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Using Remote Sensing and GIS to Study Morphological Analysis of Kirkuk Province

Anas A. Mohammed, Ali K.Resen*, Amen A. Mohammed
Ministry of Science and Technology, Baghdad, Iraq

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Abstract

Remote sensing is a source of up-to-date information. The present study relied on various approaches for gathering information, including descriptive, quantitative and quantitative analytical processes. Particularly, we conducted the analysis of the satellite data ETM + of the satellite Landsat7 and the digital models of Digital Elevation Model of SRTM using ArcGIS9.2. The model depends on primary mathematical equations and constitutes an essential base for GIS applications that rely on data, computer, and software, performing the processes of data entry, analysis and processing. This paper deals with the geomorphological characteristics of a selected study area in Kirkuk province. The characteristics of the water network were determined in terms of direction and the pattern of the water basin using the automated process based on the employment of the applications of the GIS. The study revealed that remote sensing is one of the beneficial techniques for monitoring the changes, geomorphological phenomena, and shapes of the earth's surface, as well as determining their dimensions and slopes through a set of analytical maps by geographic information systems for the study area.

Keywords: Remote Sensing, DEM, morphological**,** Iraq

توظيف وسائل الاستشعار عن بعد في دراسة التحليل المورفولوجي لمحافظة كركوك

أنس عبد الرزاق محمد، علي كاظم رسن*، امين عبد الرزاق محمد
وزارة العلوم والتكنولوجيا، بغداد، العراق

الخلاصة

ان الاستشعار عن بعد يعد مصدر للمعلومات الحديثة، اعتمدت الدراسة على عدة مناهج وطرق لجمع المعلومات مثل المنهج الوصفي والكمي والمنهج التحليلي الكمي والمتمثل في تحليل بيانات الصور الفضائية +ETM العائد للقمر الصناعي Landsat7 ونماذج الارتفاعات الرقمية DEM العائد للقمر الصناعي SRTM باستخدام برنامج ArcGIS9.2 التي تعتمد على المعادلات الرياضية الاساسية حيث تشكل قاعدة مهمة للتطبيقات في نظام المعلومات الجغرافية والتي تعتمد على البيانات،الحاسب الالي والبرامج وتشمل عملية ادخال وتحليل ومعالجة البيانات. يتناول هذا البحث دراسة الخصائص الجيومورفولوجية لمنطقة الدراسة وتحديد خصائص الشبكة المائية من حيث الاتجاه ونمط الحوض المائي ياستخدام المنهج الالي القائم على اساس توظيف البرامج التطبيقية المرافقة لنظم المعلومات الجغرافية.

تم تحليل المعلومات ورسمت في أشكال واوضحت الدراسة ان الاستشعار عن بعد من احسن التقنيات الحديثة لرصد التغيرات ومعرفة الظواهر الجيومورفولوجية واشكال سطح الارض وتحديد ابعادها وانحداراتها وذلك من خلال عمل مجموعة خرائط تحليلية باستخدام نظم المعلومات الجغرافية لمنطقة الدراسة.

*Email: alialbadry80@gmail.com

Introduction

Remote sensing and geographic information systems (GIS) are being increasingly used in the planning and strategic management of earth resources. Remote sensing is one of the several powerful present techniques for monitoring morphological changes, geomorphological patterns, and geomorphological phenomena, along with determining their dimensions and gradations through the work of geomorphological maps employing geographic information systems [1,2]. This can be expressed in rock formation maps, morphology forms, morphometric data (elevations and slopes), water networks and patterns of drainage. The technology is characterized by the stability of the aspect in the research area.

Satellite images are a broad reference of data which allows to acquisition of sequential data; contributes as a store of precise and authentic information. There is an increasing interest in data about land use/cover and the fundamental topographic and morphological parameters obtained from digital elevation models (DEM) in numerous practices of planning and management of water resources. GIS permits to extract information of topographic and morphological parameters from DEMs [3, 4]. The coordination between DEM with GIS demonstrated profitable outcomes in the morphological and hydrological analyses of numerous regions. DEMs have been usually embraced for morphometric analysis of river basins through the extraction of topographic parameters and stream systems. The important necessity of any DEM is that it should have the ideal precision and goals along with the absence of information voids [5]. In spite of that, in the last decade, additional progresses of DEMs worldwide with better definition of goals have allowed these tools to be more open and similar to Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) and the Shuttle Radar Topography Mission (SRTM) technologies. Accessible DEM datasets procuring stereo-images from various satellites (for example QuickBird, Landsat 7 ETM+, IKONOS, ASTER sensors, SPOT, Cartosat 1, etc.) have additionally been adopted to make DEMs utilizing a few software applications for investigating scenes [6, 7]. DEMs have been utilized in an assortment of studies where terrain and drainage variables play prominent roles, due to their extended applicability and facility of use [8].

Study Area

The geographical location of the province of Kirkuk is very important because it serves as the bridge connecting the northern governorates of Iraq to those of the center and south. It also occupies a transitional area between the mountainous region and the sedimentary plain. Thus, its surface is characterized by a variety of terrain between hills, plateaus and plains. The research area is shown in Figure-1, covering an area of approximately 9700 square kilometres, with a height of 350 to 200 meters above sea level.

Figure 1-Iraq map showing the study area.

Data Collection
1. Landsat satellite image, sensor ETM + and spatial accuracy of 30 meters,
2. DEM with spatial accuracy of 30 meters (Table-1);

Table 1-Specifications of the data used in the study

System	Landsat	SRTM
Sensor	(Enhanced Thematic Mapper Plus)	(digital elevation model)
Acquisition	2011	2014
Path/row	169/35	35° 466667' "N 44° 4' E
Revisit time	16 days	35° 28' 0" N 44° 24' 0" E

Methodology

The study aims to circumscribe the topographic, morphological and hydrological characteristics of the study area, which was accomplished by the employment of DEM with high accuracy. The ground elements were then automatically classified based on the topographical map information after it was converted from a paper map to a digital map through the recruitment of GIS applications.

The role of the DEM in a geomorphological analysis, especially in the detailed studies of small and large areas, is one of the most significant methods applied by geomorphologists to ascertain the physiological properties, due to the high accuracy of this model. In this respect, the study area is one of the regions lacking such a geomorphological treatment.

The geomorphological characteristics of the study area were determined by employing the digital elevation model, based on the topographical map and particularly the digital elevation points.

The process of production and mapping went through several stages, as follows:
1. Data encoding and input, which are either in the form of maps, tables, satellite images, or other data.
2. Processing, managing, retrieving and analyzing data which is then converted into information. This stage also includes converting the data from vector to Raster bitmap and vice versa.
3- Representing and displaying data in the form of maps and tables.

The slope characteristics, degrees of shadows, and hydrological features (water network) were determined. In this research, a series of programs were used for the purpose of displaying, storing and processing of remote sensing digital data and satellite images, which were then used in geomorphological studies and applied to the map. These programs include ArcGIS V9.2 and a set of Arc Map, Catalog, and Arc Scene for creating contour and terrain maps, derivation of drainage systems and others.

Results and Discussion

Regarding the results of the digital analysis of the DEM, the information on the geomorphological as well as hydrogeological characteristics are discussed as follows.

First, earth surface analysis using arc scene. In this type of application, all types of maps related to the characteristics of the study area can be derived by activating the applications of the surface spatial analyst (3D) such as the contour, slope, aspect, and shade maps.

The importance of each of these maps and a highlight of their role in the geomorphological analysis is illustrated as follows:
1. The solid map of the study area which wasderived from the DEM is represented in Figure-2.

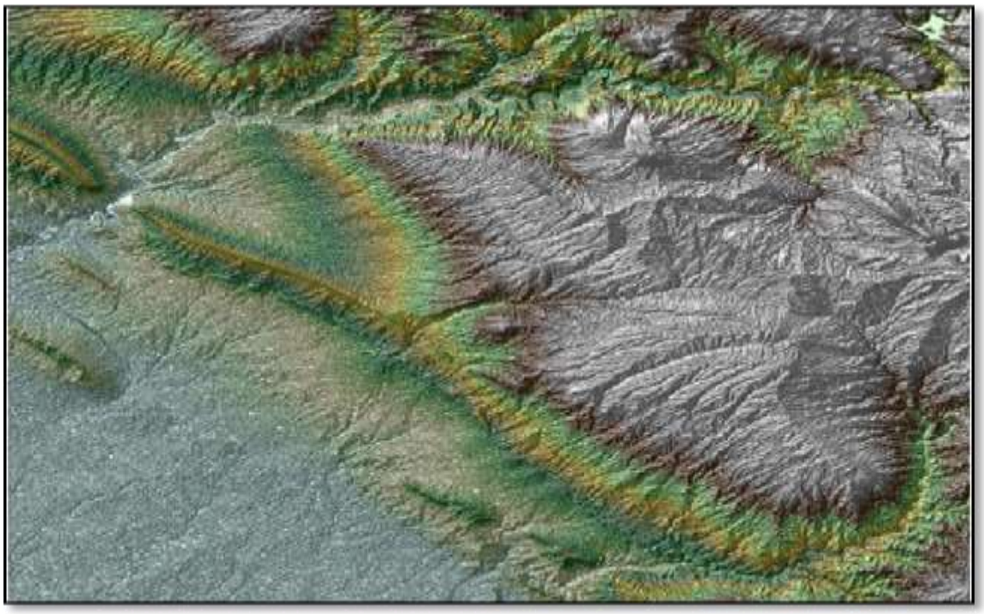

Figure 2-Solid map of the study area.

2. The contour map was produced based on Arc GIS 9.2 and spatial analyst surface (50 m). The contour map was the basis for reliable geomorphology (Figure-3).

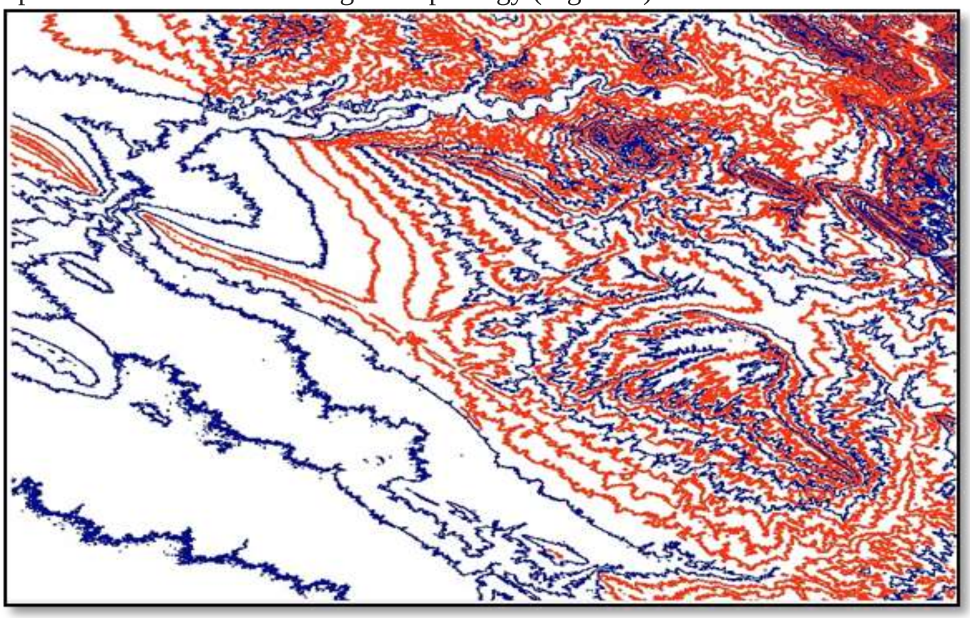

Figure 3-Contour map of the study area.

3. Due to the irregularities of the study area, which is described as flat areas with moderate slope and very steep areas, slopes were classified by degrees; flat and semi-plane areas (slope: 0-4.5), low slope areas (slope: 4-11), moderately steep areas (slope:11-19), very steep areas (slope: 20-36), extremely steep areas (slope: 36-74).

According to the DEM, the slope was calculated for each cell of the study logic, where the total maximum change rate between each cell and the adjacent cell was calculated. This type of matrix identifies the most sloping regions and the lowest areas. Steepest and flattest areas were represented by degree format, as shown in Figure-4.

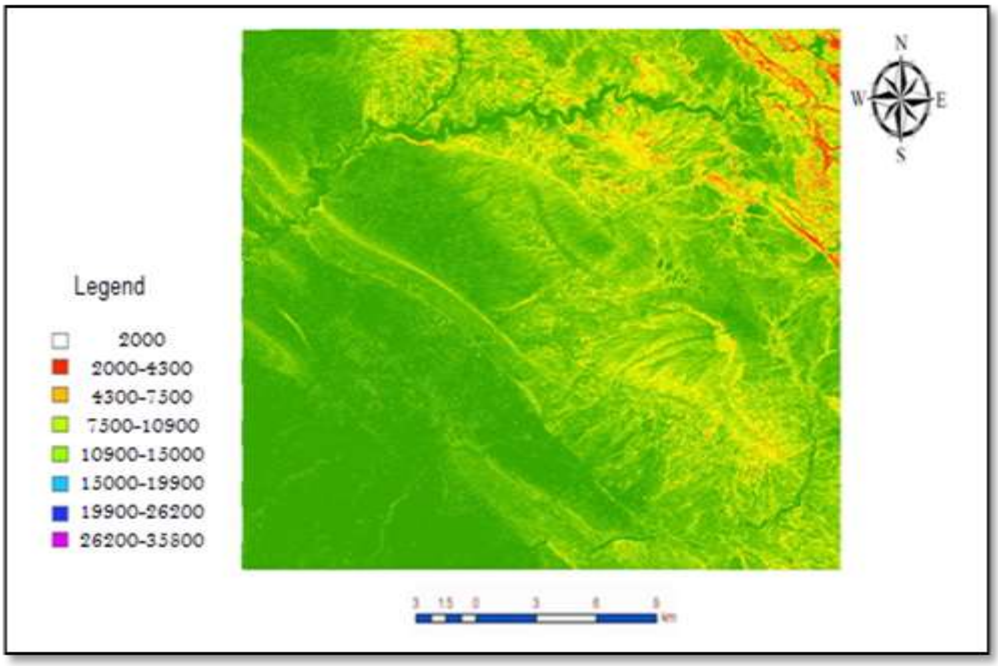

Figure 4-Slope map for the study area.

4. The Hill shade map was assembled to distinguish the cells located directly under the sun, from which it is possible to calculate the number of hours of solar brightness. Then it is possible to recognize the areas in the shade and, hence, the land uses, especially the patterns of agricultural crops, after defining their requirements for moisture and light (Figure-5).

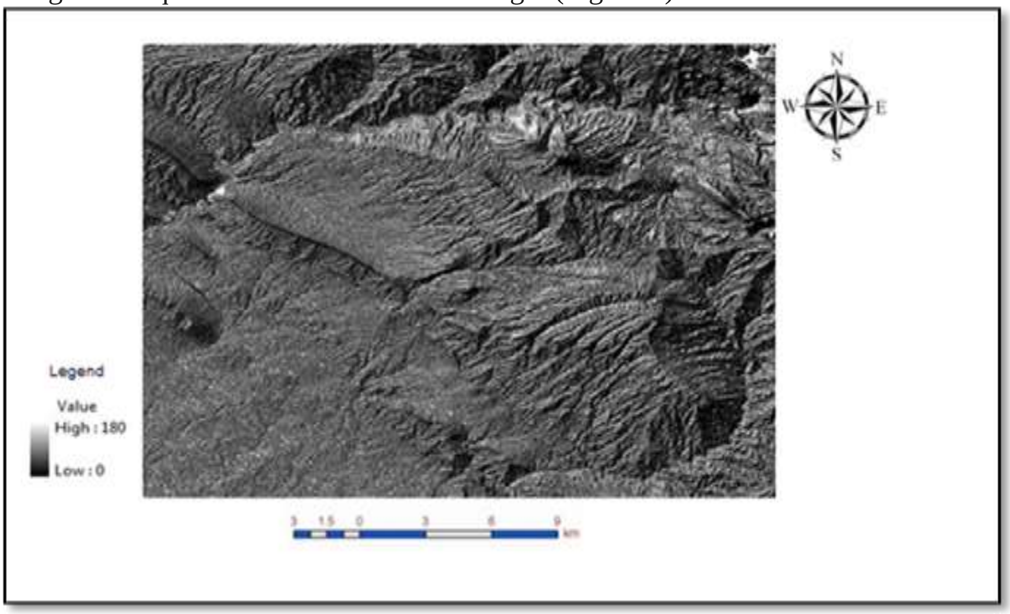

Figure 5-Hill shade map for the study area.

5. **The a**spect map described the direction of the aspect; it indicates that the aspect is north, south, northwest, or southwest. Consequently, the appearance leads to the steepest area of the aspect in a particular location and the direction of the aspect involves the sides of the hill or the mountain.
The direction of the aspect is determined clockwise and in degrees. It starts from the north at 0 degrees and ends again in the north to complete a 360-degree cycle for each pixel cell in the raster. A particular aspect provides the appearance which helps predict and reduce the risk of landslides, and also helps to identify low- aspect areas in many projects (Figure-6).

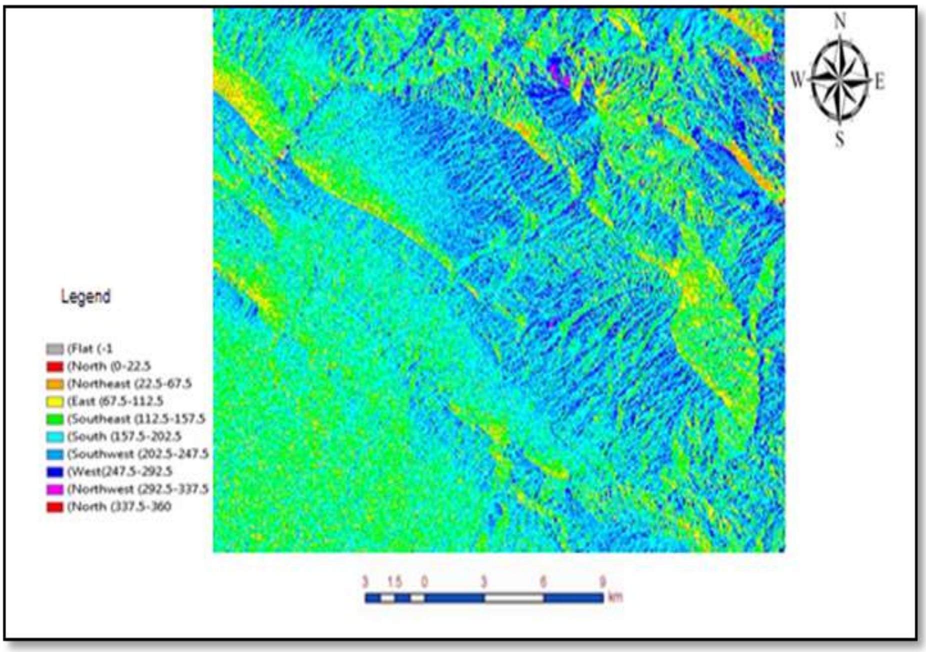

Figure 6-Aspect map of the study area

Since the shape of the earth determines the movement of water on the surface, it is possible to use the DEM data to determine the boundaries of the ponds and the conclusion of river networks and the waterways of the valleys, as well as to extract other hydrological characteristics within the sump. The initial phase of the program was prepared by using fill sinks command, which is used to reset the values of all the holes and irregular precipitations that the program will find. This allows the water to flow over the heights from one cell to another within the model in such a way that all cells can discharge their water to other cells in a fluid way in line with the topography of the earth. The failure to perform this process will lead the program to search for the next place to drain the water within the same cell. Then, the direction flow command is used to obtain the flow current (Figure-7).

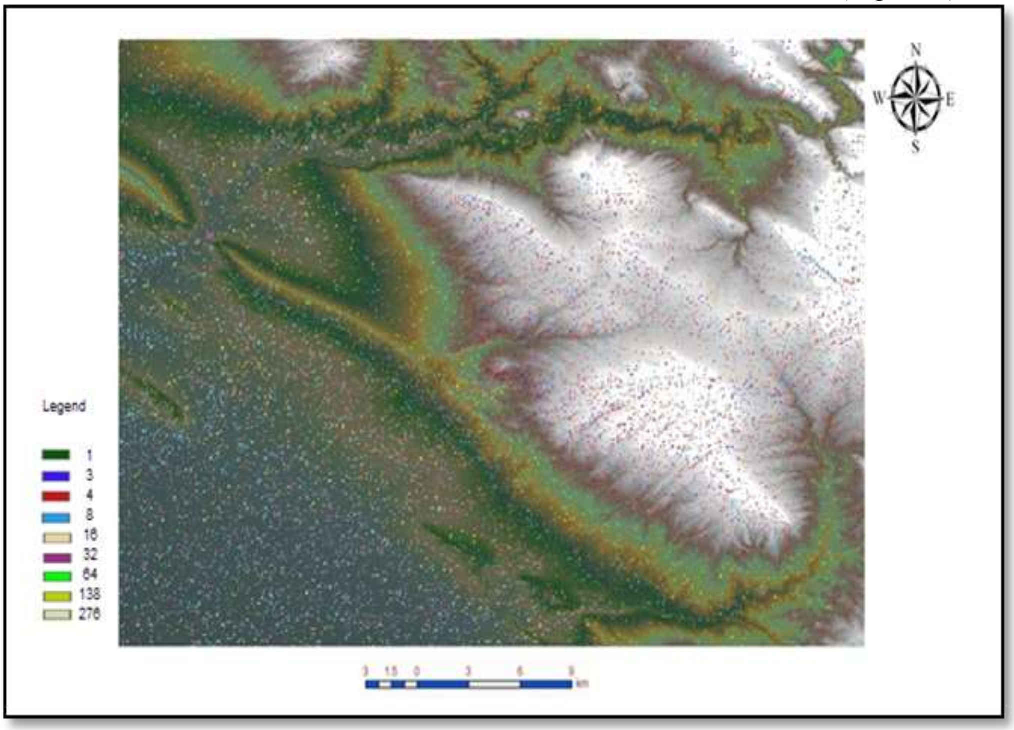

Figure 7-Flow direction map.

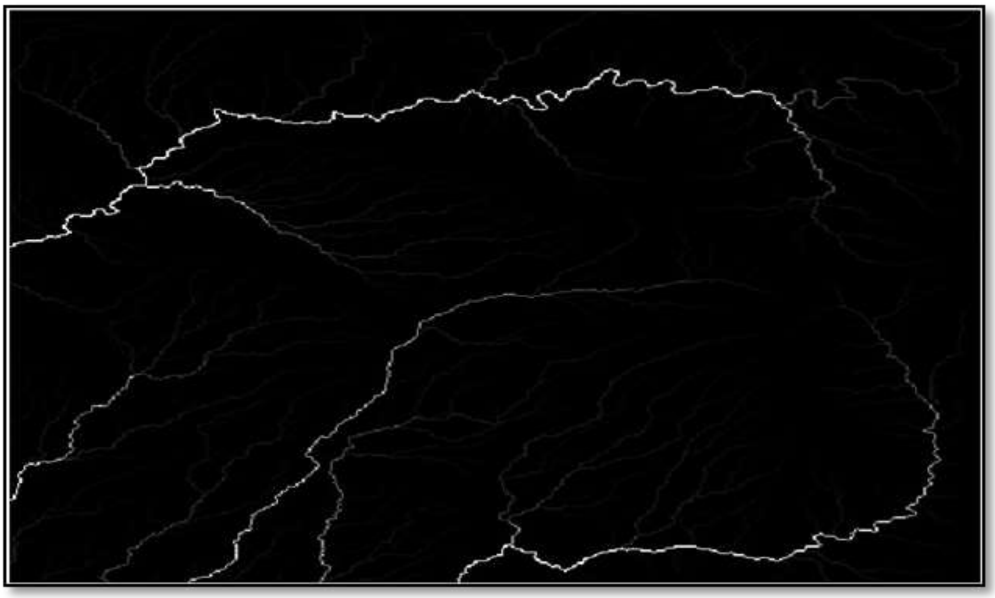

Figure 8-Flow accumulation map.

It can be seen that the large flow cells are positioned at the bottom of the water sinkhole. Through that, it can be easy to determine the cells of the Grid which accumulate the largest amount of water base during the rainstorm.

From the flow accumulation layer, a vector layer can be deduced from the river basin system by comparing the resulting layer to the riverbeds with the river layer that has been digitized from the general area maps. However, the convergence can be noticed despite the very small precision of the DEM used (Figure-9).

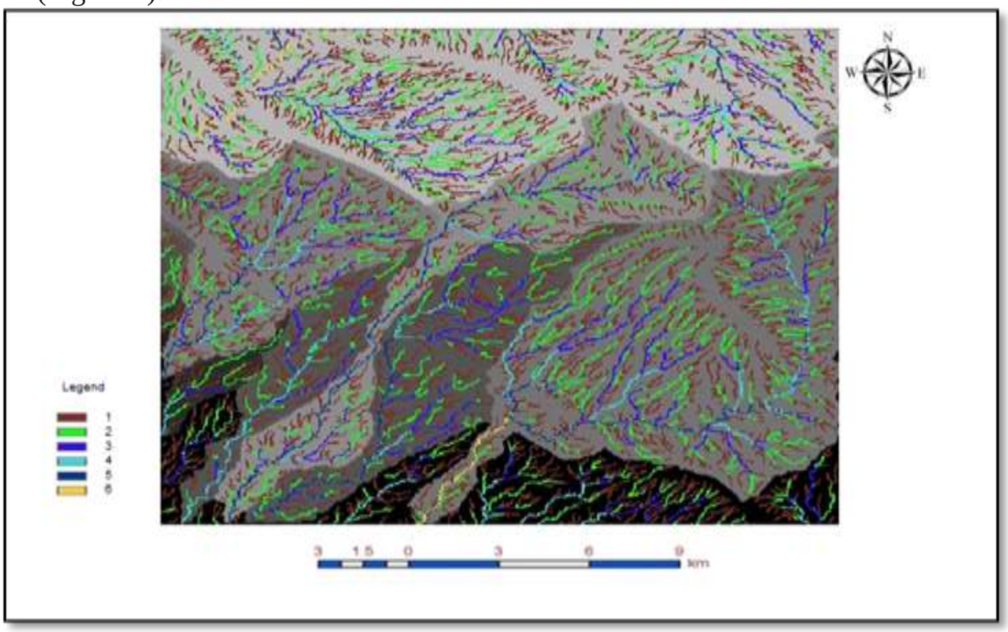

Figure 9- Drainage pattern map derived from digital elevation data with an accuracy of 30 m for the valleys and recharge basins in the study area.

Subcontractor in the former basin was concluded after identifying exit points of the sinking ponds. The data can be displayed in a three-dimensional format and it is possible to create a model of the Earth's surface using the 3D analyst extension. It is necessary to regard that it is also possible to create another layer in ArcView for aspects and, thus, to determine the direction and, accordingly, the quantity of water.

Conclusion

Morphological studies have demonstrated the use of modern techniques for remote sensing and GIS and the importance of each in obtaining accurate data and information that is difficult to access by traditional means. GIS can play a primary role in obtaining analytical and objective maps for analysis and interpretation of morphological phenomena. The contour map of the study area showed the convergence of contour lines which indicates the intensity of the slope, while the great spacing shows that the slope is low and that the prevalent degree of slope is on the northeast side.

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