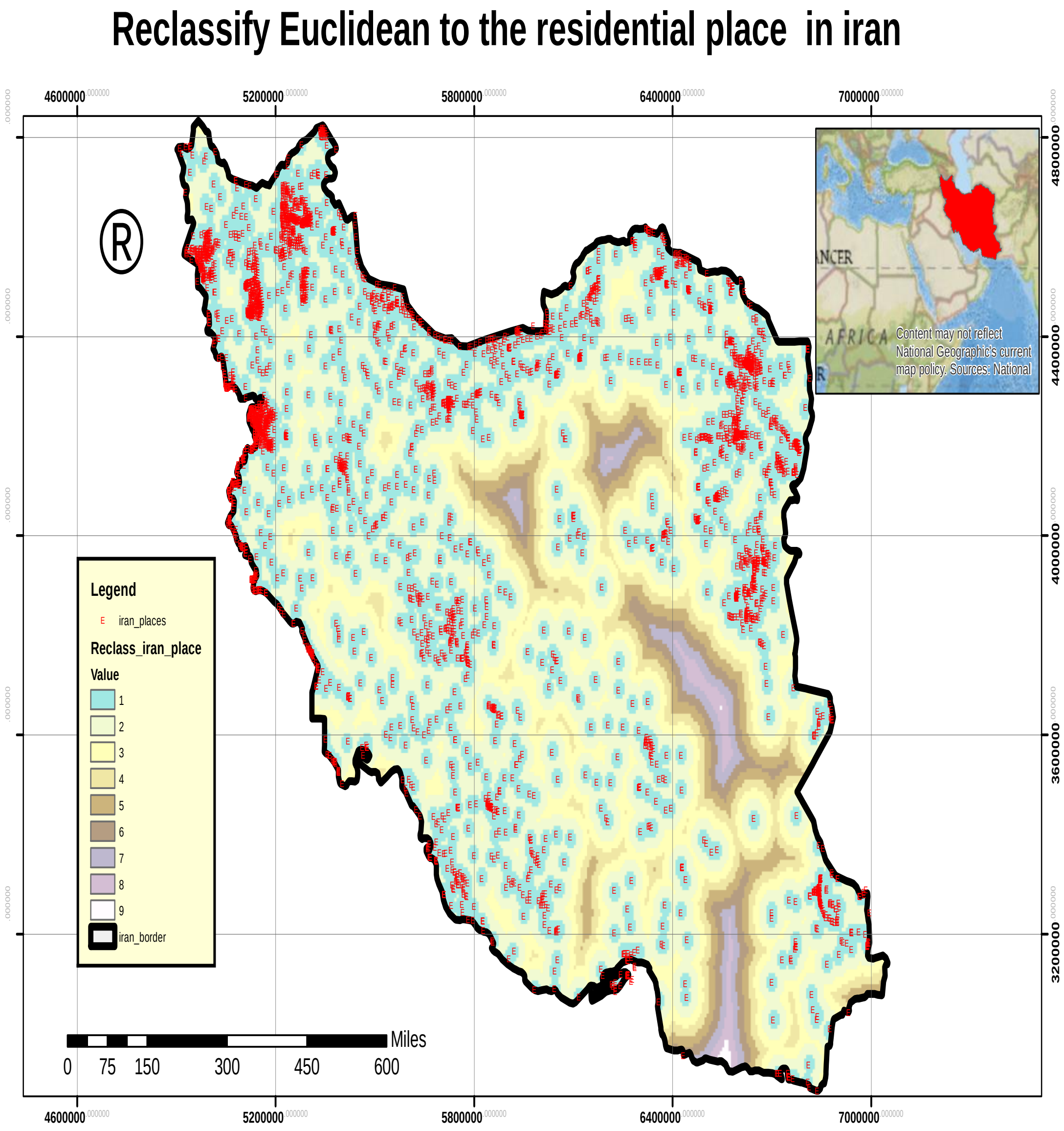
Map (5):



Source: researcher

We note from Map No. 5 that because the population is concentrated in the north, northwest, and northeast, the risk of earthquakes decreases in the central region of the residential areas.

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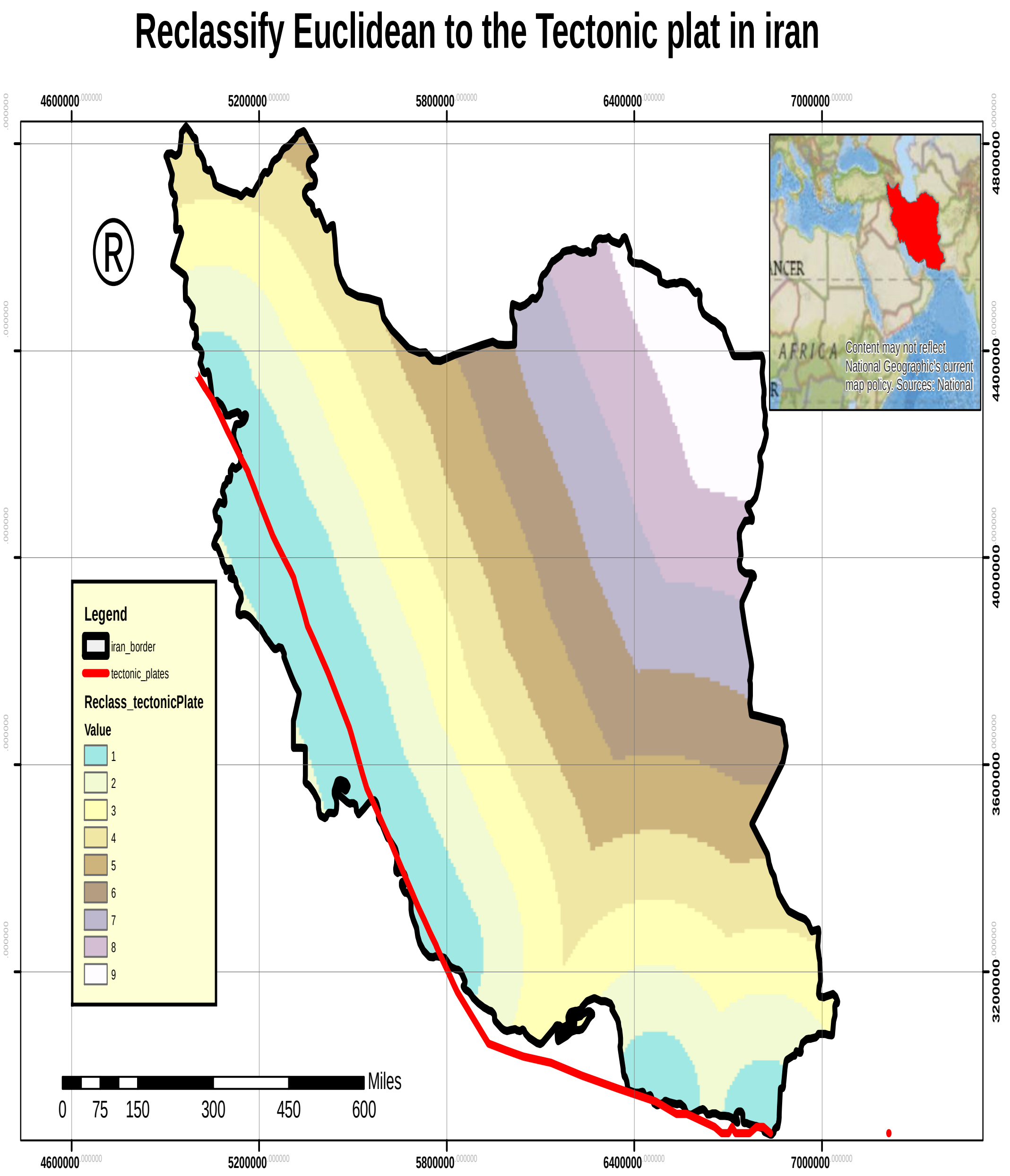
Map (6):



Source: researcher

We notice from the map no. 6 that the farther we go from the southwest towards the northeast in Iran, the risk of an earthquake decreases, meaning the farther we move away from the tectonic plates, the risk decreases.

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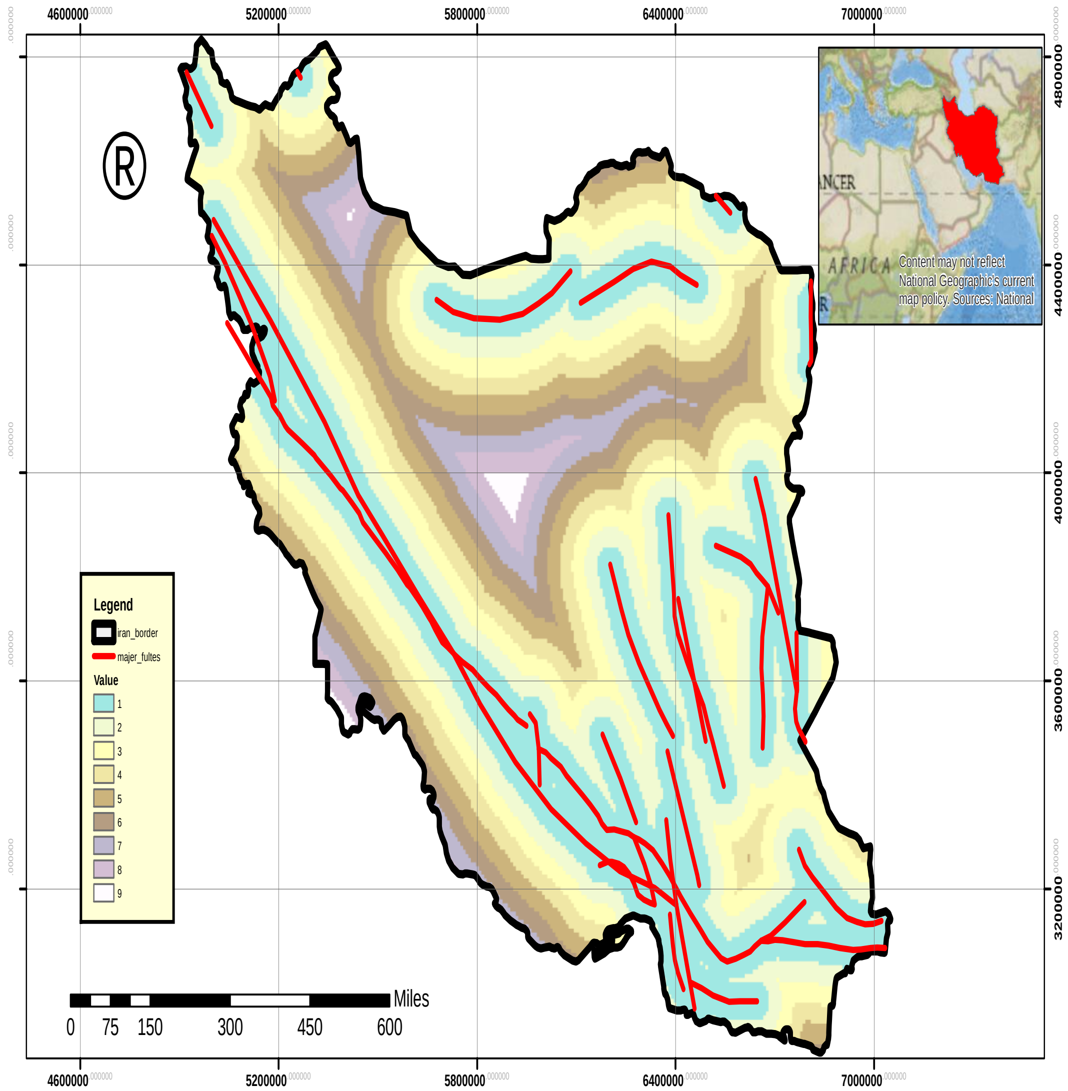
Map (7):

Reclassify Euclidean to the mijer Fault place in iran



Source: researcher

We notice in Map No. 7 that the areas most affected by the earthquake are in the southern region where the main faults are concentrated in Iran in addition to the northern region, and the more we move towards the centre, the lower the risk of the earthquake resulting from the main faults Centre.

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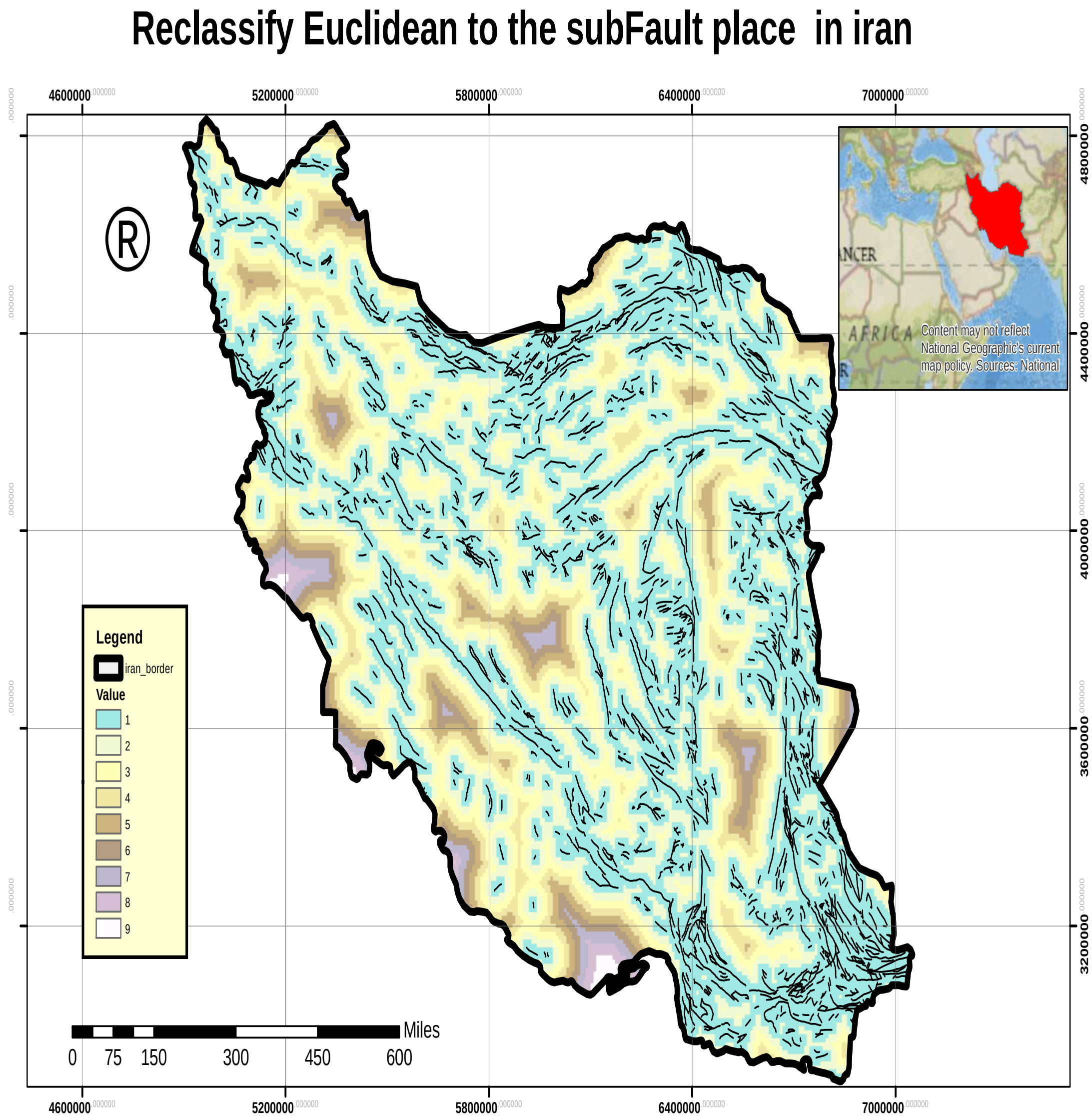
Map (8):



Source: researcher

We notice in Map No. 9 that the secondary faults are concentrated in the northern and southern regions, and that these faults have little effect on the occurrence of earthquakes.

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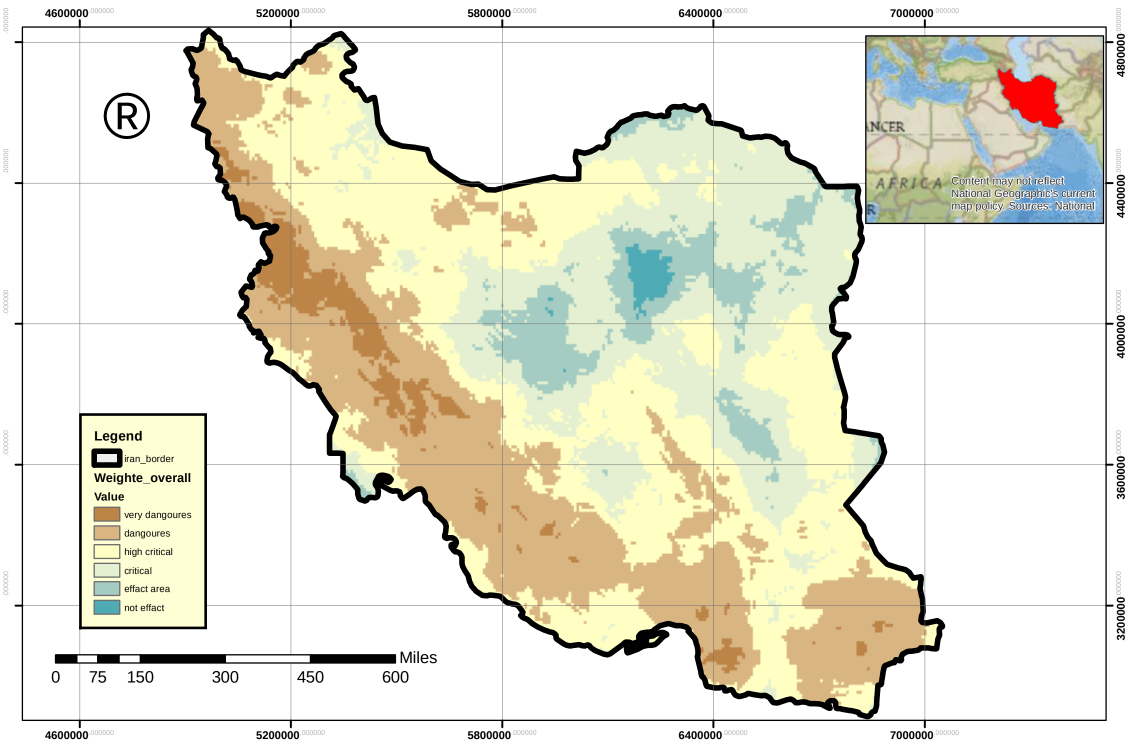
3- Weighted overall

According to the fourth hypothesis, each layer was assigned a level of significance. The proximity of residential areas to the safety distance increases the danger. As for faults, the danger increases as the distance to the fault decreases. And the greater the risk, the closer the residential areas are to the boundaries of the earthquake sites. The risk of exposure to earthquakes, which comprises (20%) of the earthquake layer, was given a greater weight than tectonic plate (25%), major faults (20%), sub fault (15%) and residential areas (20%). Display the results Map No. 1 illustrates the most hazardous regions (5)

Map (9):

Map of Dengoures area for residentia placel in Iran



Source: researcher

We notice in Map No. 9 that the area at very dangerous earthquake-prone zone to residential is equal to (198,403Km2) at a rate of (12%) is concentrated in the western region, adjacent to Iraq and close to the tectonic plate. Therefore, adequate measures must be taken to protect the existing residential areas,

The dangerous areas are concentrated in the western side of Iran, extending from the north to the south, where it covers an area (332,768 Km2) at a rate of (20%), which is a fairly large percentage. As for the High critical area by earthquake-prone, they are concentrated in the northern regions, with an area **(377,996Km²)** at a rate of (23%), The critical areas are frequent in the centre and the north-east in Iran, and it is the largest area, as it has an area(424,452 km2)in rat (26%), and this percentage is considered moderately affected by earthquakes for residential areas,

As for the areas less affected by the risk of an earthquake, they are concentrated in the middle and are considered safe from the risk of an earthquake **(285,208Km²)** at a rate of (17%), As for the areas that are not affected by the risk of earthquakes, they are concentrated in the centre and with a very small area **(14,298Km²)** at a rate of (1%). Note that the total area of Iran is (1,633,127Km²).

rate	Area in km²	Notes
12%	198403	Very dangerous area
20%	332768	Dangerous area
23%	377996	High critical area
26%	424452	Critical area
17%	285208	Affected area
1%	14298	not affected area

Table of dangerous areas for residents in Iran

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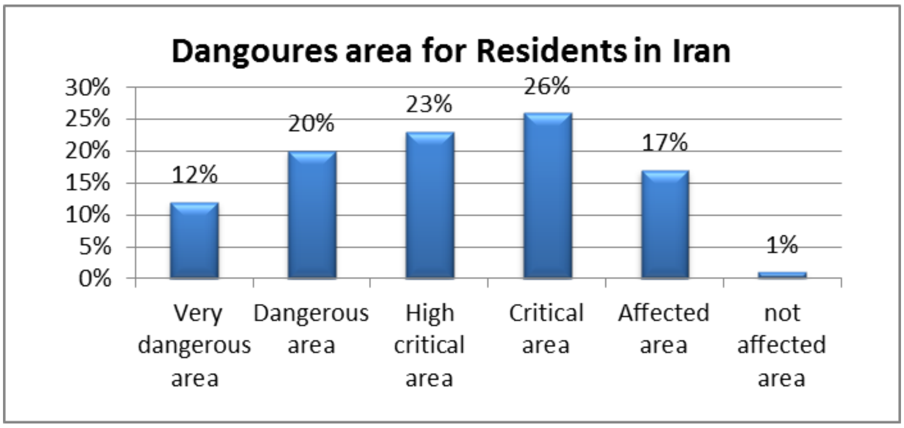
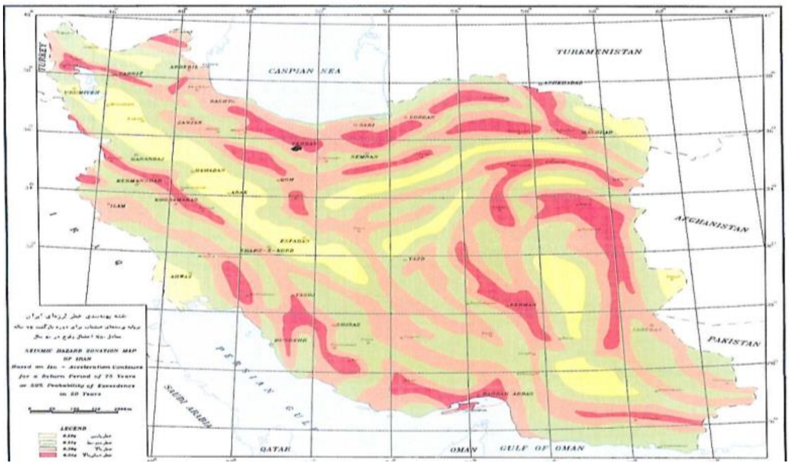


There are multiple studies to assess the risk of earthquakes, including a study authored by Behrooz Tavakoli (Tavakoli, 1999) using a program SEISRISK for probabilistic seismic hazard assessment to calculate peak ground acceleration, he find the map10

Map (10):
Seismic hazard in Iran for Behrooz Tavakoli



We notice in this study that the seismic hazard centre is in the northern side, contrary to the prediction of my study, where the seismic risks are concentrated in

the western side, and that the less dangerous areas are in the middle, as expected in my study. The results of my study are closer to reality because the seismic history is concentrated in the western and southern regions, meaning that it is the region where earthquakes occur the most.

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Conclusion

This study proposes a new method for evaluating the critical region by incorporating spatial analyses. This indicates that the final relative dangerous region differs from the site gravity percentage as a result of recent historical earthquakes and that, in addition to the fault location, some other critical region degrees require fine-tuning by introducing additional layers such as geologic layers. The model uses a new variable titled "earthquake-critical residential areas" for this purpose. In addition, the potential for varying levels of damage (depending on geological changes) is used to illustrate the uncertainties in Iran.

The area at very dangerous area earthquake-prone zone is equal to (12%) from the residential land, it is concentrated in the western region, adjacent to Iraq and close to the tectonic plate. Therefore, adequate measures must be taken to protect the existing residential areas, The dangerous areas are concentrated in the western side of Iran, extending from the north to the south (20%), which is a fairly large percentage As for the High critical area by earthquake-prone, they are concentrated in the northern regions (23%), The critical areas are frequent in the centre and the north-east in Iran, and it is the largest area (26%), and this percentage is considered moderately affected by earthquakes for residential areas, As for the areas less affected by the risk of an earthquake, they are concentrated in the middle and are considered safe from the risk of an earthquake (17%), As for the areas that are not affected by the risk of earthquakes, they are concentrated in the centre and with a very small area (1%).

Recommendation

1- In conclusion, the use of GIS technology in identifying hazardous earthquake locations in Iran is highly recommended. This approach can provide valuable insights and help authorities take proactive measures to mitigate the risks associated with earthquakes, and utilizing various analyses.

2- Understand how to manage urban planning in places where new cities are being renovated or constructed and take into account the importance of their geographical location and proximity to danger points as well as their seismic history. Planning and construction in areas where there is insufficient geological data should be handled with caution. previous experience in areas with similar tectonic and seismic regimes should be given to achieve sustainable development.

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