

وزارة
التعليم العالي والبحث العلمي
جامعة ميسان
كلية التربية الاساسية



مجلة ميسان للدراسات الأكاديمية

للعوم الانسانية والاجتماعية والتطبيقية

Misan Journal For Academic Studies
Humanits, Social and applied Sciences

ISSN (PRINT) 1994-697X

(Online)-2706-722X

اذار 2026

العدد 57

المجلد 24

2026 Mar

57 Issue

24 vol

Misan Journal

مجلة ميسان للدراسات الأكاديمية

Misan Journal

مجلة ميسان للدراسات الاكاديمية
العلوم الانسانية والاجتماعية والتطبيقية
كلية التربية الاساسية/ جامعة ميسان

اذار 2026

العدد 57

المجلد 24


MAR,2026

SSUE57

VOLE 24

 DOAJ

Google
scholar

مؤسسة الاستشهاد المرجعي ورمز
العلم والتكنولوجيا في العالم الإسلامي


IRAQI
Academic Scientific Journals

ISSN
INTERNATIONAL
STANDARD
NUMBER
ISSN PORTAL
IN COORDINATION
WITH
INTERNATIONAL
BUREAU
OF
STANDARDIZATION

doi




مرقم الايداع في المكتبة الوطنية العراقية 1326 لسنة 2009
journal.m.academy@uomisan.edu.iq
<https://www.misan-jas.com/index.php/ojs>
<https://iasj.rdd.edu.iq/journals/journal/view/298>

الصفحة	فهرس البحوث	ت
9 - 1	Caries Experience and Salivary Heat Shock Proteins in Children: A Study in Humid Iraqi Marshlands Haneen Najim Abed Ban Sahib Diab	1
21 - 10	The Role of Deontic Modality in Constructing Dystopian Fiction: A Cognitive Stylistic Analysis of Orwell's 1984 ¹ Salim Khulaif Saad, Mohammad Qasim Zaboob , Samir Talib Dawood	2
36 - 22	The Metaphorical Conceptualization of Political Closure in Post-2021 Iraqi Elections: Newspaper Headlines and Cartoons as a Case Study Khalid Wahaab Jabber	3
47 - 37	Landslide Susceptibility Modeling for Quarries Sites in Northeastern Missan: Using Fuzzy Logic Method Zahraa R. Fakher	4
65 - 48	Phenotypic and molecular investigation of biofilm formation of Enterobacter cloacae causing urinary tract infections Furqan Jabal Kadhim Mithal K. A. Al-Hassani	5
74 - 66	Analysis of General French Language Question Papers for the Third Intermediate Grade in Iraq Based on Bloom's Taxonomy Dijla Abbood Shareef Al-Turfi	6
84 - 75	Phenotypic study of bacteria isolated from patients with prostatitis Zahraa Dheyaa Gheni Israa Saeed Abbas	7
100 - 85	Gene expression analysis of the arsC Gene involved in arsenic detoxification in Pseudomonas stutzeri and Pseudomonas putida Ali Hasan Abd Saba Abdulameer kadhim Al-ziadi	8
117 - 101	The Role of Implicature in Humor on TikTok: A Pragmatic Examination of Jokes and Punchlines in Short-Form Videos Narjis Audah Rashk	9
135 - 118	An In-Depth Analysis of the Interplay of Syntax and Semantics in Modern English Prose: A Study of Selected Texts from Digital Media Raghad Hamid Mustafa	10
151 - 136	Artistic Appreciation of the Saggar Technique in the Works of Ceramist (Mariwan Jalal) Gazang Mohammed Abdulwahed	11
164 - 152	The influence of Islamic philosophy on European thought in the Middle Ages Hussam Ahmed Ali	12

187 - 165	The Educational Encoding Style in the Plays of Ahmed Kamel Ikhlas Abdul Qadir Taher Hussein	13
204 - 188	Political Wilayah between Divine Investiture and Human Election: A Comparative Study Mustafa Zaki Yahya	14
223 - 205	The Intentionality of Promotional Patterns in Pre-Islamic Poetry" A Selected Reading of al-Muthaqqib al-‘Abdī’s Nooniyah" Haitham Abdul Hussein Mariwish	15
241 - 224	The Effectiveness of the Active Recall Strategy and the Unique Path Strategy in Acquiring Social Concepts among Fifth-Grade Female Pupils and Their Vivid Memory Asraa Hussein Oleiwi	16
257 - 242	(al-Raj‘ah in Imami Doctrine: A Study on Its Reality, Possibility, and Occurrence from the Perspective of the Qur'an and the Narrations According to Imami Shi‘a Scholars) Haider Muslim Daoud	17
267 - 258	Elegies for Sons in the poetry of Al-Utbi Al-Qurashi Huda Kareem Abd	18
285 - 268	The visual stimulus in global ceramics during the period of modernism: Transformations of form and aesthetic signification Zeena Kasem Mohammed Rula Abdul-Ilah Alwan Al-Nuaimi	19
299 - 286	Mohammad Mahdi Al-Jawahiri’s Literary Stance toward Leading Figures of Modern Arabic Poetry and Prose Hadi Abd Ali Janzil Nael Abdul-Hussein Abd El Sayed	20

ISSN (Print) 1994-697X
ISSN (Online) 2706-722X

DOI: <https://doi.org/10.54633/2333-024-057-004>

Received: 1/Dec/2025
Accepted: 10/Jan/2026
Published online: 31/Mar/2026



MJAS: Humanities, Social and Applied Sciences Publishers

The university of Misan.
College of Basic Education This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution

(CC BY NC ND 4.0)
<https://creativecommons.org/licenses/by-nc-nd/4.0/>

Landslide Susceptibility Modeling for Quarries Sites in Northeastern Misan: Using Fuzzy Logic Method

Zahraa R. Fakher

Department of Petroleum Engineering, Misan University, Misan, Iraq

E-mail: geologist_2021@uomisan.edu.iq

*<https://orcid.org/0009-0004-3052-7804>

ABSTRACT:

Landslides are recognized as one of the most dangerous and often occurring natural catastrophes worldwide. Quarrying activities can dramatically enhance the danger of landslides by destabilizing slopes through drilling and heavy machinery movements. The digging process disrupts natural drainage patterns, resulting in water retention that damages soil and rock structures. The main justification of the present work is producing a landslide susceptibility model for quarries sites in northeastern Misan. This means an evaluated mixture of different indices. By applying the fuzzy logic method to remote sensing and GIS techniques. The study used spectral indices derived from multispectral Landsat. The thematic layers (indices) are: "Clay Minerals Ratio (CMR), Iron Oxide Ratio (IOR), Normalized Difference Vegetation Index (NDVI), Enhanced Vegetation Index (EVI), Normalized

Difference Moisture Index (NDMI), Normalized Difference Water Index (NDWI), Bare Soil Index (BSI), and Normalized Difference Soil Index (NDSI)". The final landslide susceptibility map identified three risk zones: low, moderate, and high. The majority of quarries in northern areas are in a high-susceptibility zone, which indicates that quarry operations are a significant source of landslide danger, with northern quarries being high risk and northeastern quarries being moderate to low risk.

KEYWORDS: Susceptibility, Quarries, Remote Sensing, Spectral Indices, Fuzzy logic, GIS

1. INTRODUCTION:

Landslides are widely recognized as one of the most prevalent and destructive natural hazards globally. Over the last three decades, researchers across the world have developed a variety of approaches for mapping the susceptibility to landslides and hazard assessment (Schuster and Fleming, 1986). Landslide incidents are caused by a variety of interdependent factors, including:

both natural forces (e.g., earthquakes, stream erosion) and human actions (e.g., deforestation, mining). (Zhong *et al.*, 2020), (Fadhil, R.M., and Ali, A.K., 2020) However, predicting the position and time of a landslide is a challenging task since geological features and slope angle parameters change significantly over short distances, and it is challenging to determine the timing, location, and severity of triggering events. Quarrying activities can dramatically enhance the danger of landslides by destabilizing slopes through drilling and heavy machinery movements (Al-Maamory and Al-Zubaidy, 2022). The digging process disrupts natural drainage patterns, resulting in water retention that damages soil and rock structures. Deforestation and plant clearance during quarry operations also impair slope stability, increasing the risk of erosion and mass wasting. In rare situations, poorly managed quarry sites have caused catastrophic landslides, threatening adjacent towns, ecosystems, and infrastructure (Al-Asadi, K.A., and Al-Khafaji, 2021) Proper land-use planning, slope reinforcement, and environmental impact assessments are critical for mitigating these hazards and ensuring sustainable quarrying methods. The remote sensing data utilized in this study were obtained from NASA's (Earth Explorer) website. The Operational Land Imager (OLI) prepares worldwide seasonal coverage of the land surface at a resolution of 30 m. Landsat 8 takes data from an altitude of 705 kilometers and a coverage area of about 185 kilometers. Some causes of landslides can be utilized as factors to determine their susceptibility. These factors can be used as an indicator to determine the risk of landslides (Pacheco Quevedo, 2023).

The main justification of the present work is producing a landslide susceptibility model for quarries sites in northeastern Misan. This means evaluated mixture of different indices. The used spectral indices derived from multispectral Landsat. The indices are: "Clay Minerals Ratio (CMR), Iron Oxide Ratio (IOR), Normalized Difference Vegetation Index (NDVI), Enhanced Vegetation Index (EVI), Normalized Difference Moisture Index (NDMI), Normalized Difference Water Index (NDWI), Bare Soil Index (BSI), and Normalized Difference Soil Index (NDSI)".

2. STUDY AREA:

2.1 GEOLOGIC SETTING

The under-investigation area is covered with Zagros foothill deposits consists of Holocene and Pleistocene alluvial sediments deposited by the Tigris River and its tributaries, principally silt, clay, and fine sand ((Jassim and Goff, 2006). Seasonal flooding promotes the deposition of nutrient-rich silts and clays along floodplains, increasing soil fertility and sustaining agriculture (Aqrawi *et al.*, 2010). Further from the river, aeolian deposit sands and silts mingle with alluvial soils, adding variation to soil texture and composition., which evolved in the mountains to the east-northeast along the Iraqi-Iranian border (Ameen, 2005).

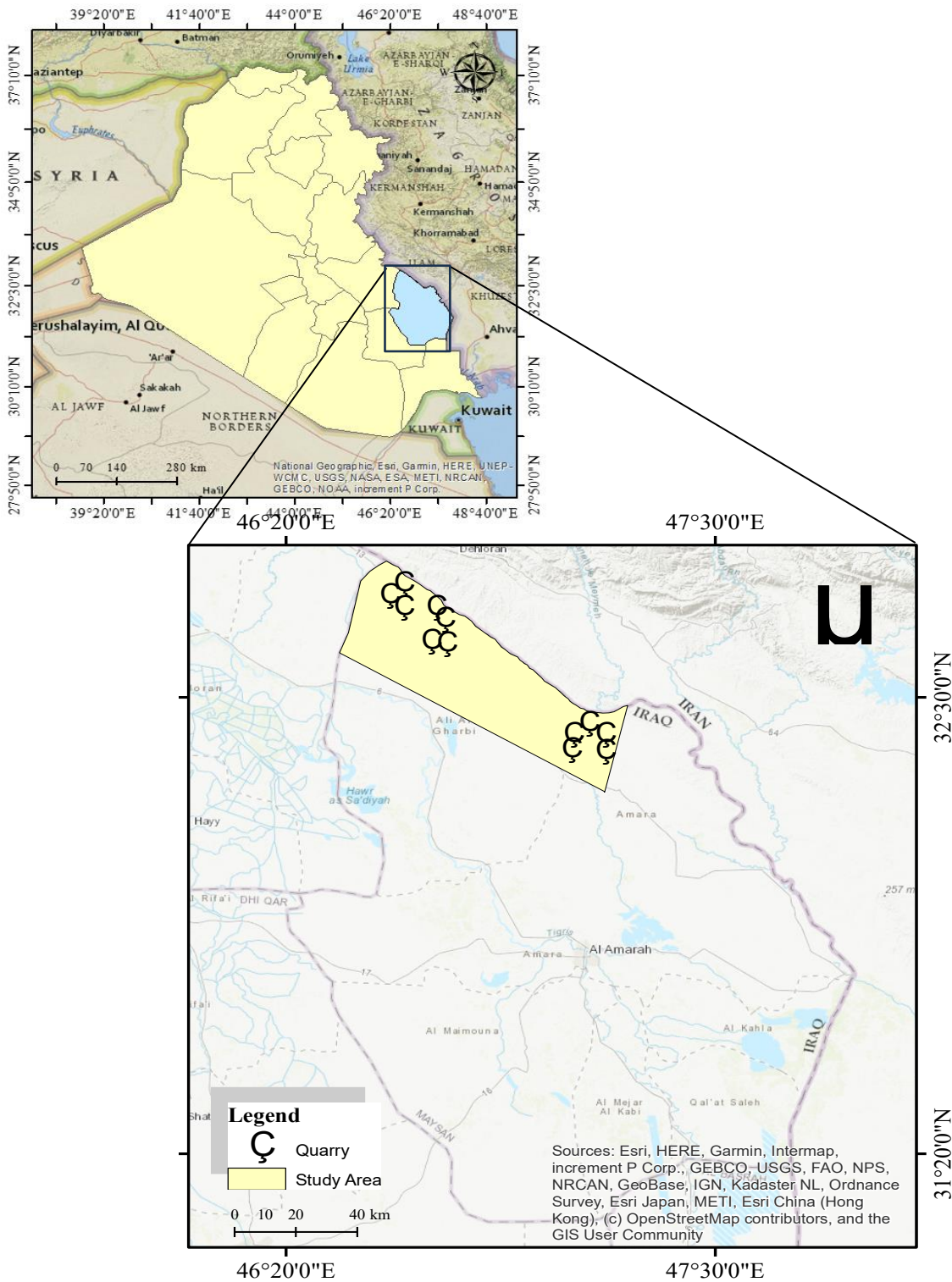


Fig.1 The Quarries site

3.METHODOLOGY:

Considering that, Landslides in an area are influenced by slope characteristics, lithology, soil type, and hydrologic/meteorological factors (Silalahi et al.,2009). Therefore, to create landslide susceptibility model. The study deals with landslide susceptibility mapping for quarry sites in North-Eastern Missan applying fuzzy logic. The following key causal factors were considered: lithology and soil composition, erosion control indicators, liquefaction and shear strength assessment, and erosion susceptibility. Thematic layers have been generated using a combination of remote sensing and GIS approaches Fig.2 and Table 1 illustrate the spectral parameters which used as factors to determine their susceptibility.

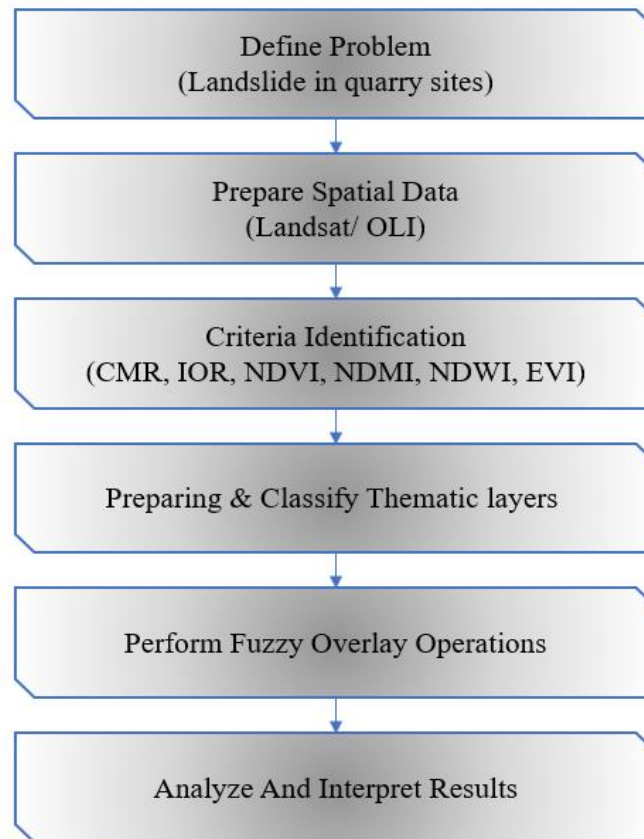


Fig.2 Procedure of The Study

- The Fuzzy Logic method/ The Fuzzy Logic approach created by Zadeh in 1965. It's commonly used to handle complicated problems, and the membership function is utilized to represent the degree of membership based on a number of variables (Zadeh, 1965). Fuzzy logic membership enables the operator to assess if a location is suitable or inappropriate. The essential premise of fuzzy membership is to replace all layers' values with an integer range of 0 to 1, where 0 represents false and 1 represents true, and all values between 0 and 1 denote a transition from 1 to 0, as shown in the following equations (Benz et al., 2004):

$$\mu(X) = 0 \text{ if } x < \min \dots\dots\dots (1)$$

$$\mu(x) = 1 \text{ if } x > \max \dots\dots\dots (2)$$

$$\text{other wise } \mu(x) = (x - \min) / (\max - \min) \dots\dots\dots (3)$$

Table 1 Characteristic of Spectral Parameters

	Used Spectral Parameters	Mathematical formula	References
Lithology & Soil Composition	Clay Minerals Ratio (CMR)	$CMR = \frac{Band\ 6\ (1.6\ \mu M)}{Band\ 7\ (2.2\ \mu M)} \dots\dots\dots (4)$	(Hunt,1977)
	Iron Oxide Ratio (IOR)	$IOR = \frac{Band\ 4\ (0.66\ \mu M)}{Band\ 2\ (0.48\ \mu M)} \dots\dots\dots (5)$	(Hunt,1970)
Erosional Control Indices	Normalized Difference Vegetation Index (NDVI)	$NDVI = \frac{Band\ 5\ (0.85\ \mu M) - Band\ 4\ (0.66\ \mu M)}{Band\ 5\ (0.85\ \mu M) + Band\ 4\ (0.66\ \mu M)} \dots\dots\dots (6)$	(Jw,1973)
	Enhanced Vegetation Index (EVI)	$EVI = 2.5 * \frac{Band\ 5\ (0.85) - Band\ 4\ (0.66)}{Band\ 5 + Band\ 6 * Band\ 4 - 7.5 * band\ 2 + 1} \dots\dots\dots (7)$	(Huete and Liu, 1994) (Huete <i>et al.</i> , 1997)
Liquefaction & Shear Strength	Normalized Difference Water Index (NDWI)	$NDWI = \frac{Band\ 3\ (0.56\ \mu M) - Band\ 5\ (0.86)}{Band\ 3\ (0.56\ \mu M) + Band\ 5\ (0.86)} \dots\dots\dots (8)$	(McFeeters,1996) (Gao, 1996)
	Normalized Difference Moisture Index (NDMI)	$NDMI = \frac{Band\ 5\ (0.85) - Band\ 6\ (1.6\ \mu M)}{Band\ 5\ (0.85) + Band\ 6\ (1.6\ \mu M)} \dots\dots\dots (9)$	(Wilson and Sader,2002) (Jin and Sader, 2005.
Erosion Susceptibility	Bare Soil Index (BSI)	$BSI = \frac{Band\ 6\ (1.6\ \mu M) - Band\ 7\ (2.2\ \mu M)}{Band\ 6\ (1.6\ \mu M) + Band\ 7\ (2.2\ \mu M)} \dots\dots\dots (10)$	(Rikimaru and Miyatake, 2002)
	Normalized Difference Soil Index (NDSI)	$NDSI = \frac{Band\ 6\ (1.6\ \mu M) - Band\ 5\ (0.85)}{Band\ 6\ (1.6\ \mu M) + Band\ 5\ (0.85)} \dots\dots\dots (11)$	(Escadafal, 1994)

- The Fuzzy Logic Overlay is necessary for applying Fuzzy logic to the criterion layers. The process includes describing the problem, establishing criteria, standardizing components, allocating weights, aggregating requirements, and testing the findings. In this work, fuzzy

gamma operators were applied, based on fuzzy algebraic product and sum. (Shahabi and Ahmad, 2015).

4. THE RESULTS

The Fuzzy Logic approach was applied to the eight thematic layers (CMR, IOR, NDVI, EVI, NDMI, NDWI, BSI, and NDSI). To successfully build a comprehensive Landslide Susceptibility Map (LSM) for the quarry's sites. Figs. (3, 4, 5, 6, 7, 8, 9, 10) illustrated the used spectral indices as thematic layers, which are subdivided into three classes (low, medium, and high).

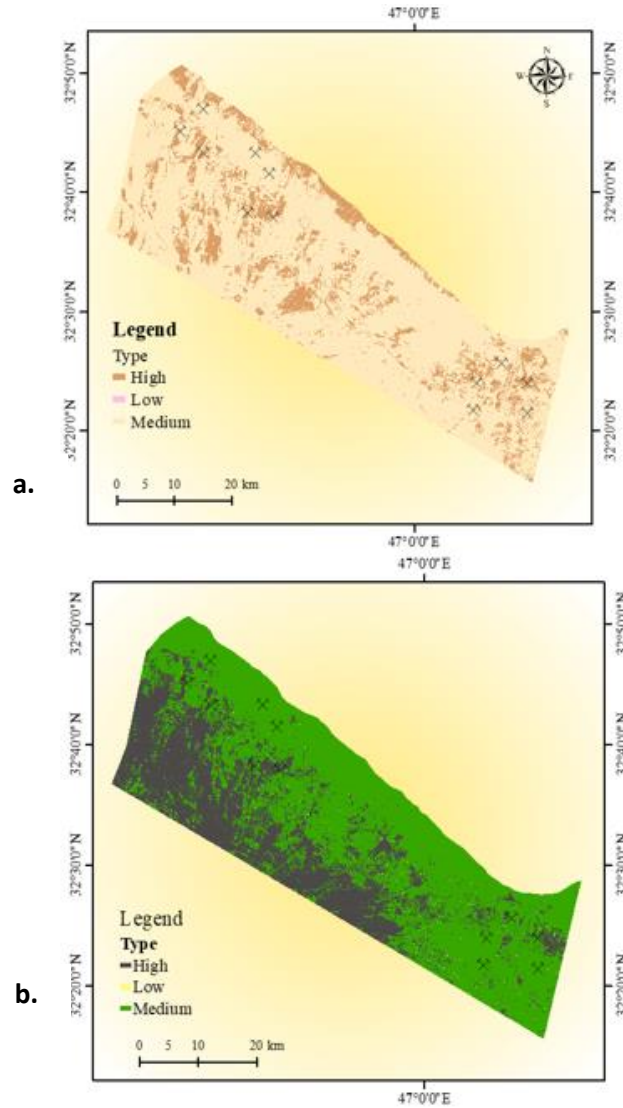


Fig. 3, a. CMR index, b. IOR index

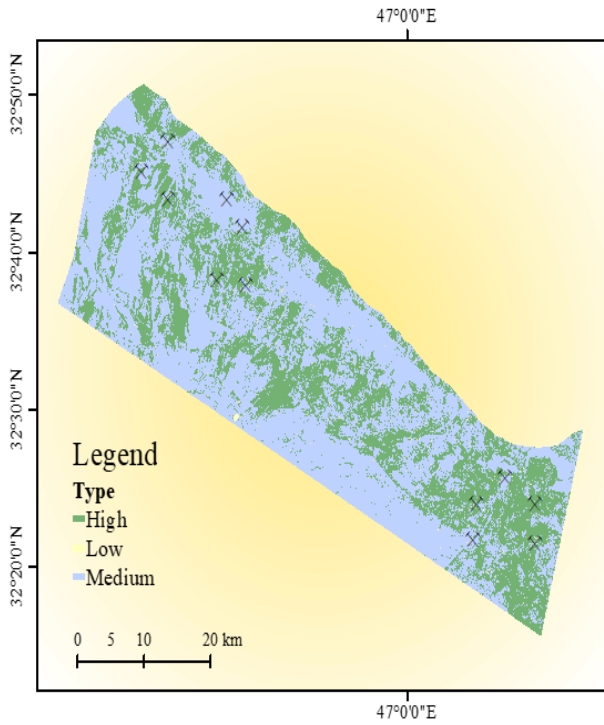


Fig.5 NDVI index

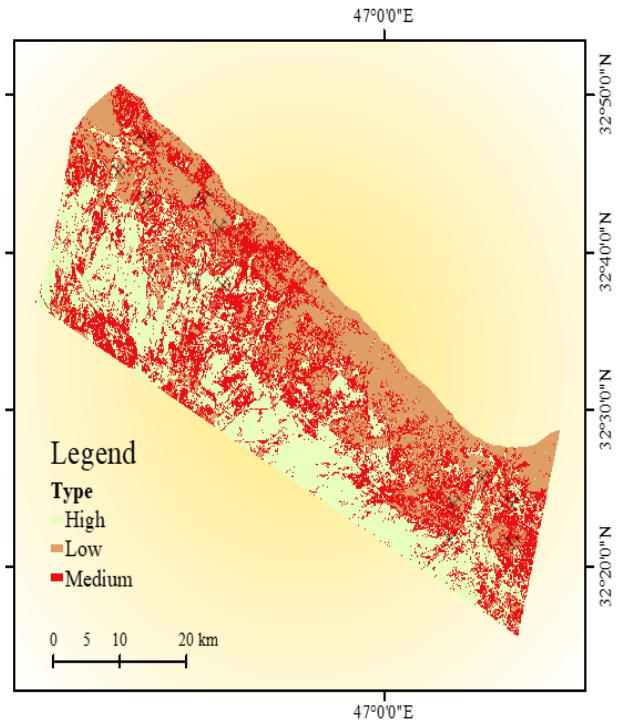


Fig.6 BSI index

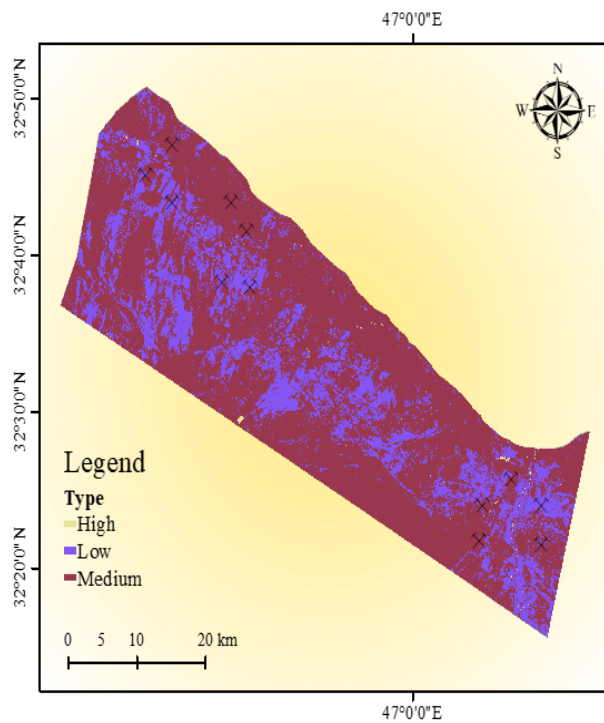


Fig.7 NDWI index

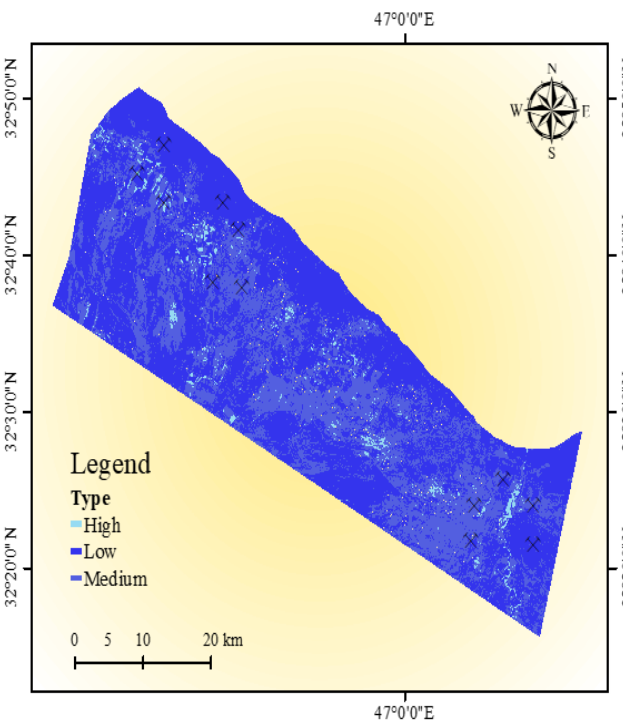


Fig.8 NDMI index

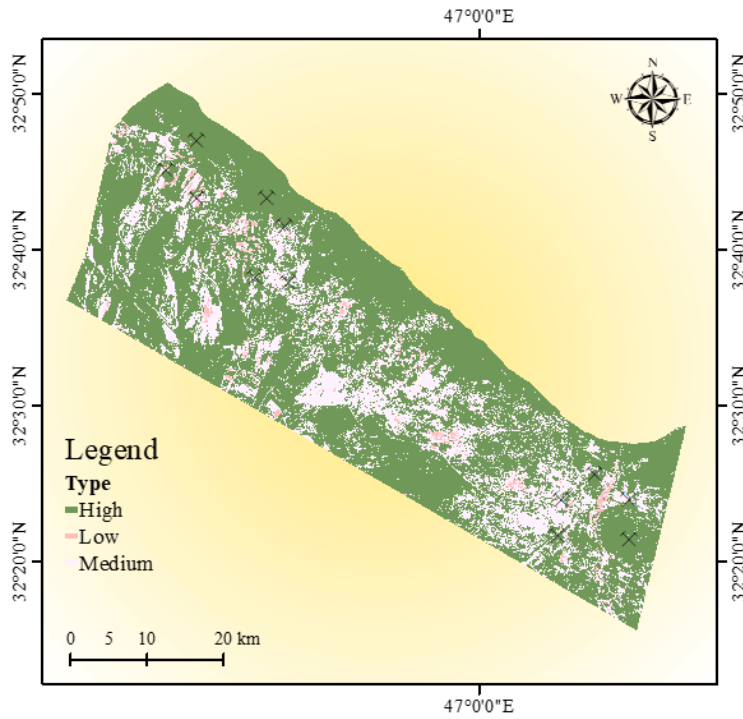


Fig.9 NDSI index

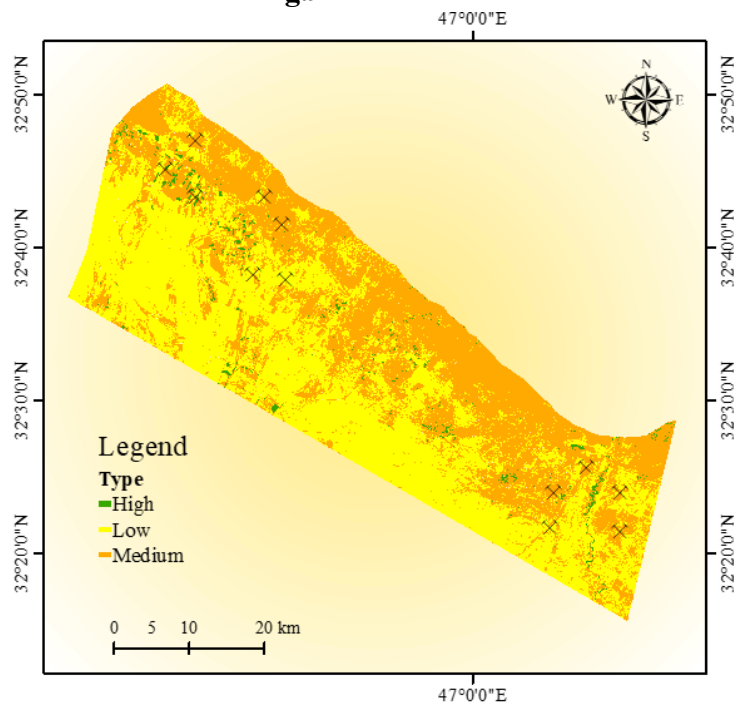


Fig.10 EVI index

The study area was zoned according to landslide susceptibility, resulting in a final map with three defined classes: low, moderate, and high. The findings show a clear spatial link between medium and high susceptibility zones and active quarrying operations.

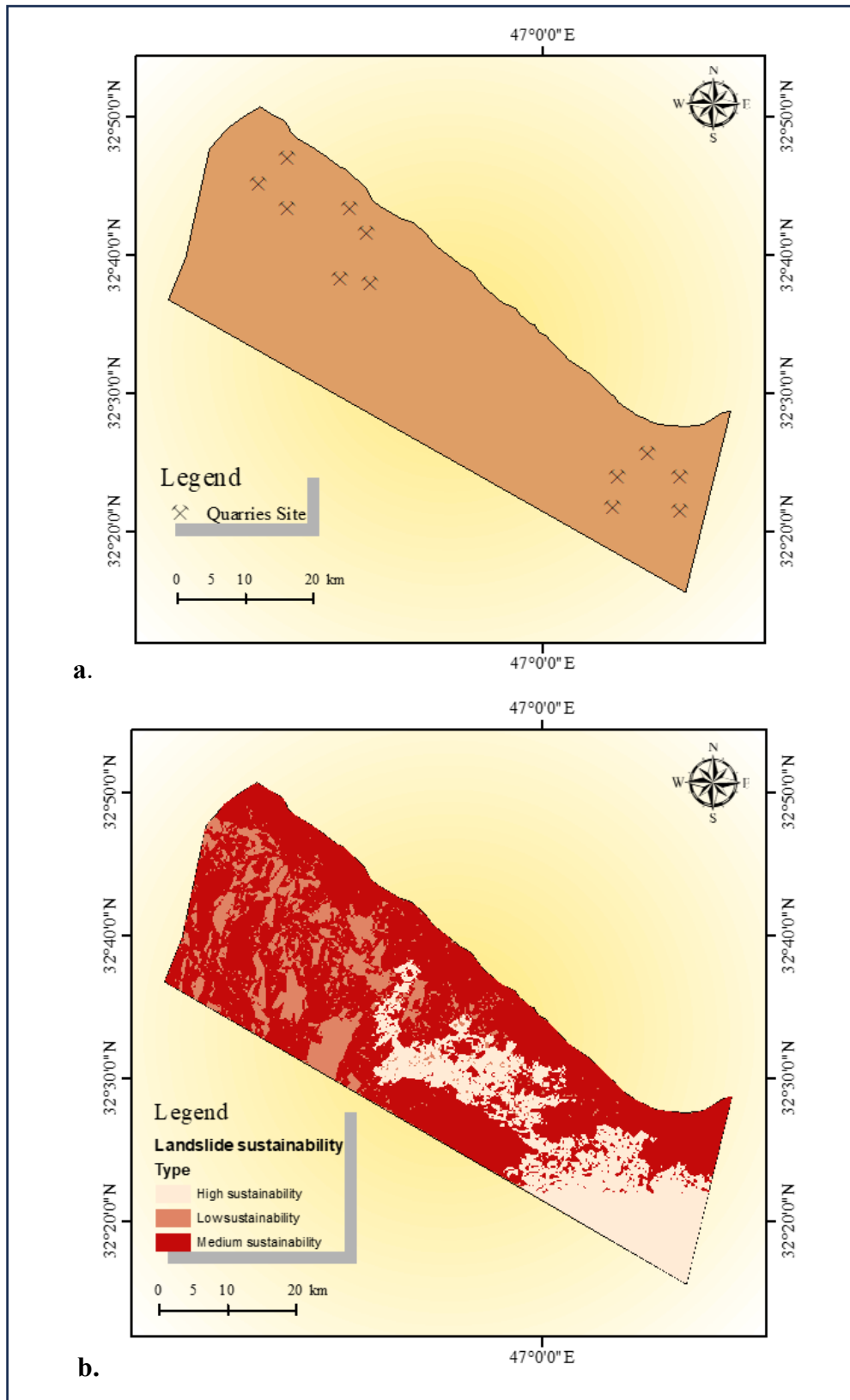


Fig.11 (a) location of active quarries, (b) Landslide Susceptibility Map (LSM)

5. DISCUSSION AND CONCLUSION

The culmination of the susceptibility analysis is a map (LSM) partitioned into three definitive zones: low, moderate, and high susceptibility. The majority of quarries in northern areas are in a high-susceptibility zone, which indicates that quarry operations are a significant source of landslide danger, with northern quarries being high risk and northeastern quarries being moderate to low risk. Planners and engineers must utilize the results of such studies to mitigate the hazard by selecting suitable locations for expansion. To reduce the risk of landslides in the research region, it is recommended to monitor deterioration and changes in natural vegetation cover. This work successfully combined Remote Sensing, GIS, and Fuzzy Logic to develop a landslide susceptibility map for quarries in northeastern Mississippi. It concluded that quarry operations are a major source of landslide risk in the area. The resulting map is a critical tool for planners and managers to reduce hazards by enforcing stronger laws, strengthening slopes, directing future construction away from high-risk areas, and monitoring vegetation. Future study could improve the model by including information on slope angle and rainfall.

6. Acknowledgement:

The author acknowledges the Technical Institute's, Surveying Department for their assistance and the data provided.

7. Declaration of Competing Interest:

The author declares that she has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper

8. REFERENCES:

- Al-Asadi, K.A., and Al-Khafaji, M.S., 2021.** Evaluation of Land Use and Land Cover Change in Amara City Using Remote Sensing and GIS Techniques. *Misan Journal for Academic Studies*, 20(41), pp. 1-18. <https://www.iasj.net/iasj/article/210417>
- Al-Maamory, A.H.K., and Al-Zubaidy, R.N.A., 2022.** Spectral Indices for Monitoring the Change in Water Bodies in Misan Province Using Remote Sensing Data. *Misan Journal for Academic Studies*, 21(44), pp. 1-15. <https://www.iasj.net/iasj/article/244056>
- Ameen, B.M., 2005.** Lithological indicators of Oligocene Gap unconformity at the boundary between high and low folded zones, NE-Iraq. *The Iraqi Geological Journal*, pp.48-56. <https://www.iasj.net/iasj/article/6180>
- Aqrabi, A.A., Goff, J.C., Horbury, A.D. and Sadooni, F.N., 2010.** The petroleum geology of Iraq. Scientific Press Ltd. DOI: 10.3997/9781468577829
- Benz, U.C., Hofmann, P., Willhauck, G., Lingenfelder, I. and Heynen, M., 2004.** Multi-resolution, object-oriented fuzzy analysis of remote sensing data for GIS-ready information. *ISPRS Journal of photogrammetry and remote sensing*, 58(3-4), pp.239-258. DOI: 10.1016/j.isprsjprs.2003.10.002
- Escadafal, R., 1994.** Soil spectral properties and their relationships with environmental parameters—examples from arid regions. In *Imaging spectrometry—A tool for environmental observations* (pp. 71-87). Springer, Dordrecht. DOI: 10.1007/978-94-011-1200-4_5

- Fadhil, R.M., and Ali, A.K., 2020.** Using Remote Sensing Techniques to Detect the Changes in Vegetation Cover in Misan Province for the Period (1990-2020). *Misan Journal for Academic Studies*, 19(40), pp. 1-14. <https://www.iasj.net/iasj/article/215890>
- Gao, B.C., 1996.** NDWI—A normalized difference water index for remote sensing of vegetation liquid water from space. *Remote sensing of environment*, 58(3), pp.257-266. DOI: 10.1016/S0034-4257(96)00067-3
- Hunt, G.R., 1970.** Visible and near-infrared spectra of minerals and rocks: I silicate minerals. *Modern geology*, 1, pp.283-300. <https://www.ruff.info/uploads/GRH70.pdf>
- Jassim, S.Z. and Goff, J.C. eds., 2006.** *Geology of Iraq*. DOLIN, sro, distributed by Geological Society of London <https://www.geology.cz/extranet-eng/publikace/online/geology-of-iraq>
- Hunt, G.R., 1977.** Spectral signatures of particulate minerals in the visible and near infrared. *Geophysics*, 42(3), pp.501-513. DOI: 10.1190/1.1440721
- Jin, S. and Sader, S.A., 2005.** Comparison of time series tasseled cap wetness and the normalized difference moisture index in detecting forest disturbances. *Remote sensing of Environment*, 94(3), pp.364-372. DOI: 10.1016/j.rse.2004.10.012
- McFeeters, S.K., 1996.** The use of the Normalized Difference Water Index (NDWI) in the delineation of open water features. *International journal of remote sensing*, 17(7), pp.1425-1432. DOI: 10.1080/01431169608948714
- Pacheco Quevedo, R., Velastegui-Montoya, A., Montalván-Burbano, N., Morante-Carballo, F., Korup, O. and Daleles Rennó, C., 2023.** Land use and land cover as a conditioning factor in landslide susceptibility: a literature review. *Landslides*, 20(5), pp.967-982. DOI: 10.1007/s10346-023-02032-8
- Rikimaru, A., Roy, P.S. and Miyatake, S., 2002.** Tropical forest cover density mapping. *Tropical ecology*, 43(1), pp.39-47. https://www.researchgate.net/publication/285768409_Tropical_forest_cover_density_mapping
- Rouse, J.W., 1973.** Monitoring vegetation systems in the great plains with ERTS. In *Third NASA Earth Resources Technology Satellite Symposium, 1973 (Vol. 1, pp. 309-317)*. <https://ntrs.nasa.gov/api/citations/19740022614/downloads/19740022614.pdf>
- Schuster, R.L. and Fleming, R.W., 1986.** Economic losses and fatalities due to landslides. *Bulletin of the Association of Engineering Geologists*, 23(1), pp.11-28 <https://aeg.web.ua.edu/publications/bulletin-archive/>
- Shahabi, H., Hashim, M. and Ahmad, B.B., 2015.** Remote sensing and GIS-based landslide susceptibility mapping using frequency ratio, logistic regression, and fuzzy logic methods at the central Zab basin, Iran. *Environmental Earth Sciences*, 73(12), pp.8647-8668. DOI: 10.1007/s12665-015-4028-0
- Silalahi, F.E.S., Arifianti, Y. and Hidayat, F., 2019.** Landslide susceptibility assessment using frequency ratio model in Bogor, West Java, Indonesia. *Geoscience Letters*, 6(1), pp.1-17. DOI: 10.1186/s40562-019-0140-4
- Wilson, E.H. and Sader, S.A., 2002.** Detection of forest harvest type using multiple dates of Landsat TM imagery. *Remote Sensing of Environment*, 80(3), pp.385-396. DOI: 10.1016/S0034-4257(01)00318-2
- Zadeh, L.A., 1965.** Fuzzy sets. *Information and control*, 8(3), pp.338-353. DOI: 10.1016/S0019-9958(65)90241-X