

Model for Hazard Mapping and Disaster Management of Land Degradation Using Geospatial Techniques in Iraq: A Review

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Abstract

In this review article, we examined the previous literature on mapping and modeling degradation risk in the spatiotemporal context of Iraq, which is located in the Near East and North Africa (NENA) region, and is particularly vulnerable to land degradation and is losing thousands of hectares of land. Land degradation has been a significant focus of academic research globally and remains a major issue in the 21st Century. The review process was meticulously designed and conducted over the past decade (from 2015 to 2025) utilizing relevant keywords. We searched several databases, including Elsevier, Springer, IEEE, MDPI, Taylor and Francis, and Wiley. Our search yielded 54 relevant research articles. We conclude that there is a research gap that needs to be addressed, represented by the development of a model that considers the spatiotemporal aspects of land degradation in line with the definitions found in global literature. Additionally, the Dhi Qar and Ninewa Governorates have not received much attention from researchers, making them largely unexplored areas in this context. We also observed that the most widely used remote sensing data in the literature came from the Landsat satellite series.

Keywords:

Land degradation, Geospatial Modeling, Spatiotemporal, Iraq.

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1. Introduction

Land degradation is a significant global issue that affects various regions worldwide. Africa's yield loss from soil erosion ranges from 2 to 40% with a mean of 8.2%. South Asia loses 36 million tons of cereal equivalent annually, which is worth US\$5,400 million due to water erosion and US\$1,800 million due to wind erosion (Bridges, 2019). Land degradation in the Near East and North Africa (NENA), including Iraq, impacts around 410 million people, and approximately 86% of the region's land is affected by land degradation and desertification (Azeez et al., 2025; Ziadat et al., 2021). It is a complex problem influenced by numerous factors. It takes many forms, classified into five components: Soil Degradation, Vegetation Degradation, Water

Degradation, Climate Degradation, and Losses Due to urban and industrial development (Dwivedi, 2018). This phenomenon has emerged as one of the most pressing environmental challenges faced by humanity today, making it essential to understand the global patterns associated with this land crisis (Právělie, 2021). Several definitions of land degradation exist, all of which emphasize the decline in land productivity. This decline is characterized by a reduction in the chemical, physical, and biological activities of the land, ultimately leading to a decrease in its economic value. These changes occur in place over a period of time (Li et al., 2021).

From a geospatial perspective, land degradation refers to changes in an input value at a specific spatial unit (such as a pixel) over a specific time period. The input value can be represented by

various indices such as the vegetation index, land use and land cover changes (LULC), or the drought index. Land degradation modelling has become increasingly complex as its factors are interdependent and interrelated; for example, drought is influenced by rainfall, temperature, and human water consumption. In addition, land degradation has a temporal dimension that influences its dynamics. Land degradation poses multiple risks and can occur through different pathways. There are seventeen recognized land degradation pathways including drought, biological invasions, coastal erosion, water-borne soil erosion, wind-borne soil erosion, land contamination, land subsidence, landslides, permafrost thaw, salinization, soil acidification, soil biodiversity loss, soil compaction, soil organic carbon loss, soil clogging, vegetation loss, and waterlogging (Právělie, 2021). Each of these pathways presents a distinct hazard encompassing a range of land degradation risks.

2. Objective and aim of study

The objective of this research review is to identify the latest studies in the field of hazard mapping and geospatial modeling of land degradation. The study has several goals: (i) To examine the role of remote sensing in modeling land degradation; (ii) To review literature that explores land degradation from a spatiotemporal perspective; (iii) To analyze existing research on land degradation modeling; (iv) To classify previous literature according to the regions of Iraq.

3. Concepts of land degradation

Understanding land degradation requires a clear grasp of what "land" means. Land can be defined as a specific area of the Earth's surface, which includes all aspects of the biosphere, both above and below this surface. This encompasses the near-surface climate, soil, terrain features, surface water bodies (lakes, rivers, marshes and swamps), sedimentary layers close to the surface and associated groundwater supplies. It includes plant and animal populations, patterns of human settlement and the physical effects of historical and current human activities (Pablo Muñoz et al., 2019). While there are more straightforward definitions of land such as "a terrestrial system that includes natural resources (soil, near-surface air, vegetation and other biota and water), ecological

processes, topography, as well as human settlements and infrastructure within that system (Henry et al., 2018), the former definition provides a more comprehensive perspective on the concept of land.

All global definitions of land degradation cited in the literature refer to a decline in land productivity (Table 1). Land degradation is not static but rather dynamic, changing with the appropriate conditions for increasing degradation (such as drought) or land restoration (such as the restoration of vegetation cover) (Hermans and McLeman, 2021; King-Okumu et al., 2021).

The concept of dynamic land degradation can be understood as a movement through three-dimensional space (Fig.1a). In this representation, the x and y dimensions (For example, longitude and latitude, or north and east on a Universal Transverse Mercator, UTM) indicate the location of a spatial unit, which can be as small as a single pixel or as large as a specific area, whereas the third dimension represents time. Each value within a spatial unit at a specific time can change in a positive or negative direction. For instance, the Normalized Difference Vegetation Index (NDVI) is a straightforward metric for assessing land degradation (Dhaidan et al., 2021; Ziboon et al., 2022; Feng et al., 2022). Over a time series (such as ten years), a shift in the NDVI value from positive (indicating the presence of photosynthetic vegetation) to negative (signifying land devoid of vegetation cover) serves as evidence of land degradation. Conversely, an increase in the NDVI value indicates land restoration (Fig.1b). Land degradation occurs over a cumulative time series and reflects a continuous decline in the land's yield, as outlined in the definitions provided in Table (1).

The complexity of modeling land degradation arises from its intricate nature. There is typically a multi-faceted and interconnected spatial relationship among the various elements contributing to land degradation in a specific area (Právělie, 2021).

For example, the decline in vegetation cover can result from several factors: drought (climate degradation), overgrazing (human-caused degradation), and soil salinization (chemical degradation). Identifying the primary cause of land degradation is challenging. Is it drought that leads to decreased vegetation cover, which in turn exposes the soil to solar radiation, increasing land surface temperatures (LST), elevating evaporation

rates, and ultimately causing salinization? (Zheng et al., 2022) Or is it overgrazing those results in reduced vegetation?

Table 1: Global definitions of land degradation.

No	Definition	reference
1	A consistent decrease in the bio-productivity of terrestrial ecosystems over time is commonly referred to as land degradation.	Li et al.(Li et al., 2021)
2	Land degradation is a widespread, systemic occurrence that manifests in various forms across all regions of the terrestrial environment.	Scholes et al.(Pandit et al., 2018)
3	Land degradation entails a decline in the physical, chemical, or biological condition of land, potentially limiting its productive capacity.	Grainger (Grainger, 2015)
4	A long-term decline in ecosystem function and productivity	Lorenz et al. (Lorenz et al., 2019)
5	Land degradation arises from insufficient management of natural resources, such as soils, water, and vegetation.	Sutton et al.(Sutton et al., 2016)
6	The temporary or permanent loss of land's potential for production as a result of inadequate land management.	Zika and Erb (Zika and Erb, 2009)
7	The reduction in biological productivity and the decrease in the complexity of terrestrial ecosystems are collectively referred to as land degradation.	Stavi and Lal(Stavi and Lal, 2015)
8	Land degradation refers to the decline or loss of biological or economic productivity in arid regions.	D'Odorico et al. (D'Odorico et al., 2013)
9	The long-term loss of ecosystem function and productivity brought on by disturbances from which land cannot recover on its own is known as land degradation.	Bai et al.(Bai et al., 2008)
10	Land degradation is the decline in ecosystem functions and productivity over time, leading to a decrease in the economic value of land-derived services and products, caused by natural changes or human activities	Turner et al (Turner et al., 2016)

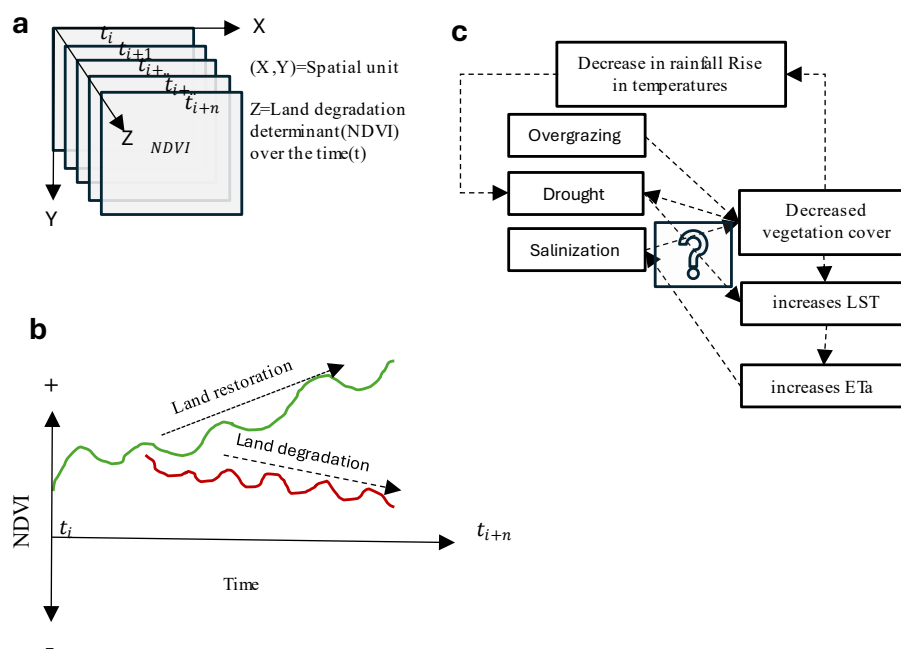


Fig.1: Concept of land degradation: a- Three-dimensional representation of land degradation; b- Representation of land degradation and land restoration in the time dimension based on the NDVI value; c- The relationship between the factors leading to land degradation.

Alternatively, could the salinity of the soil itself be a primary factor? (Al-Helaly et al., 2022) (Fig. 1c). Understanding the relationships among these degradation factors and their sequences is complex and requires a thorough analysis of the risks associated with land degradation. This

analysis is essential for restoring the land and developing an effective reclamation plan.

In summary, land degradation is a complex issue that spans both spatial and temporal dimensions. To properly investigate this phenomenon, researchers must consider the extent

of the factors driving land degradation in spatial and temporal aspects.

4. Materials and Methods

The first step in our research methodology is to derive appropriate keywords. We have selected the keywords "hazards", "land degradation", "geospatial", "Time series", and "spatial-temporal". In some literature, the term "geospatial" refers specifically to Geographic Information Systems (GIS). In contrast, the abbreviation "GIS" is used more generally. Additionally, we have identified the most influential factors or pathways that lead to land degradation. Among the seventeen degradation pathways, Právělie (2021) identified five main factors leading to land degradation. These factors are drought, soil erosion, salinity, loss of organic carbon, and loss of vegetation cover.

The next step in our research methodology is to design the research process. We have conducted the research using the Google Scholar search engine and identified reputable sources of references and previous literature including Elsevier, Springer, IEEE, MDPI, Taylor and Francis and Wiley. The time frame for our research spans the previous ten years from 2015 to 2025 (Fig. 2). The restricted search terms we used are "Iraq" AND "degradation" AND "hazards" AND "geospatial" OR "GIS" AND "Time series" AND "spatial-temporal". The literature search results must contain the term "land degradation". Each result also needs to include at least one of the following terms: "Landsat," OR "Sentinel," OR "MODIS," which refer to the data sources used by researchers in the literature. Additionally, we employed terms related to the five main pathways leading to land degradation as further keywords.

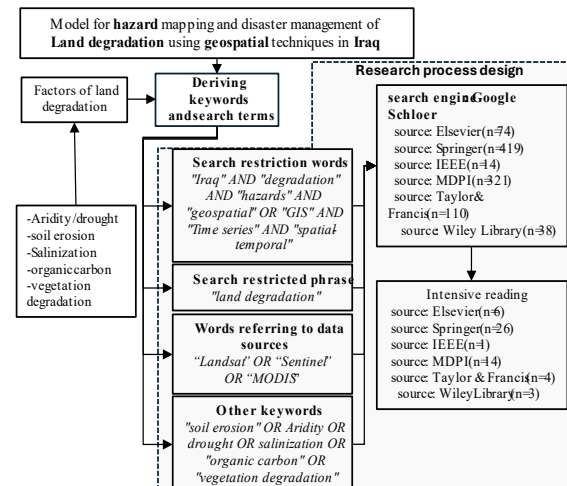


Fig. 2: Research methodology

5. Results

We initially obtained 976 articles categorized as follows: 419 from Springer, 321 from MDPI, 110 from Taylor and Francis, 74 from Elsevier, 38 from Wiley and 14 from IEEE. The keywords and phrases used in our search are not limited to their appearance in the abstracts or titles of the research articles. After a thorough reading, we found that the number of articles directly related to our chosen keywords decreased to 54. These are distributed as follows: 26 from Springer, 14 from MDPI, 4 from Taylor and Francis, 6 from Elsevier, 3 from Wiley, and 1 from IEEE.

A. The role of remote sensing as a data source

The Landsat satellite series is the most frequently utilized satellite data in the literature. The results indicate that thirty-three articles have employed data from the Landsat satellite series (Table 2). These data are used directly or to derive various indices. In several studies, researchers utilized Landsat data obtained from the Multispectral Scanner (MSS), Thematic Mapper (TM), Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) to extract information on LULC, LST, NDVI, Normalized Difference Water Index (NDWI) and Normalized Difference Built-Up Index (NDBI) (Jasim et al., 2016; Ajaj et al., 2017; Hamad et al., 2017; Al-Abadi and Al-Ali, 2018; Hamad et al., 2018; Hameed et al., 2018; Hamad et al., 2019; Shihab and Al-hameedawi, 2020; Mustafa and Szydlowski, 2020; Kadhim et al., 2021; Khwarahm et al., 2021; Al-Quraishi et al., 2021;

Aldabbagh et al., 2022; Othman et al., 2022; Al-Hameedi et al., 2022; Gaznayee et al., 2022 b; Gaznayee et al., 2022 a; Tao et al., 2022; Rostam Hamadamin and Omer, 2023; Younus and Mohammed, 2024; Abdi et al., 2024; Kadhum et al., 2024; Al-Taei et al., 2024 ; Alzamili et al., 2025). Sahar et al. utilized the Natural Differential Sandy Land Index (NDSLII), which is derived from data collected by the MSS, TM, OLI, and TIR sensors on board Landsat satellites 5, 7, and 8, to extract and map sandy land areas (Sahar et al., 2021). Similarly, Al-Hedny and Alshujairy employed data from the MSS, TM, OLI, and TIR sensors on Landsat satellites 5 and 8 to calculate various indices, including the soil-adjusted vegetation index (SAVI), normalized difference built-up index (NDBI), structure index (UI), dry structure index (DBI), and dry bare soil index (DBSI); these indices are used to evaluate the extent of LU/LC changes resulting from uncontrolled urban expansion (Al-Hedny and Alshujairy, 2022).

In addition to data from the MSS, TM, OLI, and TIRS, Hason et al. (2020) and Khwarahm et al. (2021) utilized the Return Beam Vidicon (RBV) sensor on Landsat 1-4 to extract LULC information (Hason et al., 2020; Khwarahm et al., 2021). Kadhim et al. also derived the NDVI from the same sensors (Kadhim et al., 2021). Al-Hedny and Mhaimeed, and Othman et al. utilized MODIS-derived NDVI data with a spatial resolution of 250 meters (Al-Hedny and Mhaimeed, 2020; Othman et al., 2023). Abbas used the Multispectral Imager (MSI) aboard Sentinel-2 to derive salinization indices, which include the normalized difference salinity index (NDSI), salinity indices (SI1, SI2, SI3, SI4, SI5, and SI6), the brightness index (BI), and the vegetated soil salinity index (VSSI) (Abbas, 2023). At the same time, Ali et al. (2023) and M Amen et al. (2023) also employed the MSI on Sentinel-2 to extract LULC information.

The Sentinel-1 and Sentinel-2 satellites as well as MODIS, have been the least utilized in the literature. The C-SAR instrument on the Sentinel-1 satellite provided a digital elevation model (DEM), which Shihab and Al-hameedawi utilized

in their research (Shihab and Al-hameedawi, 2020). In contrast, many other researchers have employed DEM data from the Shuttle Radar Topography Mission (SRTM) in their studies (Mustafa and Szydlowski, 2020; Othman et al., 2022; M Amen et al., 2023; Ali et al., 2023; Othman et al., 2023). Additionally, Al-Hameedi et al. have used DEM data from the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) in their study (Al-Hameedi et al., 2022).

Climate data has also been important in land degradation research. Many studies have utilized remote sensing technology to collect climate data, including temperature, humidity, rainfall and wind. The Tropical Rainfall Measuring Mission (TRMM) has been utilized in previous literature as a source of climate data, including rainfall (Shihab and Al-hameedawi, 2020; Othman et al., 2022; Othman et al., 2023), as well as CHIRPS, which has been used less frequently in previous studies (Abdullah and Mustafa, 2025).

B. Spatial-temporal dimension

Much of the previous literature has focused on researchers collecting data for specific years, as there is no established time series for data collection. Few studies have investigated regular or irregular time series to examine land degradation or its factors. For instance, Jasim et al. extracted LU/LC change information from irregular time series data with different periods in 2001, 2007, and 2013 (Jasim et al., 2016).

Ajaj et al. collected data over two-time frames: short-term (1990-2002 and 2002-2014) and long-term (1990-2014). During each period, they selected only two scenes from the study area in western Iraq (Ajaj et al., 2017). Hamad et al. collected data across two different periods: the first, in 1998, and the second, in 2015. In their study, there was no time series of data (Hamad et al., 2017). Hameed et al. used a long series of rainfall data from the GLDAS-2 database to analyze the Standardized Precipitation Evapotranspiration Index (SPEI) (Hameed et al., 2018).

Table 2: Data, data sources, temporal extension, and models used to represent spatiotemporal extension in the literature.

Reference	Satellite	Data /Indexes	Temporal dimension	Spatiotemporal
(Jasim et al., 2016)	Landsat 5,7,8	LULC	Irregular time series	MLC
	ASTER	DEM	Single scene	

(Ajaj et al., 2017)	Landsat 5,7,8	LULC	Irregular time series	MLC
(Hamad et al., 2017)	Landsat 5,7,8	NDVI	Irregular time series	Non
	SRTM	DEM	Single scene	
(Al-Abadi and Al-Ali, 2018)	Landsat 8	LULC	Single scene	Non
	SRTM	DEM	Single scene	
(Hamad et al., 2018)	Landsat 7,8	LULC	Irregular time series	Non
(Hamad et al., 2019)	Landsat8	NDVI	Single scene	Non
	MODIS	VHI, VDI	Regular time series	
(Al-Quraishi et al., 2020)	Landsat 7	NDVI, NDWI, LST	Single scene	Non
(Al-Hedny and Mhameed, 2020)	MODIS	NDVI	Regular time series	Non
(Mustafa, 2020)	ASTER	DEM	Single scene	MLC
	Landsat 8	LULC	Single scene	
(Shihab and Al-Hameedawi, 2020)	Landsat 8	LULC, STL	Single scene	Non
	TRMM	Rainfall, wind speed	Single scene	
	Sentinel-1	DEM, aspect, slope	Single scene	
(Mustafa and Szydłowski, 2020)	Landsat 5,7,8	LULC	Regular time series	Non
	SRTM	DEM	Single scene	
(Hason et al., 2020)	Landsat 1-8	LULC	Regular time series	Non
(Sahar et al., 2021)	Landsat 5,7,8	NDSLI	Irregular time series	Non
(Kadhim et al., 2021)	Landsat 1-8	NDVI	Irregular time series	Non
(Khwarahm et al., 2021)	Landsat 1-8	LULC	Irregular time series	CA–Markov
(Muneer et al., 2021)	Landsat 8	Row data	Single scene	Non
(Al-Quraishi et al., 2021)	Landsat 5,7,8	NDVI	Regular time series	Non
		NDWI		
(Karimi Hazhir and Mustafa, 2022)	Landsat 8	LULC	Single scene	Non
(Aldabbagh et al., 2022)	Landsat 5,7,8	NDVI	Irregular time series	Non
		LULC		
(Al-Hedny and Alshujairy, 2022)	Landsat 5,8	SAVI, NDBI, UI, DBI, DBSI	Irregular time series	
(Othman et al., 2022)	SRTM	DEM	Single scene	Non
	TRMM	Rainfall	Single scene	
	Landsat 8	LULC	Single scene	
	TRMM	Rainfall	Single scene	
(Al-Hameedi et al., 2022)	Landsat5,8	LULC, LST	Irregular time series	Non
	ASTER	DEM	Single scene	
(Gaznayee et al., 2022 b)	Landsat 5,7 8	NDVI	Regular time series	Non
		LST		
(Gaznayee et al., 2022 a)	Landsat 5,7 8	NDWI	Regular time series	Non
(Mzuri et al., 2022)	Landsat 8	DEM	Single scene	Non
		LULC		
(Amen et al., 2023)	SRTM	DEM	Single scene	Non
	Sentinel-2A	LULC	Single scene	
(Ali et al., 2023)	SRTM	DEM	Single scene	Non
	Sentinel-2A	LULC	Single scene	
(Othman et al., 2023)	SRTM	DEM	Single scene	Non
	MODIS	NDVI	Irregular time series	
	TRMM	Rainfall	Regular time series	
	satellite	Data type	Temporal dimension	spatiotemporal
(Tao et al., 2022)	Landsat 5,8	LULC	Regular time series	Non
(Abbas, 2023)	Sentinel-2	NDSI, SI1, SI2, SI3, SI4, SI5, SI6, and BIVSSI	Single scene	Non
(Rostam Hamadamin and Omer, 2023)	Landsat 5,8	NDVI	Irregular time series	Non
(Younus and Mohammed, 2024)	Landsat 8	NDVI, VCI, NDWI	Single scene	Non
(Abdi et al., 2024)	Landsat 8	LULC, NDVI	Single scene	Non
(Kadhum et al., 2024)	Landsat 5,8	LST, NDVI	Regular time series	Non
(Al-Taei et al., 2024)	Landsat 7,8	LULC	Single scene	Non
(Waeli et al., 2024)	Landsat5,9	Row Data	Irregular time series	Non

(Al-Sulttani et al., 2025)	Landsat 8	Row Data	Single scene	Non
(Abdullah and Mustafa, 2025)	Sentinel-2	(LULC)	Single scene	ML
	CHIRPS	Rainfall, Temperature	Irregular time series	
(Alzamili et al., 2025)	Landsat 8	NDVI, NDBI, LST	Single scene	Non

Mustafa and Szydlowski studied LULC change in both temporal and spatial contexts (Mustafa and Szydlowski, 2020). In their research, they selected specific years across a time series that spanned from 1989 to 2019, recording their observations approximately every ten years. Tao et al. adopted similar approaches (Tao et al., 2022). In contrast, Hassan et al. utilized a long time series of Landsat satellite data to monitor land cover change in the Iraqi Marshlands, with their data collection spanning roughly 48 years (Hason et al., 2020). Their method involved selecting a scene for each year. Other researchers adopted similar approaches (Al-Quraishi et al., 2021; Gaznayee et al., 2022 b; Gaznayee et al., 2022 a; Kadhum et al., 2024). In addition, some researchers have recorded their observations using irregular time series data in their studies (Sahar et al., 2021; Kadhim et al., 2021; Khwarahm et al., 2021; Aldabbagh et al., 2022; Al-Hedny and Alshujairy, 2022; Othman et al., 2023; Waeli et al., 2024; Abdullah and Mustafa, 2025) (Table 2).

Most researchers in the literature present their results using thematic layers to illustrate the spatial dimensions of the factors of land degradation. Even those who use time series data present their results with separate thematic layers for each year. Very few studies have used models to visualize changes in both the temporal and spatial dimensions. For example, Khwarazm et al. and Al-Al-Hameedi et al. applied a Cellular Automata (CA)-Markov chain (CA-Markov) approach to investigate LULC and visualized these changes in both the spatial and temporal dimensions (Khwarahm et al., 2021; Al-Hameedi et al., 2022). Additionally, Abdullah and Mustafa employed machine learning (ML) models to identify changes in LULC as indicators of forest degradation (Abdullah and Mustafa, 2025). They visualized these changes in both spatial and temporal dimensions.

C. Land degradation modeling

Three articles focused directly on modeling land degradation. Mzuri et al. presented a study assessing land degradation in Duhok Governorate using the Analytic Hierarchy Process (AHP) (Mzuri et al., 2022). The inputs for their model

included topographical information, rainfall, vegetation cover and LULC. Hamad and Surucu examined the sensitivity of the Harrir study area to land degradation using a modified Mediterranean Desertification and Land Use (MEDALUS) method (Hamad and Surucu, 2024). Their MEDALUS method incorporated inputs such as management quality, soil quality, climatic quality, and vegetation quality. Abdi et al. assessed land degradation in the Shaqlawa area employing various machine learning (ML) algorithms (Abdi et al., 2024). Their model inputs included land topography, soil type, LULC, weather information, and vegetation cover. A common aspect among these three studies is that they did not consider the temporal dimension of their model inputs. The data collected in each of these studies were not in a time series. Ajaj et al. investigated the detection of LCLU change using the maximum likelihood classifier (MLC) method in the western Iraq study area (Ajaj et al., 2017). Jasim et al. employed a combined model of Fuzzy AHP and MLC to investigate the impact of human and climatic factors on the development of land degradation phenomena in the study area of Anbar (Jasim et al., 2016). Hanson et al. collected data from a long-time series to study the impact of drought on the Iraqi marshes. In their study, drought was identified as a contributing factor to land degradation (Hason et al., 2020). However, the primary focus was not on land degradation itself. They employed the MLC method for supervised image classification, utilizing data collected from the Landsat satellite series, which dates back to 1972. This data collection method involved an irregular time series.

Gaznayee et al. examined the impacts of drought on vegetation cover and LST in the Kurdistan region (Gaznayee, 2022 b). They applied the Mann-Kendall test to identify monotonic trends and used Sen's Slope estimator to determine a non-parametric linear trend within their dataset. Their data consisted of time series for LST and NDVI. The Mann-Kendall and Sen's Slope tests focus on evaluating monotonic trends and the magnitude of the slope in a temporal dimension. To address spatial dimension issues,

the researchers utilized the Pearson correlation coefficient (PCC) to compare data for two consecutive years, such as 1999 and 2000. Using the same methodology and study area, Gaznayee et al. presented a study on the severity and frequency of drought (Gaznayee et al., 2022 a). However, they relied on different data sources and indices. Kadhum et al. took a similar approach to explore the correlation between human activities and severe climate fluctuations in Basra (Kadhum et al., 2024). They used the PCC to analyze the relationship between LST and NDVI. Almamalachy et al. utilized the Spearman correlation coefficient (SCC) to compare data derived from MODIS for two consecutive years to the monitoring of agricultural drought and changes in vegetation cover in Iraq (Almamalachy et al., 2020). The study of changes in vegetation cover, as mentioned in previous literature, is considered an indicator of land degradation, as researchers have implicitly or explicitly referred to this issue. Khalaf and Hummadi utilized six meteorological drought indices to assess the drought conditions affecting the Al-Botamaa area in Salah Al-Din Province. They gathered data on rainfall, temperature, evapotranspiration, and precipitation from the Prediction of Worldwide Energy Resources (POWER) database. Their findings were presented in a temporal dimension (Khalaf and Hummadi, 2023).

Numerous studies have investigated vegetation changes in Iraq using various methodologies and in different regions. For instance, Sayl et al. applied a weighted linear combination in the Wasit study area (Sayl et al., 2021). Sahar et al. utilized the K-Means method for supervised image classification in the Muthanna study area (Sahar et al., 2021). At the same time, Younus and Mohammed also employed the K-Means method for supervised image classification in the Diyala River basin (Younus and Mohammed, 2024). Additionally, Tao et al. employed a different approach, utilizing the MLC method for supervised image classification in conjunction with the CA–Markov approach in the regions of Baghdad, Basra, and Erbil (Tao et al., 2022). Khwarahm et al. used the same approach to investigate losses to Urban/industrial development as indicators of land degradation in the Duhok study area (Khwarahm et al., 2021). Moreover, Al-Hedny and Alshujairy explored urban and industrial development losses using the K-Means

method for image classification in the Babylon study area (Al-Hedny and Alshujairy, 2022), and Mustafa and Szydłowski focused on similar losses in Erbil, also using supervised K-Means classification (Mustafa and Szydłowski, 2020).

Other studies have focused on the impact of urban and industrial development on vegetation cover loss, often considering it alongside various other factors. For instance, Kadhim et al. conducted research in the Basra area using the Coupled Human and Natural Systems (CHANS) model. Their analysis highlighted the relationship between human activities related to urban development and the resulting loss of vegetation cover. Additionally, a study by Karimi Hazhir and Mustafa in the Zakho area utilized a Multi-Criteria Decision Analysis (MCDA) model. This study expanded the parameters to include human impact, loss of vegetation cover, urban development, and soil erosion.

Several studies have focused on soil erosion as a significant factor in land degradation, employing various models. The most notable among these is the Revised Universal Soil Loss Equation (RUSLE), which has been applied in rugged areas of Iraq including the Khabur River basin (Othman et al., 2022), the Darbandikhan Lake basin (Othman et al., 2023), Ali al-Gharbi (Ali et al., 2023), and Dohuk Governorate (Mehri et al., 2024).

Al-Bawi et al. used the AHP-Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) model to investigate soil erosion and gully formation resulting from flash floods in Maysan Governorate (Al-Bawi et al., 2021). Meanwhile, Al-Sulttani et al. applied a range of machine learning algorithms to study soil erosion caused by wind and the formation of aeolian sand in the Najaf-Samawah area (Al-Sulttani et al., 2025). Awadh conducted an analytical study of wind-induced soil erosion across Iraq utilizing weather observations and a simple linear regression model (Awadh, 2023).

Additionally, three studies in our results addressed chemical soil degradation. Hamad et al. conducted a study to evaluate the release of heavy metals into soil in Haljurd-Sakran National Park. In their study, they employed the Inverse Distance Weighting (IDW) method to spatially represent areas with chemical degradation resulting from demining (Hamad et al., 2019). Bokde et al. utilized machine learning algorithms to investigate

soil salinization in Baghdad, Karbala, Diwaniya and Al Amarah (Bokde et al., 2021). Abbas employed polynomial regression to study soil salinization in the Wasit Governorate (Abbas, 2023).

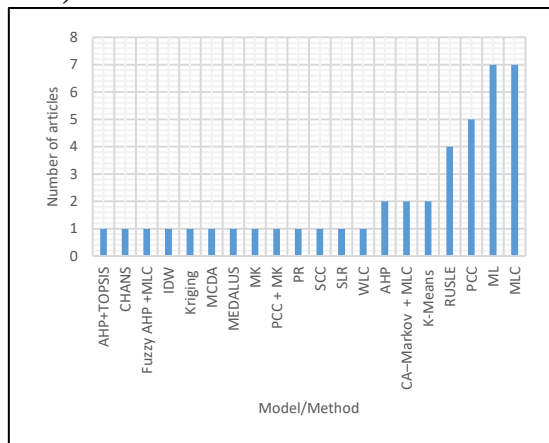


Fig. 3: A histogram of the most commonly used models or methods for modeling the causative factors of land degradation in previous literature.

In summary, our review of the literature reveals that ML and MLC methods are the most commonly used for studying land degradation and its contributing factors (Fig. 3). A total of 14 articles were identified that employed these models, with seven specifically utilizing ML techniques. The RUSLE model was referenced in four articles. Both the AHP model and the K-Means method were utilized in two articles each. Other models and methods were mentioned in only one article apiece. Notably, some researchers combined two models in their studies; for instance, the CA-Markov approach and the MLC were used in two research articles, while the Fuzzy AHP was integrated with the MLC method in one article. One article uses TOPSIS, which is part of the AHP model.

D. Land degradation categories

Based on our findings, we categorized the existing literature into five main categories: Chemical Degradation, Climate Deterioration, Losses Due to Urban and Industrial Development, Soil Degradation, and Vegetation Degradation. Each of these main categories contains several sub-categories. For instance, under Chemical Degradation, we identified sub-categories such as soil alkalinity and salinization (Fig. 4a).

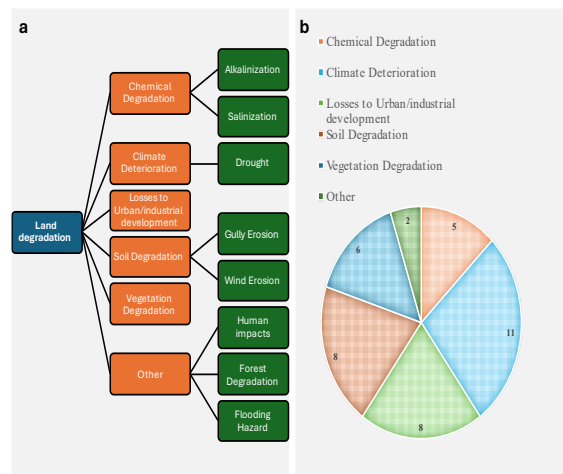


Fig. 4: Land degradation categories in previous literature.

A significant portion of existing research has focused on degradation associated with climate change with a particular emphasis on drought (Ajaj et al., 2017; Şarlak and Mahmood Agha, 2018; Hason et al., 2020; Al-Quraishi et al., 2020; Al-Hedny and Mhaimeed, 2020; Almamalachy et al., 2020; Hason et al., 2020; Al-Quraishi et al., 2021; Gaznayee et al., 2022 a; Khalaf and Hummadi, 2023; Kadhum et al., 2024). Eight articles highlighted urban development as a contributing factor to degradation (Jasim et al., 2016; Hamad et al., 2018; Mustafa, 2020; Khwarahm et al., 2021; Al-Hameedi et al., 2022; Al-Hedny and Alshujairy, 2022; Al-Hameedi et al., 2022; Naser and Al-Tuwayyij, 2023). At the same time, another six addressed vegetation loss as a factor contributing to land degradation (Hamad et al., 2017; Sayl et al., 2021; Sahar et al., 2021; Aldabbagh et al., 2022; Tao et al., 2022; Younus and Mohammed, 2024). Additionally, eight articles examined soil degradation including issues like wind erosion and the formation of gullies (Al-Abadi and Al-Ali, 2018; Al-Bawi et al., 2021; Othman et al., 2022; Othman et al., 2023); Ali et al., 2023; Mehri et al., 2024; Al-Sulttani et al., 2025; Awadh, 2023). Five articles highlighted the chemical degradation of soils including salinization and alkalization (Hamad et al., 2019; Bokde et al., 2021; Abbas, 2023; Sharaa et al., 2020; Jamil et al., 2023). Other articles classified degradation under additional factors such as forest degradation and human impact on vegetation cover (Kadhim et al., 2021; Abdullah and Mustafa, 2025) (Fig. 4b).

E. Previous literature on land degradation by region in Iraq

In Duhok and Al-Muthanna Governorates, extensive studies have been conducted on land degradation and its primary causes compared to other regions. Six research articles on land degradation have been published in the study areas of Duhok and Al-Muthanna Governorates (Fig. 5). Baghdad and Erbil Governorates followed, with four research articles each. In Sulaymaniyah, only two research papers were published. The remaining Iraqi regions have published only one research paper each, except for Dhi Qar and Ninewa. Notably, Dhi Qar and Ninewa did not have any research papers published on land degradation or its primary factors.

6. Discussion

In this literature review, we have found three studies that explicitly address the issue of land degradation. A common feature among these articles is their use of LCLU as indicators for measuring land degradation (Mzuri et al., 2022; Hamad and Surucu, 2024; Abdi et al., 2024). However, it should be noted that the data in these three studies cover only one year and lack a temporal dimension. Time-series data are essential for effectively studying land degradation.

Only six studies have examined land use and land cover (LULC) changes in the spatiotemporal dimension. Three of them employed a maximum likelihood classifier and post-classification methodology (Jasim et al., 2016; Ajaj et al., 2017; Mustafa, 2020), two utilized integrated Markov cumulative analysis models (Khwarahm et al., 2021; Al-Hameedi et al., 2022), and one employed machine learning (Abdullah and Mustafa, 2025). Significant weaknesses in this literature relate to data collection methodologies lacking continuous time series. The researchers selected specific periods but did not provide a clear justification for their choices.

Researchers have relied heavily on the products of the Landsat satellite series, as evidenced in the literature. The Landsat series has been operational since 1972, offering high temporal resolution for data collection. Improvements made to the Landsat series, particularly with Landsat 8, have led many researchers to adopt this data for monitoring and characterizing both natural and human-induced changes in land use and land cover on a global

scale (Loveland and Irons, 2016). Landsat 8 data have several advantages, including higher radiometric and geometric resolution, improved acquisition processes, and wider spectral bands. In comparison to MODIS, which has a spatial resolution of 250 m, Landsat boasts a spatial resolution of 30m. Additionally, in terms of its operational history, Landsat predates Sentinel-1, which was launched in 2014.

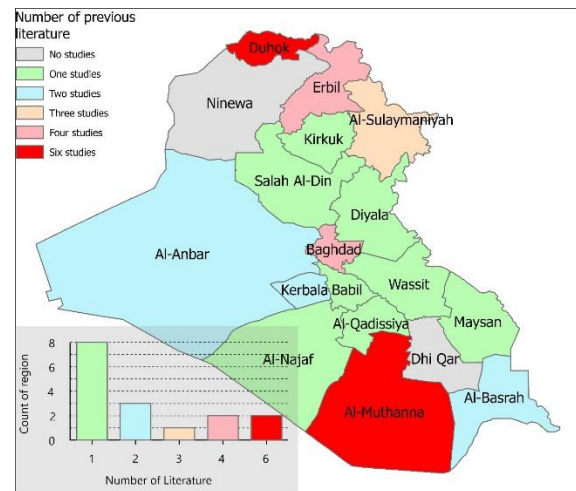


Fig. 5: Map (Not to scale) of the regions in Iraq where land degradation or the factors leading to it were studied.

7. Conclusion

Land degradation is a multidimensional phenomenon occurring in three dimensions: spatial (x, y) and time. Three studies have explicitly focused on land degradation modeling. However, this article does not consider the temporal dimension of land degradation according to international definitions. Most previous research examining the factors of land degradation has relied on data from the Landsat satellite series. The use of ML models has shown promise in modeling the factors of land degradation, and most of the studies found in our literature examined climate degradation, particularly drought, as a significant factor in the formation of the land degradation phenomenon in Iraq. It is worth noting that Dhi Qar and Ninewa Governorates have not received much attention from researchers regarding land degradation and its underlying causes. This review of the available literature highlights a significant research gap: the lack of studies that address land degradation from both a temporal and spatial perspective. This research gap opens new horizons for research in spatiotemporal modeling,

especially in geographic information systems, to model phenomena with a spatial and temporal dimension. Furthermore, we did not find any specific strategies in the literature for collecting data across consecutive time series. This makes data mining research crucial for developing databases that address historical data for Iraq including LULC, climate data, pollution and environmental data, hydrological data, etc., as these types of data are essential for studying land degradation.

8. Conflict Of Interest

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

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10. References

- Abbas, J.A.A., 2023. Soil salinity assessment by using spectral salinity indices in Al-Sweira project middle of the Iraqi alluvial plain. *International Journal of Environmental Science and Technology*, 20(10), 10847–10860. <https://doi.org/10.1007/s13762-022-04733-4>
- Abdi, B., Kolo, K. and Shahabi, H., 2024. Assessment of land degradation susceptibility within the Shaqlawa subregion of Northern Iraq-Kurdistan Region via synergistic application of remotely acquired datasets and advanced predictive models. *Environmental Monitoring and Assessment*, 196(11), 1103. <https://doi.org/10.1007/s10661-024-13284-9>
- Abdullah, M. H. and Mustafa, Y.T., 2025. Machine Learning and SHAP-Based Analysis of Deforestation and Forest Degradation Dynamics Along the Iraq–Turkey Border. *Earth*, 6(2). <https://doi.org/10.3390/earth6020049>
- Ajaj, Q.M., Pradhan, B., Noori, A.M. and Jebur, M.N., 2017. Spatial Monitoring of Desertification Extent in Western Iraq using Landsat Images and GIS. *Land Degradation and Development*, 28(8), pp. 2418–2431. <https://doi.org/10.1002/ldr.2775>
- Al-Abadi, A.M. and Al-Ali, A.K., 2018. Susceptibility mapping of gully erosion using GIS-based statistical bivariate models: a case study from Ali Al-Gharbi District, Maysan Governorate, southern Iraq. *Environmental Earth Sciences*, 77(6), 249. <https://doi.org/10.1007/s12665-018-7434-2>
- Al-Bawi, A.J., Al-Abadi, A.M., Pradhan, B. and Alamri, A.M., 2021. Assessing gully erosion susceptibility using topographic derived attributes, multi-criteria decision-making, and machine learning classifiers. *Geomatics, Natural Hazards and Risk*, 12(1), 3035–3062. <https://doi.org/10.1080/19475705.2021.1994024>
- Aldabbagh, Y.A.N., Shafri, H.Z.M., Mansor, S. and Ismail, M.H., 2022. Desertification prediction with an integrated 3D convolutional neural network and cellular automata in Al-Muthanna, Iraq. *Environmental Monitoring and Assessment*, 194(10), 715. <https://doi.org/10.1007/s10661-022-10379-z>
- Al-Hameedi, W.M.M., Chen, J., Faichia, C., Nath, B., Al-Shaibah, B. and Al-Aizari, A., 2022. Geospatial Analysis of Land Use/Cover Change and Land Surface Temperature for Landscape Risk Pattern Change Evaluation of Baghdad City, Iraq, Using CA–Markov and ANN Models. *Sustainability*, 14(14). <https://doi.org/10.3390/su14148568>
- Al-Hedny, S.M. and Alshujairy, Q.A.T., 2022. Unplanned Urban Sprawl Impact on Cultivable Soil Degradation. In A. M. F. Al-Quraishi, Y. T. Mustafa, and A. M. Negm (Eds.), *Environmental Degradation in Asia: Land Degradation, Environmental Contamination, and Human Activities* (pp. 505–520). Springer International Publishing. https://doi.org/10.1007/978-3-031-12112-8_23
- Al-Hedny, S. and Mhaimeed, A., 2020. Drought Monitoring for Northern Part of Iraq Using Temporal NDVI and Rainfall Indices (pp. 301–331). https://doi.org/10.1007/978-3-030-21344-2_13
- Al-Helaly, M. H., Alwan, I.A. and Al-Hameedawi, A. N., 2022. Environmental Investigation of Bahar Al-Najaf Region Using Sentinel-2 Images. *Engineering and Technology Journal*, 40(5), 732–742. <https://doi.org/10.30684/etj.v40i5.2245>
- Ali, A. Ak., Al-Abbadi, A.M., Jabbar, F. K., Alzahrani, H. and Hamad, S., 2023. Predicting Soil Erosion Rate at Transboundary Sub-Watersheds in Ali Al-Gharbi, Southern Iraq, Using RUSLE-Based GIS Model. *Sustainability*, 15(3). <https://doi.org/10.3390/su15031776>
- Almamalachy, Y. S., Al-Quraishi, A. M. F. and Moradkhani, H., 2020. Agricultural Drought Monitoring Over Iraq Utilizing MODIS Products. In A. M. F. Al-Quraishi and A. M. Negm (Eds.), *Environmental Remote Sensing and GIS in Iraq*, pp. 253–278. Springer International Publishing. https://doi.org/10.1007/978-3-030-21344-2_11
- Al-Quraishi, A. M. F., Gaznayee, H. A. and Crespi, M., 2021. Drought trend analysis in a semi-arid area of Iraq based on Normalized Difference Vegetation Index, Normalized Difference Water Index and Standardized Precipitation Index. *Journal of Arid Land*, 13(4), 413–430. <https://doi.org/10.1007/s40333-021-0062-9>
- Al-Quraishi, A. M. F., Qader, S. H. and Wu, W., 2020. Drought Monitoring Using Spectral and Meteorological Based Indices Combination: A Case Study in Sulaimaniyah, Kurdistan Region of Iraq. In A. M. F. Al-Quraishi and A. M. Negm (Eds.), *Environmental Remote Sensing and GIS in Iraq*, pp. 377–393. Springer International Publishing. https://doi.org/10.1007/978-3-030-21344-2_15
- Al-Sultani, A. H., Al-Zubaidi, E. A., Rabee, F., Al-Kasob, G. F., Abdul Maulud, K. N., Shakir, H. S. and Yaseen, Z. M., 2025. Developing aeolian sand spectral index using multispectral imagery and machine learning

- models: A representative case study in Iraq. *Journal of Arid Environments*, 229, 105382. <https://doi.org/10.1016/j.jaridenv.2025.105382>
- Al-Taei, A. I., Alesheikh, A. A. and Boloorani, A. D., 2024. Evaluating the effects of land use/land cover change on the emergence of hazardous dust sources in the Tigris-Euphrates Basin. *Spatial Information Research*, 32(5), 569–582. <https://doi.org/10.1007/s41324-024-00581-1>
- Alzamili, M. H. E., Mahmood, V. and Rao, P. J., 2025. Assessment of urban heat island based on remote sensing and geo-spatial approach in Al-Kut Region, Iraq. *Journal of Earth System Science*, 134(2), 103. <https://doi.org/10.1007/s12040-025-02558-6>
- Awadh, S. M., 2023. Impact of North African Sand and Dust Storms on the Middle East Using Iraq as an Example: Causes, Sources, and Mitigation. *Atmosphere*, 14(1). <https://doi.org/10.3390/atmos14010180>
- Azeez, M. H., Al Sharaa, H. M. J. and Ziboon, A. R. T., 2025. Mapping agricultural lands at risk of meteorological drought in Iraq using geostatistics. *Engineering and Technology Journal*, 43(5), 351–364. <https://doi.org/10.30684/etj.2025.155327.1855>
- Bai, Z. G., Dent, D. L., Olsson, L. and Schaepman, M. E., 2008. Proxy global assessment of land degradation. *Soil Use and Management*, 24(3), 223–234. <https://doi.org/https://doi.org/10.1111/j.1475-2743.2008.00169.x>
- Bokde, N. D., Ali, Z. H., Al-Hadidi, M. Th., Farooque, A. A., Jamei, M., Maliki, A. A. Al, Beyaztas, B. H., Faris, H. and Yaseen, Z. M., 2021. Total Dissolved Salt Prediction Using Neurocomputing Models: Case Study of Gypsum Soil Within Iraq Region. *IEEE Access*, 9, 53617–53635. <https://doi.org/10.1109/ACCESS.2021.3071015>
- Bridges, E. M., 2019. Response to Land Degradation. In E. M. Bridges, I. D. Hannam, L. R. Oldeman, F. W. T. P. de Vries, S. J. Scherr and S. Sombatpanit (Eds.), *Response to land degradation*. CRC Press. <https://doi.org/10.1201/9780429187957>
- Dhaidan, B. A., Alwan, I. A. and Al-Khafaji, M. S., 2021. Utilization of Satellite Images-Based Indices for Assessment of Al-Hammar Marsh Restoration plan. *Engineering and Technology Journal*, 39(8), 1328–1337. <https://doi.org/10.30684/etj.v39i8.2149>
- D’Odorico, P., Bhattachan, A., Davis, K. F., Ravi, S. and Runyan, C. W., 2013. Global desertification: Drivers and feedbacks. *Advances in Water Resources*, 51, 326–344. <https://doi.org/10.1016/j.advwatres.2012.01.013>
- Dwivedi, R. S., 2018. *Geospatial technologies for land degradation assessment and management*. CRC Press.
- Feng, S., Zhao, W., Zhan, T., Yan, Y. and Pereira, P., 2022. Land degradation neutrality: A review of progress and perspectives. *Ecological Indicators*, 144, 109530. <https://doi.org/10.1016/j.ecolind.2022.109530>
- Gaznayee, H.A.A., Al-Quraishi, A.M.F., Mahdi, K., Messina, J.P., Zaki, S.H., Razvanchy, H.A.S., Hakzi, K., Huebner, L., Ababakr, S.H., Riksen, M. and Ritsema, C., 2022a. Drought Severity and Frequency Analysis Aided by Spectral and Meteorological Indices in the Kurdistan Region of Iraq. *Water*, 14(19). <https://doi.org/10.3390/w14193024>
- Gaznayee, H.A.A., Al-Quraishi, A.M.F., Mahdi, K. and Ritsema, C., 2022b. A Geospatial Approach for Analysis of Drought Impacts on Vegetation Cover and Land Surface Temperature in the Kurdistan Region of Iraq. *Water*, 14(6). <https://doi.org/10.3390/w14060927>
- Grainger, A., 2015. Is Land Degradation Neutrality feasible in dry areas? *Journal of Arid Environments*, 112, 14–24. <https://doi.org/10.1016/j.jaridenv.2014.05.014>
- Hamad, K. O. and Surucu, A., 2024. Land degradation sensitivity and desertification risk in Harrir region, northern Iraq. *Heliyon*, 10(5), e27123. <https://doi.org/10.1016/j.heliyon.2024.e27123>
- Hamad, R., Balzter, H. and Kolo, K., 2017. Multi-Criteria Assessment of Land Cover Dynamic Changes in Halgurd Sakran National Park (HSNP), Kurdistan Region of Iraq, Using Remote Sensing and GIS. *Land*, 6(1). <https://doi.org/10.3390/land6010018>
- Hamad, R., Balzter, H. and Kolo, K., 2019. Assessment of heavy metal release into the soil after mine clearing in Halgurd-Sakran National Park, Kurdistan, Iraq. *Environmental Science and Pollution Research*, 26(2), 1517–1536. <https://doi.org/10.1007/s11356-018-3597-3>
- Hamad, R., Kolo, K. and Balzter, H., 2018. Land Cover Changes Induced by Demining Operations in Halgurd-Sakran National Park in the Kurdistan Region of Iraq. *Sustainability*, 10(7). <https://doi.org/10.3390/su10072422>
- Hameed, M., Ahmadalipour, A. and Moradkhani, H., 2018. Apprehensive Drought Characteristics over Iraq: Results of a Multidecadal Spatiotemporal Assessment. *Geosciences*, 8(2). <https://doi.org/10.3390/geosciences8020058>
- Hason, M. M., Abbood, I. S. and Odaa, S. aldeen., 2020. Land cover reflectance of Iraqi marshlands based on visible spectral multiband of satellite imagery. *Results in Engineering*, 8, 100167. <https://doi.org/10.1016/j.rineng.2020.100167>
- Henry, B., Murphy, B. and Cowie, A., 2018. *Sustainable land management for environmental benefits and food security. A Synthesis Report for the GEF*. Washington DC, USA, 127.
- Hermans, K. and McLeman, R., 2021. Climate change, drought, land degradation and migration: exploring the linkages. *Current Opinion in Environmental Sustainability*, 50, 236–244. <https://doi.org/10.1016/j.cosust.2021.04.013>
- Jamil, S. K., Al-Sharaa, H. M. and Abass, A. S., 2023. Environmental planning for monitoring soil contamination in Iraq’s lama facility using GIS methods. *IOP Conference Series: Earth and Environmental Science*, 1129(1), 012030. <https://doi.org/10.1088/1755-1315/1129/1/012030>
- Jasim, M.A., Shafri, H.Z.M., Hamedianfar, A. and Sameen, M.I., 2016. Land transformation assessment using the integration of remote sensing and GIS

- techniques: a case study of Al-Anbar Province, Iraq. *Arabian Journal of Geosciences*, 9(15), 667. <https://doi.org/10.1007/s12517-016-2697-y>
- Kadhim, A. A., Shortridge, A. and Al-Nasrawi, A. K. M., 2021. Causes and consequences of environmental degradation along the Shatt Al-Arab River: a coupled human and natural systems (CHANS) perspective. *GeoJournal*, 86(6), pp. 2709–2722. <https://doi.org/10.1007/s10708-020-10225-0>
- Kadhun, S. A., Awad, A., Abed, S. A., Janaydeh, M., Al-Khayat, A. and Al-Hemoud, A., 2024. Land surface temperature and NDVI patterns in the petroleum and non-petroleum regions in Southern Iraq (Al-Basra). *Environment, Development and Sustainability*. <https://doi.org/10.1007/s10668-024-05145-9>
- Karimi, H., Mustafa, Y.T., Hossini, H., Al-Quraishi, A.M.F., 2022. Assessment of Land Degradation Vulnerability Using GIS-Based Multicriteria Decision Analysis in Zakho District, Kurdistan Region of Iraq. In: Al-Quraishi, A.M.F., Mustafa, Y.T., Negm, A.M. (eds.) *Environmental Degradation in Asia*. Earth and Environmental Sciences Library. Springer, Cham. https://doi.org/10.1007/978-3-031-12112-8_3
- Khalaf, A. and Hummadi, A., 2023. Time Series Analysis of Drought Indices for Monitoring Desertification and Land Degradation. *Iraqi National Journal of Earth Science (INJES)*, 23, 189–202. <https://doi.org/10.33899/earth.2023.139660.1068>
- Khwarahm, N. R., Najmaddin, P. M., Ararat, K. and Qader, S., 2021. Past and future prediction of land cover land use change based on earth observation data by the CA-Markov model: a case study from Duhok Governorate, Iraq. *Arabian Journal of Geosciences*, 14(15), 1544. <https://doi.org/10.1007/s12517-021-07984-6>
- King-Okumu, C., Tsegai, D., Sanogo, D., Kiprop, J., Cheboiwo, J., Sarr, M. S., Inacio da Cunha, M. and Salman, M., 2021. How can we stop the slow-burning systemic fuse of loss and damage due to land degradation and drought in Africa? Current Opinion in Environmental Sustainability, 50, 289–302. <https://doi.org/10.1016/j.cosust.2021.04.008>
- Li, H., Yang, X. and Zhang, K., 2021. Understanding global land degradation processes interacted with complex biophysics and socioeconomics from the perspective of the Normalized Difference Vegetation Index (1982–2015). *Global and Planetary Change*, 198, 103431. <https://doi.org/10.1016/j.gloplacha.2021.103431>
- Lorenz K, Lal R, Ehlers K. Soil organic carbon stock as an indicator for monitoring land and soil degradation in relation to United Nations' Sustainable Development Goals. *Land Degrad Dev.*, 2019; 30: 824–838. <https://doi.org/10.1002/ldr.3270>
- Loveland, T. R. and Irons, J. R., 2016. Landsat 8: The plans, the reality, and the legacy. *Remote Sensing of Environment*, 185, 1–6. <https://doi.org/10.1016/j.rse.2016.07.033>
- M Amen, A.R., Mustafa, A., Kareem, D.A., Hameed, H.M., Mirza, A.A., Szydlowski, M. and M. Saleem, B.K., 2023. Mapping of flood-prone areas utilizing GIS techniques and remote sensing: a case study of Duhok, Kurdistan Region of Iraq. *Remote Sensing*, 15(4), p.1102. <https://doi.org/10.3390/rs15041102>
- Mehri, A., Karimi, H., Mustafa, Y. T., Al-Quraishi, A. M. F. and Galalizadeh, S., 2024. Predicting Soil Erosion Using RUSLE Model in Duhok Governorate, Kurdistan Region of Iraq. In A. M. F. Al-Quraishi and Y. T. Mustafa (Eds.), *Natural Resources Deterioration in MENA Region: Land Degradation, Soil Erosion, and Desertification* (pp. 171–187). Springer International Publishing. https://doi.org/10.1007/978-3-031-58315-5_9
- Muneer, A. S., Sayl, K. N. and Kamal, A. H., 2021. Modeling of spatially distributed infiltration in the Iraqi Western Desert. *Applied Geomatics*, 13(3), pp. 467–479. <https://doi.org/10.1007/s12518-021-00363-6>
- Mustafa, A. and Szydlowski, M., 2020. The Impact of Spatiotemporal Changes in Land Development (1984–2019) on the Increase in the Runoff Coefficient in Erbil, Kurdistan Region of Iraq. *Remote Sensing*, 12(8). <https://doi.org/10.3390/rs12081302>
- Mustafa, Y. T., 2020. Multi-temporal Satellite Data for Land Use/Cover (LULC) Change Detection in Zakho, Kurdistan Region-Iraq. In A. M. F. Al-Quraishi and A. M. Negm (Eds.), *Environmental Remote Sensing and GIS in Iraq* (pp. 161–180). Springer International Publishing. https://doi.org/10.1007/978-3-030-21344-2_7
- Mzuri, R. T., Mustafa, Y. T. and Omar, A. A., 2022. Land degradation assessment using AHP and GIS-based modelling in Duhok District, Kurdistan Region, Iraq. *Geocarto International*, 37(25), 7908–7926. <https://doi.org/10.1080/10106049.2021.1987534>
- Naser, M. A. and Al-Tuwayyij, H. 2023. Evaluation of Solid Waste Management in Al- Samawah City. *E3S Web Conf.*, 427. <https://doi.org/10.1051/e3sconf/202342704001>
- Othman, A. A., Ali, S. S., Salar, S. G., Obaid, A. K., Al-Kakey, O. and Liesenberg, V., 2023. Insights for Estimating and Predicting Reservoir Sedimentation Using the RUSLE-SDR Approach: A Case of Darbandikhan Lake Basin, Iraq–Iran. *Remote Sensing*, 15(3). <https://doi.org/10.3390/rs15030697>
- Othman, A. A., Obaid, A. K., Sissakian, V. K., Maamar, A. F. A., and Shihab, A.T., 2022. RUSLE Model in the Northwest Part of the Zagros Mountain Belt. In A. M. F. Al-Quraishi, Y. T. Mustafa and A. M. Negm (Eds.), *Environmental Degradation in Asia: Land Degradation, Environmental Contamination, and Human Activities* (pp. 287–306). Springer International Publishing. https://doi.org/10.1007/978-3-031-12112-8_14
- Pablo Muñoz, Laurene Torterat, Mariano Gonzalez-Roglich (CI), Mario Negre, Rose MBA-Mebiame, Daniele Malerba and Jose Antonio Cuesta Leiva., 2019. *Land Degradation, Poverty and Inequality*. www.unccd.int/about-us/global-mechanism
- Pandit, R., Scholes, R., Montanarella, L., Brainich, A., Barger, N., ten Brink, B., Cantele, M., Erasmus, B., Fisher, J., Gardner, T. and Holland, T., 2018. Summary

- for policymakers of the assessment report on land degradation and restoration of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. https://files.ipbes.net/ipbes-web-prod-public-files/spm_3bi_ldr_digital.pdf
- Práválie, R., 2021. Exploring the multiple land degradation pathways across the planet. *Earth-Science Reviews*, 220, 103689. <https://doi.org/10.1016/j.earscirev.2021.103689>
- Rostam Hamadamin, R. and Omer, L. W., 2023. NDVI forest cover changes at high altitudes of the Sulaymaniyah Governorate of Kurdistan Region, northern Iraq, 1984–2021. *Geography*, 108(2), pp. 74–85. <https://doi.org/10.1080/00167487.2023.2217630>
- Sahar, A. A., Alhadithi, A. A., Hassan, M. A. and Jasim, A. A., 2021. Integrated remote sensing and GIS for developed new spectral index for estimating Sandy land and its potential hazards. Case study: north-east Al-Muthanna Province area, south of Iraq. *Arabian Journal of Geosciences*, 14(3), 191. <https://doi.org/10.1007/s12517-021-06490-z>
- Şarlak, N. and Mahmood Agha, O. M. A., 2018. Spatial and temporal variations of aridity indices in Iraq. *Theoretical and Applied Climatology*, 133(1), pp. 89–99. <https://doi.org/10.1007/s00704-017-2163-0>
- Sayl, K. N., Sulaiman, S. O., Kamel, A. H., Muhammad, N. S., Abdullah, J. and Al-Ansari, N., 2021. Minimizing the Impacts of Desertification in an Arid Region: A Case Study of the West Desert of Iraq. *Advances in Civil Engineering*, 2021(1), 5580286. <https://doi.org/10.1155/2021/5580286>
- Sharaa, H.M.J.Al, Obaidy, A.H.M.J.Al., and Ziboon, A.R.T., 2020. Assessment of Heavy Metal Contamination in the Soil of Al-Muthanna Storage Site using Geospatial techniques. *IOP Conference Series: Materials Science and Engineering*, 737(1), 012218. <https://doi.org/10.1088/1757-899X/737/1/012218>
- Shihab, T. H. and Al-hameedawi, A. N., 2020. Desertification Hazard Zonation in Central Iraq Using Multi-criteria Evaluation and GIS. *Journal of the Indian Society of Remote Sensing*, 48(3), 397–409. <https://doi.org/10.1007/s12524-019-01079-2>
- Stavi, I. and Lal, R., 2015. Achieving Zero Net Land Degradation: Challenges and opportunities. *Journal of Arid Environments*, 112, pp. 44–51. <https://doi.org/10.1016/j.jaridenv.2014.01.016>
- Sutton, P. C., Anderson, S. J., Costanza, R. and Kubiszewski, I., 2016. The ecological economics of land degradation: Impacts on ecosystem service values. *Ecological Economics*, 129, pp. 182–192. <https://doi.org/10.1016/j.ecolecon.2016.06.016>
- Tao, H., Hashim, B. M., Heddiam, S., Goliatt, L., Tan, M. L., Sa'adi, Z., Ahmadianfar, I., Falah, M. W., Halder, B. and Yaseen, Z. M., 2022. Megacities' environmental assessment for Iraq region using satellite image and geo-spatial tools. *Environmental Science and Pollution Research*, 30(11), pp. 30984–31034. <https://doi.org/10.1007/s11356-022-24153-8>
- Turner, K. G., Anderson, S., Gonzales-Chang, M., Costanza, R., Courville, S., Dalgaard, T., Dominati, E., Kubiszewski, I., Ogilvy, S., Porfirio, L., Ratna, N., Sandhu, H., Sutton, P. C., Svenning, J.-C., Turner, G. M., Varennes, Y.-D., Voinov, A. and Wratten, S., 2016. A review of methods, data, and models to assess changes in the value of ecosystem services from land degradation and restoration. *Ecological Modelling*, 319, pp. 190–207. <https://doi.org/10.1016/j.ecolmodel.2015.07.017>
- Waeli, A. M. T. Al, Al-Azawi, F. W. and Hamid, H. M., 2024. Evaluation of the sensitivity of Al-Husseiniya soils in Karbala to erosion using Landsat sensors. *Environmental Challenges*, 14, 100857. <https://doi.org/10.1016/j.envc.2024.100857>
- Younus, M. H. and Mohammed, R., 2024. Spectral Drought Indices: A Methodology for Detecting Basin-Wide Drought. *Ecohydrology and Hydrobiology*, 24(1), pp. 178–187. <https://doi.org/10.1016/j.ecohyd.2023.07.006>
- Zheng, W., Yang, Z., Wang, X., Wang, H., Yu, X., Wang, L.-P. and He, B., 2022. Impacts of evaporation and inundation on near-surface salinity at a coastal wetland park. *Marine Pollution Bulletin*, 185, 114373. <https://doi.org/10.1016/j.marpolbul.2022.114373>
- Ziadat, F. M., Zdruli, P., Christiansen, S., Caon, L., Monem, M. A. and Fetsi, T., 2021. An Overview of Land Degradation and Sustainable Land Management in the Near East and North Africa. *Sustainable Agriculture Research*, 11(1), 11. <https://doi.org/10.5539/sar.v11n1p11>
- Ziboon, A., Albayati, M. and Dalhel, F., 2022. Monitoring Soil Degradation in the Mesopotamian Plain Using GIS and Remote Sensing Techniques. *Engineering and Technology Journal*, 40(5), pp. 649–660. <https://doi.org/10.30684/etj.v40i5.2121>
- Zika, M. and Erb, K.-H., 2009. The global loss of net primary production resulting from human-induced soil degradation in drylands. *Ecological Economics*, 69(2), pp. 310–318. <https://doi.org/10.1016/j.ecolecon.2009.06.014>



نموذج لرسم خرائط المخاطر وإدارة الكوارث الناجمة عن تدهور الأراضي باستخدام

التقنيات الجغرافية المكانية في العراق: مراجعة

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الملخص

في هذه المقالة المراجعة، روجعت الأدبيات السابقة حول رسم خرائط ونمذجة مخاطر التدهور في السياق المكاني الزمني للعراق، الذي يقع في منطقة الشرق الأدنى وشمال إفريقيا، العراق معرض على نحو خاص لتدهور الأراضي، ويفقد آلاف الهكتارات من أراضيه. كان تدهور الأراضي محورا مهما للبحث الأكاديمي عالميا، ولا يزال يمثل قضية رئيسية في القرن الحادي والعشرين. صممت عملية المراجعة بدقة، وتم البحث مدى العقد الماضي (من 2015 إلى 2025)، باستخدام الكلمات الرئيسية ذات الصلة. لقد بحثنا في العديد من قواعد البيانات، بما في ذلك Elsevier و Springer و IEEE و MDPI و Taylor & Francis و Wiley. أسفر بحثنا عن 54 مقالة بحثية ذات صلة. خلصنا إلى وجود فجوة بحثية يجب معالجتها والتي هي: تطوير نموذج يأخذ في الاعتبار الجوانب المكانية الزمنية لتدهور الأراضي بما يتماشى مع التعريفات الموجودة في الأدبيات العالمية. بالإضافة إلى ذلك، لم تحظ محافظتنا ذي قار ونيوى باهتمام كبير من الباحثين، مما يجعلها مناطق غير مستكشفة إلى حد كبير في هذا السياق. لقد لاحظنا أيضا أن بيانات الاستشعار عن بعد الأكثر استخداما في الأدبيات جاءت من سلسلة أقمار لاندسات.

الكلمات المفتاحية:

تدهور الأراضي، جغرافي-مكاني، نمذجة المكان-الزمن، العراق.

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