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Geographical Assessment of Environmental Quality in Hasakah Province using Geography Information system (GIS) and Remote Sensing (RS) in SYRIA

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Abstract

This study aims to assess environmental quality in the Al-Hasakah Province of Syria using Geographic Information Systems (GIS) and remote sensing techniques. This assessment is conducted in the context of a growing interest in the impact of environmental factors on health and quality of life. The research revolves around analyzing the environmental effects of various sources, such as waste, oil pollution, and population density, to comprehend the environmental status and guide efforts toward protection and sustainable development. The study relies on geospatial information techniques for spatial analysis and satellite imagery to understand changes in the environmental landscape. The results provide a comprehensive overview of the environmental quality in the region, paving the way for policy direction and actions to preserve environmental health and enhance the well-being of the population.

The comprehensive results revealed that approximately 79% of the study area exhibits a state of low to very low environmental quality, while the high and moderate states contributed 2% and 19%, respectively. The integrated analysis of environmental quality in AL-Hasakeh Province enhances the protection of ecological environments and contributes to achieving sustainable development in the region, fostering improvements in the constructed environment.

Keywords: *Environment Quality, AL-Hasakah, GIS, RS.*

Introduction

The environmental ramifications of armed conflicts have been conspicuously overlooked in broader discussions surrounding military engagements. Particularly pertinent is the imperative to mitigate the impact of conflict-induced environmental degradation on civilian populations (1). The protracted conflict in Syria serves as a poignant example, wherein sustained shelling and widespread destruction have imparted enduring consequences on the ecological landscape, natural resource availability, economic rehabilitation, and, consequently, the sustenance of civilian livelihoods.

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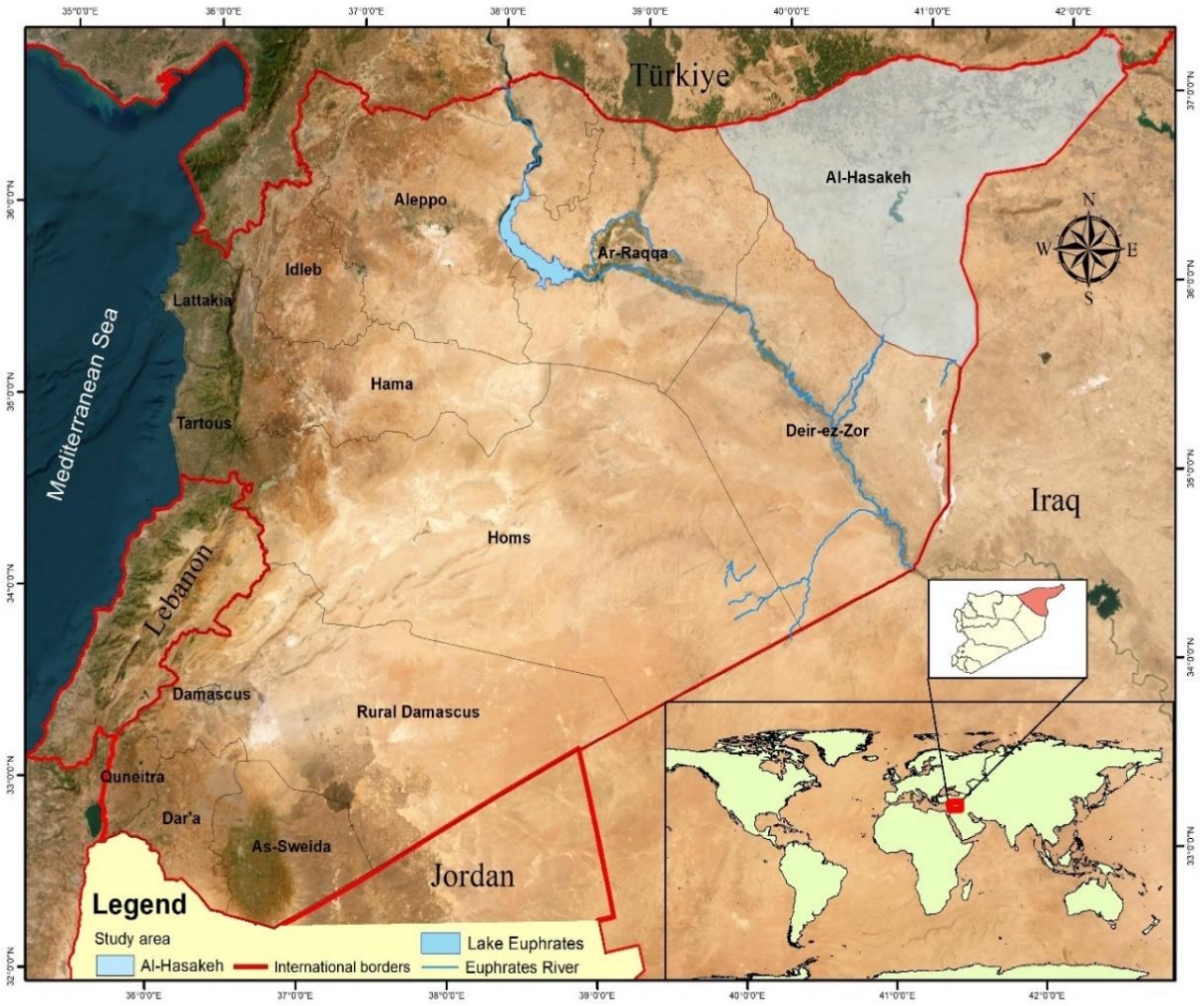
The aftermath of warfare often bequeaths toxic footprints, exerting profound and lasting implications on the health and well-being of individuals and their communities even after the cessation of hostilities. In an epoch characterized by precipitous environmental decline stemming from climate change, extensive urbanization, and the diminishing quality of natural resources, the state of the environment assumes escalating significance. This extends beyond considerations of public health to encompass pivotal socio-economic opportunities and strategies for fostering peace. Such considerations are crucial in forestalling potential conflicts arising from the competition over scarce resources.(2) Assessment of ecological and environmental quality have seen great attention in the last years. However, due to the complexity of the systemic, most of the previous studies emphasized on some particular parameters(3).

The GIS-based multicriteria evaluation was employed to assess environmental quality in AL-Duhok Province (4). The main objective of this research is to assess environmental quality in Al-Hasakah Province, with a focus on both natural and anthropogenic criteria, utilizing Geographic Information Systems (GIS) and a multi-factor analysis approach. Anthropogenic criteria encompass factors such as population density, solid waste production rates, oil extraction, and its byproducts. The state of the human environment was provided and delineated within the GIS environment, in addition to an analysis of natural environmental quality based on land coverage, land use, and average precipitation levels. Remote sensing was employed to enhance data collection through the provision of high-resolution satellite imagery. In the following case study, the methods employed will be described, results presented, discussions conducted, and necessary conclusions drawn.

Case study:

The current study focuses on Al-Hasakah Province, located in northeastern Syria, as illustrated in map (1.) The population of Al-Hasakah Province is approximately 422,000 people. The governorate is comprised of four regions: Al-Hasakah, Qamishli, Malikiya, and Ras al-Ain. The region's economy was traditionally reliant on agricultural products before the Syrian crisis, but it underwent substantial changes due to the crisis, climate variations, and a shift towards dependence on crude oil sales, natural gas production, and associated traditional refining industries.

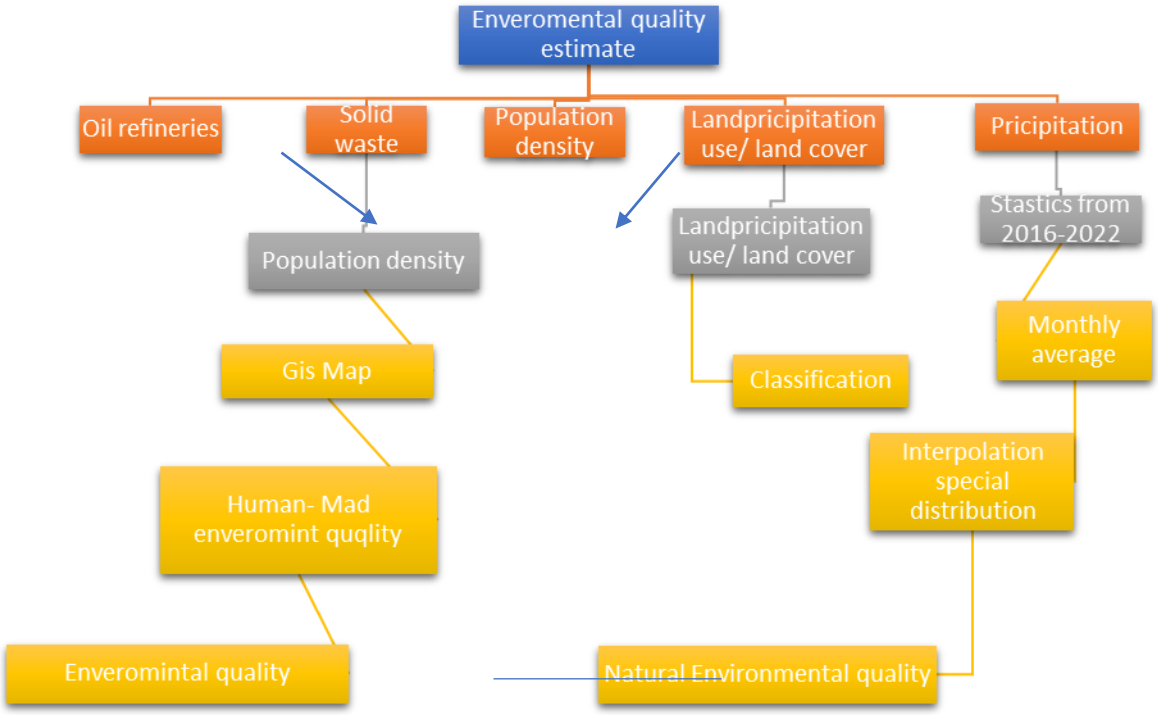
According to the Köppen-Geiger climate classification system, Al-Hasakah Province features a borderline semi-arid (BSh) and a Mediterranean (Csa) climate. Summers are extremely hot and dry, while winters are cold and wet. Rainfall occurs mainly during the cooler months, with the heaviest precipitation in late winter and early spring.



Map1 case study, AL-Hasakah Province

Method:

To identify the factors in this research, we initially conducted a review of similar studies to find aspects influencing the environmental condition. Based on data accessibility, population density, solid waste production, oil extraction methods, and their byproducts were considered as influencing factors. The overall methodology is depicted in the general chart as illustrated in Figure (1).



Population Density:

Population density (the number of individuals per square kilometer) is considered a vital factor influencing the environment. It is a measure of the number of people in a specific area. In this study, population density information was initially obtained for each sub-region. Subsequently, this information was transformed into a Geographic Information Systems (GIS) database. The areas were then calculated using ArcGIS software. By dividing the population figures by the area of each sub-region, the population density for each sub-region and the entire governorate was computed. The calculated population density is then classified into four categories, from Category 1 to Category 3, with increasing density indicating a decrease in environmental quality from Category 1 to Category 3. Refer to Figure (2).

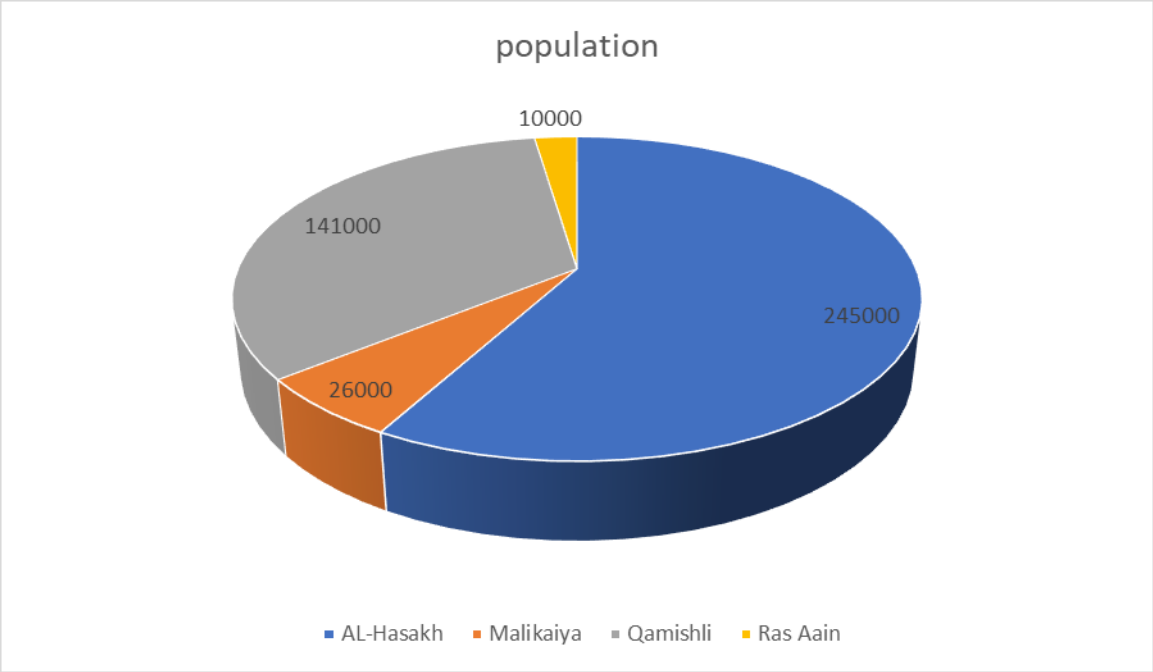


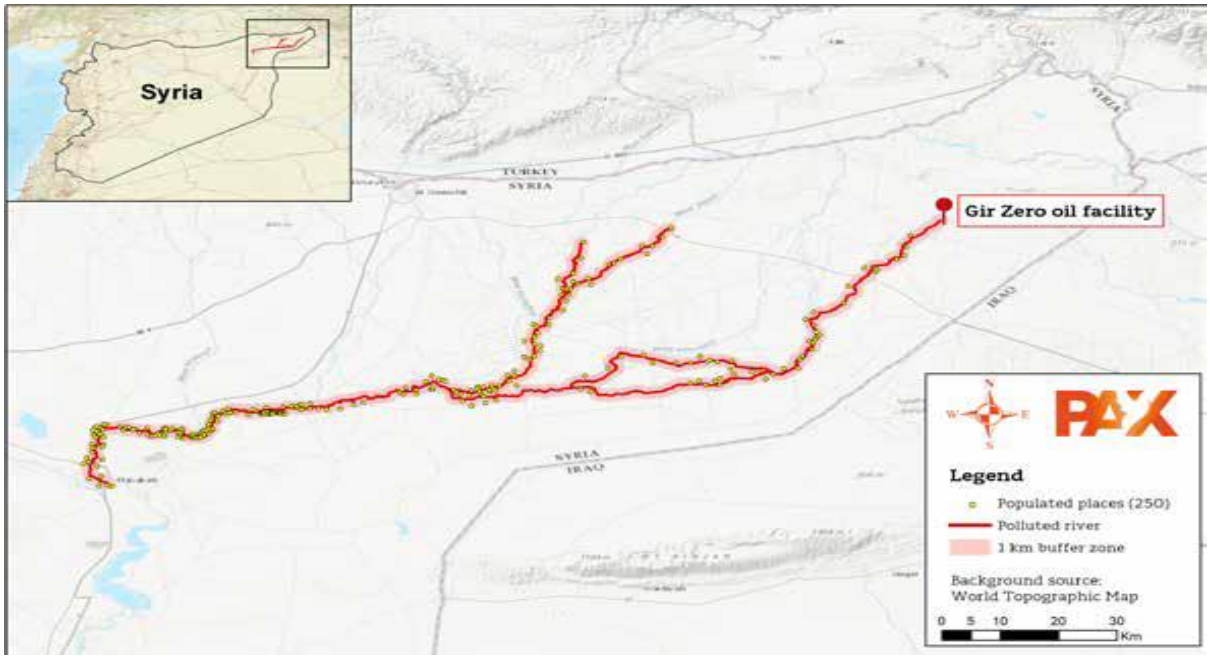
Figure .2: Number of populations in AL-Hasakah province (sources: 5)

Oil Industry (Crude Oil Refining and its Leaks):

Since the onset of the Syrian crisis, concerns about river pollution from oil waste have been a recurrent issue in humanitarian response planning. For instance, in 2014, an assessment of needs by ACAPS, based on open-source reports, highlighted concerns about river pollution from waste and oil.

A portion of crude oil has been refined using traditional methods, resulting in low-quality gasoline and diesel. Hazardous oil streams, such as those in the Kar Zero region, have formed, transforming the course of the Ramila River (approximately 160 km long) into a conduit for liquid oil waste. Seasonal floods further spread the oil to agricultural areas along the riverbanks, where more than 250 small towns and villages are located, according to the United Nations Office for the Coordination of Humanitarian Affairs and land monitoring via satellite imagery.

Due to traditional methods and a lack of safety measures, these practices pose high explosion risks and are expected to lead to severe soil and water contamination.



Map. 2: Polluted oil in AL-Hasakah Province (sources: 6)

The oil industries (random oil refining and its leaks) constitute major sources of environmental pollution in Al-Hasakah Province. Areas with high concentrations of oil refining industrial units face a higher level of environmental pollution. The number and locations of oil industry units in Al-Hasakah Province were obtained from the Oil and Energy Resources Department of the Autonomous Administration in the study area, as illustrated in Figure (3). These locations were then transferred to ArcGIS software, and the number of refining industries in each sub-region was calculated. The number of industries was then classified into three categories, where Category 1 represents the lowest density and damage, and Category 3 represents the highest density and damage. From Category 1 to Category 3, the likelihood of environmental pollution increases, and the quality decreases.

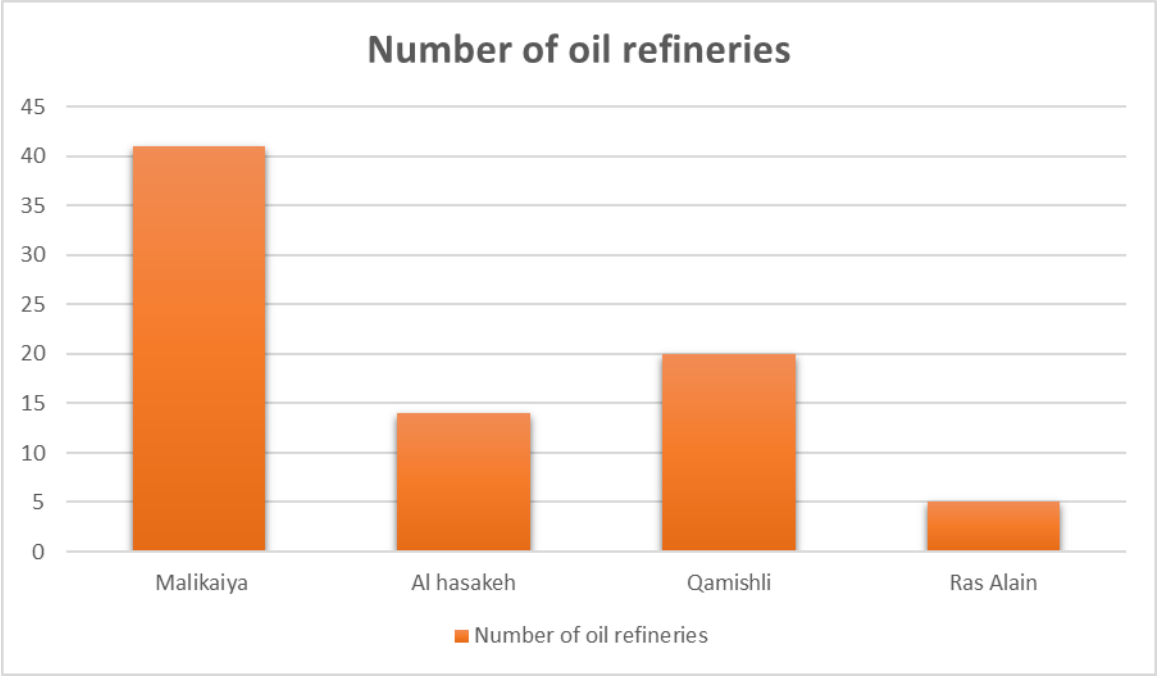


Figure. 3: Number of oil refineries in AL-Hasakah Province (sources: 7)

Solid Waste:

The accumulation of solid waste can cause significant health problems and an unfavorable living environment if a safe and appropriate management plan is not implemented. Unfortunately, solid waste is not effectively dealt with in Al-Hasakah Province as it should be. To calculate solid waste in the Province and administrative regions, the daily waste generation rate per person was obtained from the municipalities of the governorate. The rate ranges from approximately 0.65 to 1.26 kg per person per day. The waste generation rate was then multiplied by the population, as shown in Table 1, and the generated solid waste was calculated for each region.

Table 1 RATE OF SOLID WASTE GENERATION IN AL-HASAKEH PROVINCE (SOURCE: 8)

District	Rate of waste generation(person per kg daily)
Al-Hasakah	0.88
Qamishli	1
Malikiyah	1.26
Ras -Alain	0.65

Comprehensive Analysis:

The factors identified manually represent human-induced industrial factors, including population density, solid waste generation, and the locations of oil industries and their leaks. As mentioned, these factors were calculated for the maps of the entire governorate as well as for small units in each province using ArcGIS software. They were aggregated to determine the quality of the human environment. Given the prevalence of traditional oil refineries, which discharge their waste into some rivers, causing environmental pollution, as previously mentioned, the coefficient for liquid industrial waste was allocated, as shown in Table (2).

The human environment map comprises four levels, as illustrated in [figure], where the high level represents high quality (better), the medium level, and the low level represents low quality (poor), while the fourth level represents very low quality (worst).

Table 2 WEIGHT OF THE CRITERIA

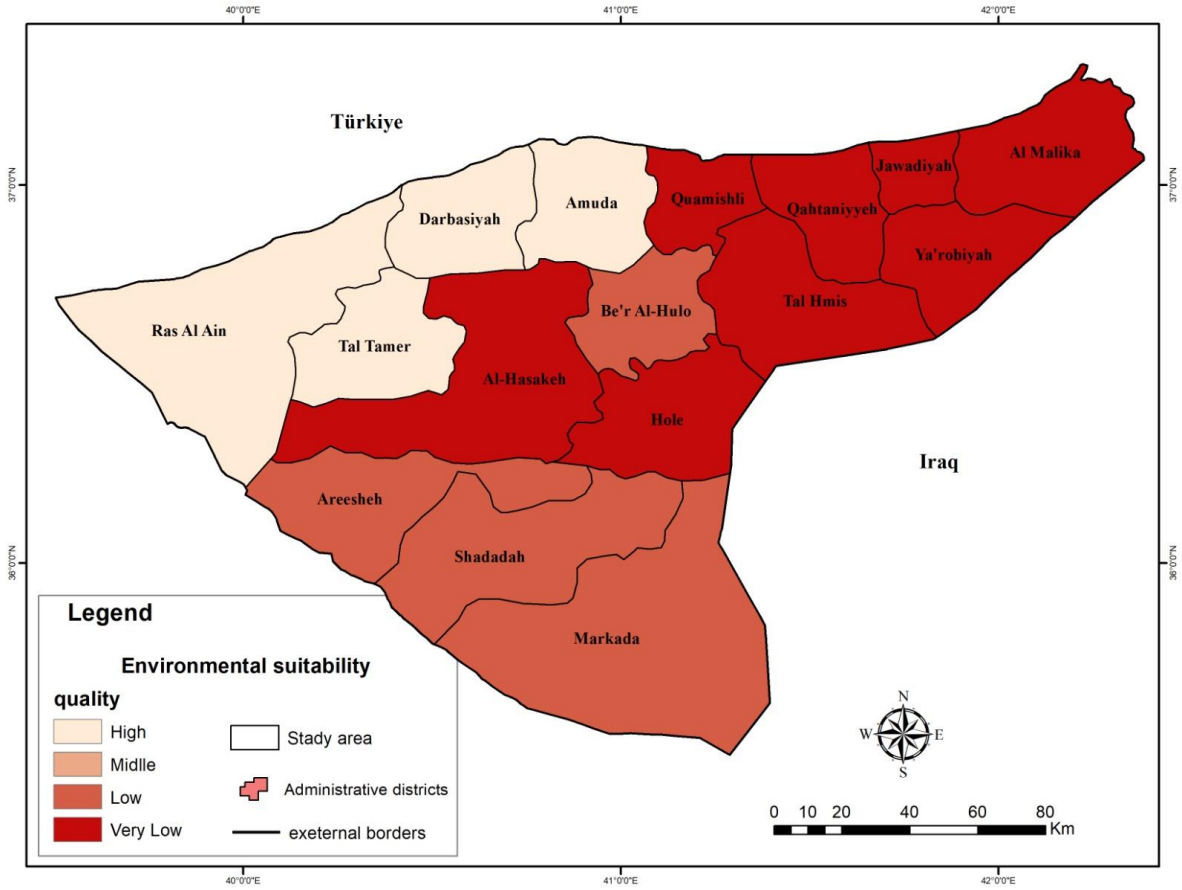
Human Factors	Wight(important)
Liquid oil waste	0.5
Pollution density	0.25
Solid waste	0.25

Results:

Human-made environmental quality was achieved through the analysis of population density, liquid waste density from oil refining, and solid waste generation. Maps of the factors were created and aggregated to display the final map (Figure 2) of human environment quality in the governorate and as small units for each region. The map was classified into four groups: high quality (good), medium, low quality (poor), and very low quality (worst), as shown in Table 3 and Map 2. The percentage for each category is displayed. Overall, approximately 79% are low to very low and unsuitable for living, while around 2% and 19% are high and medium, respectively.

TABLE 3 Percentage and area of quality class

Class (quality)	Area(percent)	Area(KM^2)
High	2	466
Middle	19	4427
Low	49	11417
Very low	30	6990
Sum	100	23300



MAP 3Human-made quality of the environment in AL-Hasakeh province

Discussion and conclusion:

Through data analysis, the climate in the Al-Malikiyah region was found to be the worst compared to other study areas. This can be attributed to the high density of random oil refineries, which discharge their waste, especially liquids, into the land and valleys, causing soil, water, and air pollution. The population in this region is also concentrated. In contrast, other regions are relatively better, with Qamishli ranking second and third, and Al-Hasakah ranking fourth in terms of pollution and unsuitability for living. Generally, southern and western regions are relatively better than the northern and eastern regions in the study area.

The overall results indicate that most areas suffer from environmental problems. Nevertheless, pollution from other areas in the province and cities contributes negatively to environmental pollution and the decline in the quality of life. It can be concluded that

the province faces environmental issues, particularly from a natural perspective due to improper human use. Inability to properly handle solid waste is evident, with a large number of random and traditional refineries and the inability to control and dispose of liquid waste, damaging agricultural lands and depleting natural resources in the study area. This makes the situation critical, requiring urgent and close treatment of waste and reducing emissions into nature.

This research has demonstrated the capability of geographic information systems (GIS) for spatial analysis and remote sensing compared to traditional methods. Using the province as a case study can reveal the current state of regional environmental quality and efficiently address regional problems. This study is a step toward future work to determine environmental quality assessment. It also provides a framework for adding new criteria, such as natural risks and hazards, soil erosion, as well as describing environmental pollution and quality.

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