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ASSESSMENT OF SEISMIC FAULT RISKS ON SPATIAL PLANNING AND DEVELOPMENT IN ARAS SEZS BASED ON LULC

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***Abstract**: Identifying seismic fault zones is crucial for assessing the seismic risks and therefore affecting the land cover plan for a specific area. Urban areas built on seismically active fault zones are more susceptible to earthquakes compared to areas covered with dense forests or agricultural lands. The North-West Iran, Aras Special Development Zones (SEZs) are one of the areas with prominent land cover in near future due to its reachability to multiple countries. Analyzing the relationship between land cover types and seismic fault zones in the Aras SEZ can provide valuable insights into the susceptibility of different land cover types to seismic events. We used Land Use/Land Cover (LULC) method to assess the impact of seismic fault zones on land use in the Aras SEZs which involves evaluating the potential impact of earthquakes on different land uses and activities. This assessment can help identify areas that are most susceptible to seismic hazards and prioritize them for risk mitigation measures. In conclusion, our assessment of seismic fault risks on spatial planning and development in Aras SEZs suggests valuable insights to ensure the safety and resilience of future investments and developments.*

Keywords: *Seismic faults, Risk Assessment, LULC, Spatial Planning and Development, Aras SEZs.*

Introduction: The relationship between human civilizations and the natural environment has been greatly impacted by urbanization [1]and urban development [2,3]. As cities become more densely populated and land becomes a more valuable yet scarce resource, equitable and sustainable urbanization and space development for people's needs[4] have emerged as major global concerns [5]. As a fresh start, new urban development rules [6] and a regeneration plan are developed, stressing competitive advantages to make the area appealing and to prevent the city's degenerative processes [7]. The economic impact of planning, as determined by the synergy formed by the project network structure, determines the program's efficiency [8].

Previously, city urbanization was based on climate, water reservoirs, geography, social and religious factors [9]. Developing and growing nations face new challenges due to rapid and unequal urban expansion and population inflow, which restrict the adoption of innovative urban planning approaches[5,10]. The physical structure of a city has a significant impact on the appeal of urban amenities, adding to the complexity of its setting [11], employment[12], and branding[13] for city management concerns[14,15]. As a new beginning, tailored spatial development plans and a regeneration plan are created, focusing on competitive advantages to make the area more appealing and to prevent degenerative processes[6][5]. The effectiveness of the program is measured by the economic impact of the plan as determined by the synergy produced by the project network structure [8].

Regional administrations are increasingly justifying mega-events based on their alleged legacy value and the belief that everyone in the area will benefit [16]. The spatial arrangement of cities has a significant impact on environmental quality and citizen satisfaction [17]. In other words, unplanned and market-driven regional growth promotes rapid evolution but poses problems for long-term regional development [9,18,19]. In comparison to the large volumes of ecological, infrastructure, and numerical data used by planners, spatially categorized, social, and perceptual data are insufficient [20].

Identifying seismic fault zones in is crucial for assessing the seismic risk. Seismic fault zones are regions where the Earth's crust is fractured, leading to potential seismic activity. Various geophysical techniques can be used to map the fault zones, such as seismic surveys, GPS surveys, and geodetic measurements. It provides valuable insights on the susceptibility of different land cover types to seismic occurrences.

This study aimed to analyze the relationship between land cover types and seismic fault zones in the Aras SEZs. Through seismic fault assessment and on LULC in the Aras SEZs for the last decade during planning and development process. It can provide valuable insights into the susceptibility of different land cover types to seismic events. Assessing the impact of seismic fault zones on land use in the Aras SEZ involves evaluating the potential impact of earthquakes on different land uses and activities. This assessment can help identify areas that are most susceptible to seismic hazards and prioritize them for risk mitigation measures.

By understanding the land cover types, identifying seismic fault zones, and analyzing the relationship between land cover types and seismic fault zones, appropriate risk mitigation strategies can be developed. These strategies will ensure that spatial planning and development in the Aras SEZ is both sustainable and resilient to seismic hazards. This article employs conventional IMRAD and conclusion to arrange and express the information of each section from section one to section five in the following.

Material. In urban planning and spatial reorganization studies, quantitative methods are commonly used. Statistical analysis, geographical analysis, and modeling techniques are examples of these methodologies. These technologies allow for the collection and analysis of enormous volumes of data, revealing patterns and trends in city planning and spatial reorganization. It is vital to consider quantitative methods for systematically evaluating remodeling courses for sustainability and identifying key aspects [21]. For the dataset we used Satellite image (Landsat 8) accessed through USGS for year 2013 and 2023. For the aims of this study ArcMap 10.4.1 software was used for data processing and spatial analysis.

Region of Interes: The Aras Free Trade-Industrial Zone (AFTZ) is a designated territory in Iran's North-West region. It is critical to the country's economy, attracting considerable investments and development initiatives in recent years. However, due to its placement along active seismic fault zones, this region is also prone to seismic activity. To ensure long-term spatial planning and development in the Aras SEZs, it is critical to identify and reduce seismic fault hazards. AFTZ along the Asia-Europe and Silk Road corridors in the North West of the Islamic Republic of Iran. Its geostrategic importance for Iran and the BRI, its capacity as a free trade and industrial park, and its proximity to European and CIS consumer markets, all led to its appeal for a variety of reasons: geography, nature, history, culture, economics, and spatial factors. The AFTZ covers sections of Jolfa-Hadishar-Marand (R1), Siyahrood-Ayri (R2), Noorduz (R3), Khodaafarin (R4), and Golibeiglu (R5). Foreign Direct Investment (FDI) has been identified as a significant influence on urban 50eveloppment in emerging nations[22,23].

The Chinese government suggested the Belt and Road (B&R) Initiative as a multi-country platform along present Eurasia as an economic direction for cross-border infrastructure connections [24] and others [4]. The AFTZ's different geospatial features are depicted in Fig. 1. An earthquake's magnitude is determined by its strength and duration of seismic waves. Minor earthquakes measure 3 to 4.9, moderate to strong earthquakes measure 5 to 6.9, major earthquakes measure 7 to 7.9, and great earthquakes measure 8 or more. Spatial position of Seismic Faults in AFTZ peresented in Fig. 2.

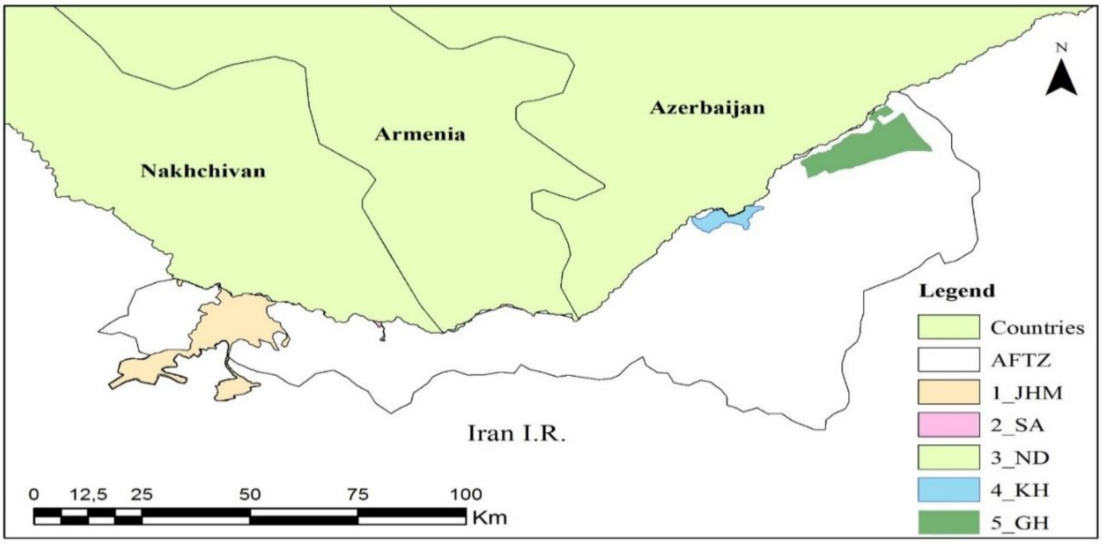

Fig. 1 Map of the AFTZ's geographical location, its distinct regions, and its nearby countries

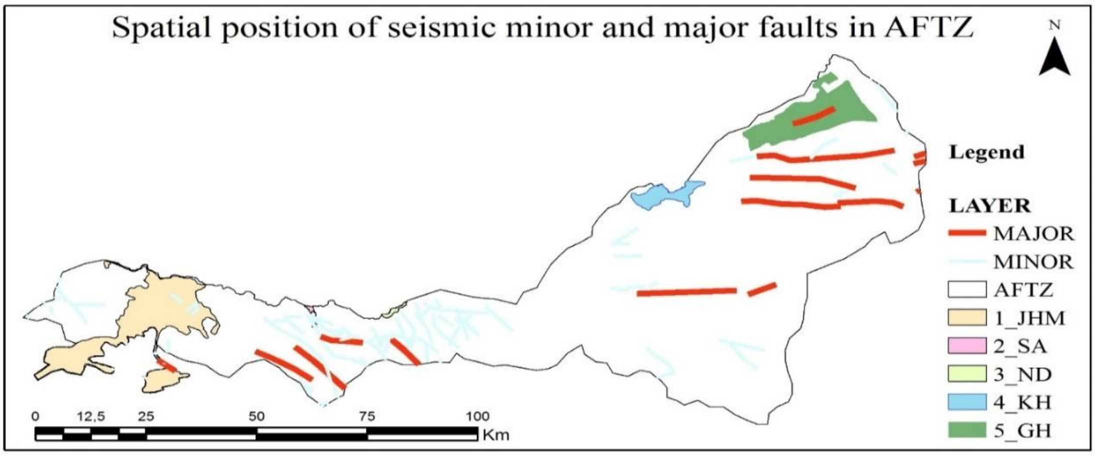

Fig. 2 Spatial position of Seismic Faults in AFTZ

Method: Analyzing the relationship between land cover types and seismic fault zones in the Aras SEZ provides valuable insights into the susceptibility of different land cover types to seismic events[25]. For example, urban areas built on seismically active fault zones are more susceptible to earthquakes compared to areas covered with dense forests or agricultural lands. Applied Steps for Unsupervised LULC in this study includes followings;

Data Collection: Collect relevant remote sensing data such as satellite imagery or aerial photographs. Ensure that the data covers the area of interest and includes multiple spectral bands.

Data Pre-processing: Cleaning and preprocessing of the collected data to remove any noise or artifacts. This involves radiometric calibration, atmospheric correction, and geometric correction to ensure the data is accurate and ready for analysis.

Feature Extraction: Extract relevant features from the preprocessed data. This involves converting the data into a suitable format, such as a spectral reflectance or vegetation index, that used for further analysis.

Clustering: Apply unsupervised clustering algorithms to group similar pixels or objects together based on their extracted features.

Land Cover Classification: Assigning land cover labels to the clusters based on their spectral characteristics and any additional information available, such as ground truth data or ancillary data sources. This step involves interpreting the clusters and assigning them with appropriate land cover classes.

Post-processing and Map Generation: Refining the classified maps by applying post-processing techniques. This may involve spatial filtering, majority voting, or spatial smoothing to improve the visual appearance and accuracy of the final land cover map. Production of the final land cover map by visualizing the classified results. This can be done by assigning different colors or symbols to each land cover class. Including a legend and scale to provide context and interpretation of the map.

Results: Based on applied methodology results for LULC in 2013-2023 period for each region presented in. Due to the high impact of seismic faults on the built environment our research results focus on the built-up as presented in Table 1. According to calculated results for LULC in the 2013-2023 period in the Aras SEZs belong to changes that happened on barren land and vegetation land use land cover to Built-up land use land cover. As illustrated on the density map of seismic faults and major and minor faults in the AFTZ (check Figure 3) region 2 and region 3 are adjacent to the high risk area. In the west part, we have four major faults which are of high density, on the other side, in the east part (R1) very low and low risks. In the center-east (R4), it is in very low risk areas. Meanwhile, in the middle of west part of SEZs (R5), we have a high risk in the middle of the region which can cause major consequences in the case of earthquake.

Table 1 LULC results for Aras SEZs (Five regions) and entire AFTZ.

R1-Change(2013-2023)	Area (SqKm)
Barren land – Built-up	15176
Built-up – Barren land	2593
Built-up – Built-up	0.73
Built-up – Vegetation	6845
Built-up – Water	0.8
Vegetation – Built-up	8665

R2-Change(2013-2023)	Area (SqKm)
Barren land – Built-up	0.56
Built-up – Built-up	0.838
Built-up – Vegetation	0.108
Vegetation – Built-up	0.276

R3-Change(2013-2023)	Area (SqKm)
Barren land – Built-up	0.754
Built-up – Barren land	0.087
Built-up – Built-up	0.585
Built-up – Vegetation	0.173
Built-up – Water	0.003
Vegetation – Built-up	0.101
Water - Built-up	0.186

R4-Change(2013-2023)	Area (SqKm)
Barren land – Built-up	4053
Built-up – Barren land	0.032
Built-up – Built-up	1742
Built-up – Water	0.003
Vegetation – Built-up	0.733

R5-Change(2013-2023)	Area (SqKm)
Barren land – Built-up	1423
Built-up – Barren land	0.327
Built-up – Built-up	0.316

AFTZ-Change(2013-2023)	Area (SqKm)
Barren land – Built-up	20653.314
Built-up – Barren land	2593.446

Built-up – Vegetation	1431	Built-up – Built-up	1744.469
Built-up – Water	0.004	Built-up – Vegetation	8276.281
Vegetation – Built-up	7689	Built-up – Water	0.81
Water - Built-up	0.002	Vegetation – Built-up	16355.11
		Water - Built-up	0.188

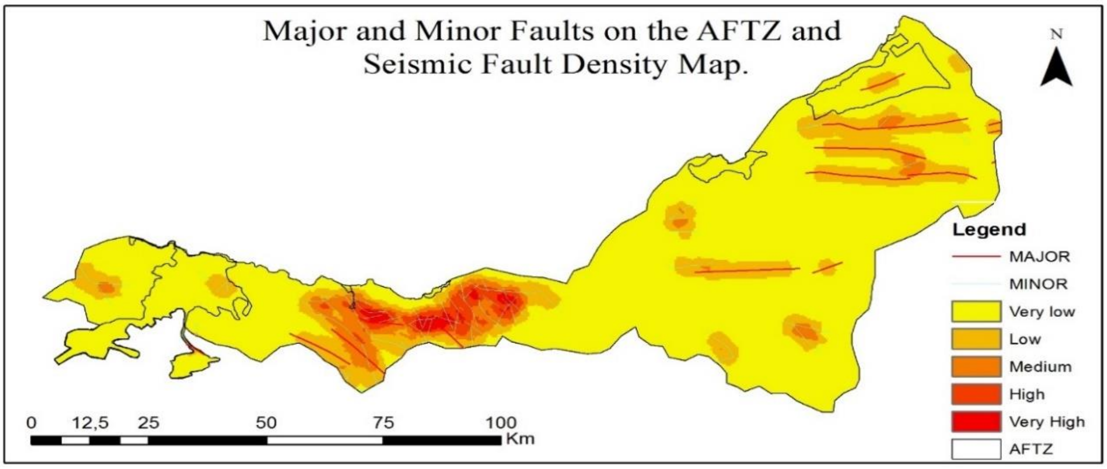

Figure 3 Density map of seismic faults and faults in the AFTZ

Discussion and Conclusion: Hypothetical, predictive analytics and inferences from this research study are offered to resolve issues related to the growing of SEZ towards low risk seismic faults, and promote policies and programs that help to provide valuable insights into the susceptibility of different land cover types to seismic occurrences. Due to the high necessity of built-ups in SEZs, it is highly considered to convert barren lands into built-ups which accordingly avoids the negative effects of environmental hazards. As depicted in Table 1, the majority of LULC are based on barren land conversion to buildups, which still needs to be considered in future expansions.

As visualized in Section 4, the effects of planning of SEZ built-up infrastructure should go along with the consideration of seismic faults in the specific target areas. The R1 (the largest SEZ) built-ups are in one of the safest areas of the Aras SEZs. It can be considered to grow equally towards the east and west up to specific areas specified in Figure 3 Despite the high density of low risks in R2 and R3, the build-up should focus on the northern part of the SEZ, and consider avoiding the southern part, as it includes areas with major seismic faults.

For future development of built-ups within Aras SEZs, the expansion of R4 towards the south-east part can be considered since it has the safest areas for growth. The R5, as mentioned earlier, has a major seismic fault right in the middle of the built-up which should be avoided by separating the zone into two areas which can avoid the seismic fault in the center. Therefore, R5 built-up can grow towards its north-west to avoid major consequences in the future.

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СЕЙСМИЧЕСКИЙ РИСК: СОВРЕМЕННОЕ СОСТОЯНИЕ

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Аннотация. *В статье разработаны и зарегистрированы программные продукты по использованию возможностей современных ArcGI- технологий при оценке сейсмического риска территорий и приведена технология его использования на примере некоторых городов Узбекистана.*
Ключевые слова: *Сейсмический риск, сейсмическая опасность, ущербообразующие, экзогенные, геологические, процессы, геоэкологический риск, сейсмогенные зоны.*

Научные исследования по сейсмическому риску в Узбекистане так же, как и в России, некоторое время имели эпизодический характер. Эти исследования были начаты в Институте сейсмологии АН РУз в лаборатории Инженерной сейсмологии под руководством профессора Б.М. Мардонова и доктора физ.-мат. наук Ю.К. Чернова с участием кандидата геол.-мин. наук В.А. Исмаилова и кандидатов технических наук Р.Ш. Инагамова и С.А. Тягунова.

Основным принципиальным недостатком работ в период эпизодических исследований по сейсмическому риску в Узбекистане является практически слабое разграничение понятий «сейсмического риска» и «сейсмической опасности» и соответственно трактовка сейсмического риска для территории Узбекистана как вероятности не превышения определенного уровня сейсмической опасности территории [1].

Основой для них явилась новая концепция районирования территории Узбекистана по степени сейсмического риска (Р.Ш. Инагамов, Н.Г. Мавлянова, 2003), которая начала реализовываться в рамках проекта фундаментальных научных исследований (Н.Г. Мавлянова и др., 2004, 2005).

Результаты анализа, обобщения и развития исследований по сейсмическому риску в Узбекистане за этот период послужили основой для докторской диссертации Н.Г. Мавляновой «Сейсмический риск в Узбекистане», которая защищена в 2007 г., где Н.Г. Мавляновой сделан подробный анализ исследований как международного опыта оценки сейсмического риска, так и республиканского со времени его зарождения по настоящее время [2].

Исследования проведены во всех сейсмоопасных регионах мира, таких как: Америка, Япония, Германия, Италия, Китай, Россия, Индия, Пакистан и другие государства, где происходят сильные землетрясения. Была разработана и предложена трехуровневая оценка сейсмического риска для Узбекистана, как наиболее оптимальная: на уровне городов, областей и в целом по республике. Разработана методика анализа, оценки и расчета сейсмического риска урбанизированных территорий. На протяжении последующих 10 лет институтом сейсмологии во главе с Н.Г. Мавляновой продолжены исследования по оценке потенциала факторов сейсмического риска на основе грантов ГКНТ РУз: в 2007–2011 гг. по контракту ФА-Ф6-Т076 по теме «Закономерности формирования и изменения инженерно-геологических условий и факторов