Desertification categorisation based on spatial analysis and remote sensing technology

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Abstract. This paper illustrates techniques based on multi-criteria evaluation for categorising desertification in the north-west of Iraq. Desertification is recognised as not only one of the major dilemma threatening human communities but also reduces productivity such that the whole economy is affected. The aim of this paper is to produce a desertification map for the study area that identifies risk zones through modelling and mapping by using Analytical Hierarchy Process (AHP), which is one of the Multiple Criteria Decision Making, based GIS for the selection process. In order to produce a desertification categorisation for the study area, numbers of criteria were identified depending on the questionnaires provided by experts. The produced desertification hazard map shown in figure 3 indicates that 3.98% of the area is under very high sensitivity to desertification. The remaining area under high sensitivity is 7.25% and moderate sensitivity is 25.97%. The most hazardous areas are found in the middle and south parts of the study area. This paper including its methodology can be extrapolated to different desertification problems.

Keywords:
Desertification, spatial analysis, remote sensing.

1. Introduction
Changes in climate and human activity have led to increased surface temperature, reduced precipitation and have increased the risk of desertification in the research area. The data used included landscapes and meteorological data. The main objective of this work was to identify the areas most exposed to desertification in Iraq and to quantify the contributing factors to desertification. Desert areas are mapped by field surveys, remote sensing data, questionnaires and various maps. Numbers of criteria based on literature reviews and experts’ opinions that played a role in the desertification are selected. To this end, we have adapted the AHP calculation for the desertification hazard mapping, which is generally utilized for different mapping procedures.

The desertification is a genuine ecological issue with consequences on soil and organic efficiency [1]. This is as yet a significant ecological issue in the 21st century [2]. The Desertification problem distinguished desertification as "degradation in dry, semi-dry, and low-lying regions brought about by environmental change and human action" [1, 3, and 4]. Thus, the effect of desertification was inspected, considering the level of defincelessness or reaction of the environment. These zones are liable to anthropogenic dry spell and weights related to overgrazing and wrong utilization of the rural land. In the course of the last couple of decades, a broad decrease in plant spread has been distinguished as one of the primary purposes behind
GIS/AHP analysis was used to create a decision hierarchy. It is also called decision modelling and it simply consists of a hierarchy to analyse the decision on desertification mapping. Areas of investigation are located in the north-west of Iraq as shown in ‘figure 1’. This study helps to identify the areas of risk of desertification, which is an important task before prevention and control measures. The desertification card, which presents the level of danger of this phenomenon, was conducted using a multi-critical assessment method that uses geographic information systems. It is expected to serve as a guide for the planners to take steps to reduce the land degradation in the area.

The specific objectives are:

- Produce land use land cover map through elect pixel-based classification method.
- Prepare the form for the importance of individual topographic attributes for desertification based on the ratio value by experts.
- Weight of each factor was determined with the contribution of Analytical Hierarchy Process (AHP).

1.1 Study Area

The study area is located between 44°- 46° longitudes and 32° - 34° 30' latitudes ‘figure 1’. It covers a large part (30,545.249 km²) of Iraq including Diyala, Baghdad, Wasit, Al Anbar, Karbala, and Babylon provinces. The geography of Iraq is diverse and falls into five main regions: the desert.

2. Methods and materials

2.1. Questioners

The goals of Questionnaire were as follows:

- Specifying factors/criteria, which are appropriate and adequate for evaluation study in desertification Iraq. Fifteen experts were reviewed. There are two answers: 'yes' and 'no'. When answered ‘yes’ the expert would complete the second part of the questionnaire. Otherwise, he or she would suggest other criteria and give reasons and any other information he or she thought was relevant.
- The experts records his or her opinion about the relative importance of the given factors or criteria regarding the risk of desertification. Experts give relative importance on each scale for each factor compared with the other twenty-five experts surveyed as shown in table 1.

### Table 1. Information about the experts.

| Country      | Turkey | Iraq | UK | Germany | Australia | \(\Sigma\) Experts |
|--------------|--------|------|----|---------|-----------|-------------------|
| Geomatic     | -      | 6    | -  | -       | -         | 6                 |
| Environment  | 2      | 3    | 1  | -       | 2         | 8                 |
| Hydrology    | -      | -    | -  | 5       | 1         | 6                 |
| Geology      | 1      | 1    | 1  | -       | 2         | 5                 |
| \(\Sigma\)Experts | 3     | 10   | 2  | 5       | 5         | 25                |
2.2. Data collection
To make the search include specific locations, a lot of spatial information will be needed. In this vein, there were three types of information collected as follow:

- Office information was received by different Iraqi Ministries.
- Field data were collected directly from fieldwork.
- The survey of experts came through the identification of questionnaires.

The information gathered through fieldwork can be reused using various tools such as GPS. Regardless the field visits to the area of interest, which are often the most useful and accurate data since their compilation using new techniques, as well as data collection using questionnaires were very useful for calculating weights (percentages of importance). However, they can be dissected using measurable methods. LANDSAT OLI image, Modis and SAR Sentinel 1and 2 were used in this paper. Software used as follows:

- Arc GIS 10.4 software.
- Super decisions software.
2.3. **Criteria**

The decision-making criteria are the indicators used to assess the potential of the target. Each option will be assessed against these criteria in order to understand how well they fit the purpose of the task. Selection of criteria was controlled by reviewing literature with a survey of expert’s survey on identification of desertification hazard zoning.

The total indicators for desertification hazard mapping were climate, geology, vegetation, agriculture, social and economic issues, urban and industrial development (technology) in addition to the spatial factors, based on literature and questionnaire provided by experts, were as follow: [11-17].

- Aspect.
- Rainfall.
- Slope.
- Land Cover and Land use.
- Temperature.
- Wind Speed.

2.4. **GIS based AHP**

A weighted linear combination is an analytical approach that may be used whilst handling multi-characteristic selection making or whilst a couple of characteristics need to be considered. Each criterion is assigned a weight based totally on its significance. The effects are multi-characteristic spatial capabilities with very last rankings. A land suitability evaluation is an instance of a technique the usage of a weighted linear combination. Analytical Hierarchy Process presented by Saaty in 1977, is a very well-known tool for calculating the weighting factors required using a matrix in which all recognized important criteria are opposed to each other and reproducible preference elements. All the criteria/factors that are considered important in terms of choice are considered one by one in the pairing comparison matrix, which is the measure to express the relative slope between the factors. Consequently, the numerical characteristics that declare the relative importance of one component to another should be directed to each factor. Since it is known from the mental examination that an individual cannot simultaneously analyse more than 7 ± 2 components, Saaty initiated a correlation scale consisting of properties that operate from 1 to 9 depicting significance forces.

Thus, when determining the matrix equation \( MW = L_{\text{max}}W \), it can have the M matrix in this way. Saaty gave a consistency proportional to Consistency Ratio (CR), which is a lone numeric file to test the combination of rough test network consistency. In this way, it is described that the consistency Index (CI) ratio of the consistency record is normal in the Random Index (RI) list [18].

\[
\text{CR} = \frac{\text{CI}}{\text{RI}} <= 0.1 \quad (1)
\]

RI values according to
The consistency index CI can be easily understood from the matrix with

\[
\text{CI} = \frac{(L_{\text{max}} - n)}{(n - 1)} \quad (2)
\]

Where
Lmax is the greatest value of the preferential matrix n is the matrix sequence. Given Master's information and experience propose a modification of the preference matrix if the consistency ratio CR is greater than 0.1 See figure 2.
3. Results and discussion

3.1. Desertification Hazard Zonation

The produced desertification hazard map shown in ‘figure 3’ indicates that 3.98% of the area is under very high sensitivity to desertification. The area under high sensitivity is 7.25% and moderate sensitivity is 25.97% of the total area. The most hazardous areas are found in the middle and south parts of the study area. In general, the map shows that the northern part of area is less sensitive to desertification. Since the experts have given high weights to rainfall, aspect and LULC indicators as had shown in ‘figure 2’. The AHP examines a hard and fast assessment standards and opportunity alternatives that must be the fine choice. It is crucial to observe that a number of the standards can be contradictory; however, it isn't always normal that the exceptional answer is to optimize every character criterion in place of accomplishing the maximum suitable compromise the various unique standards. AHP assigns a weight to every assessment criterion by using the evaluation of the standards for choice making. The better the burden, the greater crucial the applicable criterion is.
Then, for a specific criterion, the AHP allocates every score alternative in line with the assessment among the selection-making pairs on this criterion. The better the rating, the higher the capability to satisfy the criterion. Finally, the AHP combines criterion standards and choice rankings, as a consequence defining international ratings for every choice and score. The international fee of an alternative is the weighted cost of the consequences received for all standards.

The AHP is a completely flexible and effective process because the signs and consequently the very last rating are derived from the relative assessment of the standards and competencies supported by means of the consumer. The calculations made with the aid of the AHP are continually primarily based at the choice of the decision-makers, so AHP may be visible as a device capable to change the choice makers (each qualitative and quantitative) options right into a multi-standards continuum. In addition, the AHP is suitable due to the fact there is no need to construct a complicated professional device that consists of the know-how of decision makers.

On the opposite hand, the AHP person may additionally want a massive variety of opinions, especially concerning issues associated with many standards and alternatives. Although every assessment is quite simple as it most effective calls for the decision maker to mention how alternatives or comparable standards, the workload of the evaluation undertaking can be unreasonable.

Figure 3. Desertification hazard zonation map produced by AHP method.
4. Conclusions
The consequences of paper imply that the AHP is honestly beneficial to provide superior options in controlling and identifying desertification and additionally in reclaiming degraded lands. By making use of the effects of the prevailing observations, local governments in the vicinity of the barren region are capable of allotting budget to control desertification.

GIS and Weighted Linear Combination WLC as evaluation gear are precious gear that can aid the investors to discover a greater threat for desertification in order to put a long-term plan to counter it. The GIS evaluation calls for amassing facts from distinct sources with distinctive codecs to create a whole uniform database. Thus, the GIS records ought to be up to date often so that it will mirror the cutting-edge state of affairs of a place under study. Remote sensing records help to have up to date records of the area.

Also, it may assist the analysers to display the investigated region the usage of exclusive types of satellite imagery to examine the desertification expansion as an example.

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