Research Article

HYDROGRAPHIC NETWORK EXTRACTION AND WATERSHEDS DELIMITATION SOFTWARE OF THE SOUTH ORAN (NORTH WESTER ALGERIA)

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ABSTRACT

The development of space technology has allowed a better understanding and effective use of water resources through the use of Digital Terrain Models (DTM) Mapping the river system from DTM has two objectives, namely identifying first topography descriptors like hills, ridges and valleys of watersheds and second hydrological parameters to map areas of runoff recovery for a more efficient development and also a better representation of the actual land occupation. Our work is part of a methodological approach to satellite imagery processing and mapping of topographic and hydrographic parameters of watersheds. Thus, from DTM one was able to extract the full river system of the region. The results show a remarkable evolution of human activities and especially in areas of high water recovery capacity.

Keywords: remote sensing, DTM, network hydrology, geographic, steppe, west of Algeria.

1. INTRODUCTION

Since the 60's many scientists in the geographical, geological and hydrogeological areas defined analysis modes of river's system y manual calculations. Today this type of analysis has never really been used for other than experimental basis and it seems the mostly due to inadequate computer resources for automating this type of analysis. Currently the increasing availability of geographic information associated with the advent of geomatics and development of Geographic Information Systems (GIS) provides both hydrology and geomorphology by new possibilities in terms of analysis and modeling.

Therefore many researchers are working to automate the extraction of river network from digital terrain model (DTM). The altimetry information of the topography that provide the DTM conduct as well, extraction of hydrographic objects or entities and descriptions of field parameters [1-4].

The method used in our contribution is largely based on the utilization of the DTM to deterime and describe the water system.

The first step in treatment is to calculate the directions of flow. This step depends on the characteristics of the DTM and the flow direction algorithm used. From the flow directions, it was possible to extract the water system through the calculation of the accumulation of water flow.

The second part consists in the determination of sub-watersheds from the identification of outlets for our studied area.

## 2. MATERIALS AND METHODS

2.1. Study area

The study area is located about 100 kms as the crow flies south of Oran Mediterranean coast. It is a roughly flat highlands of an average altitude of 1000 m area delimited east by the province of Saida, west by the Moroccan kingdom and south by pastoral wilayas of El-Bayadh and Nâama, while the north is bordered by the Dhaya mountains range with an altitude of up to 1350 m (Figure 1). The entire studied region that we considered has an area of 18 756 km^2. It is limited to the north by latitude N34 ° 40'00" and t south by the parallel N33 ° 40'00 ", that to say a full degree, when it is bounded on the west by the W1° 40'00" longitude and to the east by E0 °

10'00 '' meridian.

Annual rainfalls range from 125 mm at the Ras El Ma station north to more than 200 mm Chott Chergui Mecheria south, while maximum temperatures are between 34.5 and 35°C, however they could reach 47 °C when the Sirocco dry wind starts to blow from south to north [5-7]. The region is then positioned in the arid bioclimatic stage with moderate cold winter [8]. It provides a buffer between the coastal Mediterranean western Algeria and arid Sahara desert.

The carbonate soils are most prevalent in this steppe ecosystem and determine large encrusted areas [9].

In the north, brown limestone soils predominate in Ras El Ma, to Redjem Demouche and El Aricha They are characterized by a 30-40 cm depth sandy loam texture on the surface and deep clay resting on a limestone crust more or less indurated. These soils have an average rate of 0.4% organic matter.
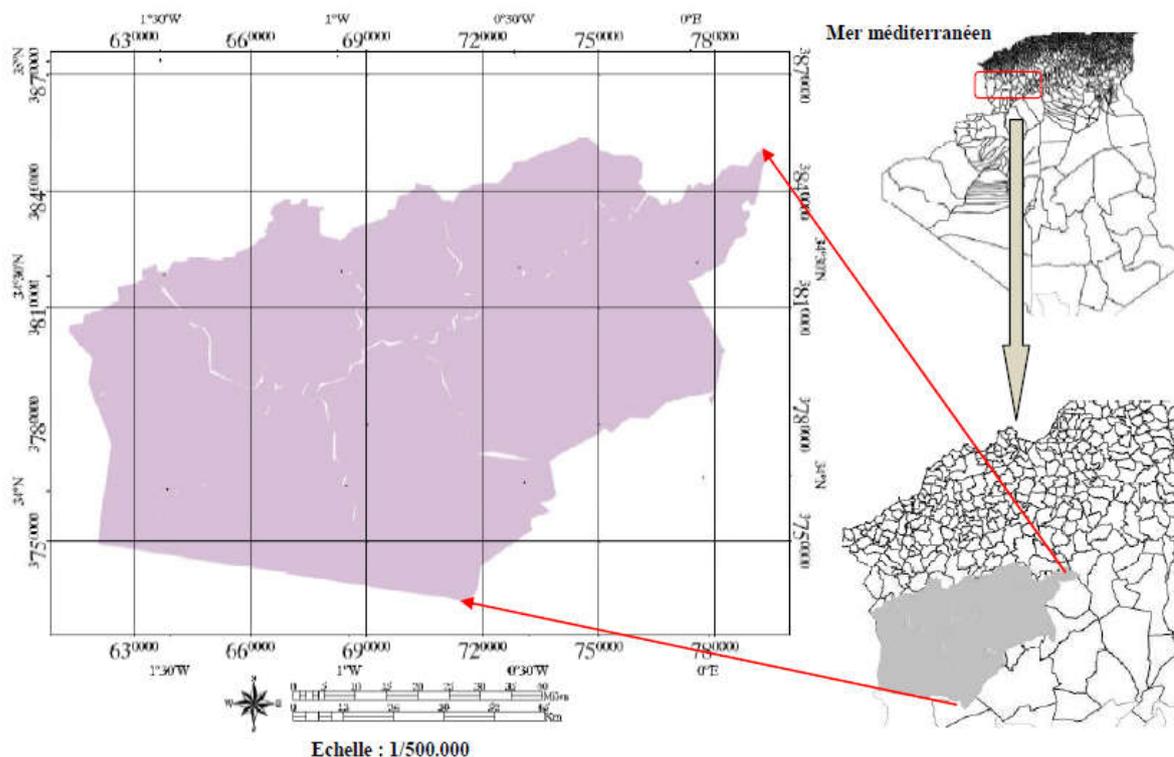
Fig.1. Location of the study area (Wester Algeria)

The slopes of the south are characterized by crusting xeric brown calcareous soil less than 30 cm deep, slightly evolved alluvial soils intake in the bottom of the river valleys, isohumic soils (sierosems) with small but homogeneous organic matter rates (0.3 to 0.5%) and saline soils

(sodium Solentchak) on the peripheral areas of Chott Chergui [10].

North, the calcimagnesic soils are very well represented in Bir El Hmam and Marhoum. They are distinguished by a loamy surface and clay-loam in depth. The limestone is present in diffuse form and weakly bound and the average rate of organic material is around 1%.

At first sight, halophilae/psammophilae steppes and chamaephytic sagebrush (*Artemisia herba-alba* Asso.) steppes are the two main forms of land use in the study area. They alone totaled more than 200,046 hectares, so more than 32.07% and 66,273 hectares or 24.94% of the total area, respectively.

The dense and very dense vegetation covers only 14,872 hectares where culminates forests areas dominated by the Aleppo pine (*Pinus halepensis*) especially and some holm oak (*Quercus ilex*) forests north of Bir El Hmam, Ras Elma, Marhoum, and Aricha, remains of the old primary Mediterranean forest while the grassland formations dominated by Alfa (*Stipa tenacissima*) and irrigated market gardens crops remain poorly represented.

The global situation analysis of land use shows changes inflicted by irregular rainfall, land clearing for agriculture and overgrazing. Livestock also experienced remarkable expansion and is justified by the increasing availability of unproductive and pastoral areas open to course [11]. Forestlands, at 8% of the overall surface of the study area, are used in particular as course space. The agricultural land yields remain very low and closely dependent on the distribution of annual rainfall [12]. The strong use of land in crops has resulted in the decrease of organic matter rate in the horizontal surface offering a favorable particle structure to water and wind erosion processes [13- 15].

2.2 Methodology

Hence, Aster Data are a fundamental source for the extraction of hydrological units ; they will allow to densify the hydrographic network significantly in the mountains. By cons, in plain area, the altitude changes mean is less than the altimetrical accuracy of Aster data, which affects quality of the extraction [16-21]. Thus, the extraction of river system requires the availability of a digital terrain model (DTM) and the preparation from this one of a raster of flow directions and a raster of accumulations thresholds.

It is for reasons of availability that our choice fell on ASTER GDEM data (Global Digital

Elevation Model). It is a mission that provides Digital Terrain Models (DTM) free and accessible from the Net. DTMs have an important role in terms of spatial analysis and their integration in a Geographical Information System gives a lot of practical information.

The study area was projected in the Universal Transverse Mercator (UTM) system in the time N30. This is the projection system commonly used by the Algerian authorities or the datum "World Geodetic SYSTEM 84 (WGS 84)".

A watershed is the reference hydrological unit that is a portion of territory whose waters flow towards an outlet that can take the form of a stream, lake or a marine extension. The delineation of this watershed can be achieved by natural limits, i.e. the ridge lines or watershed lines. In these watersheds flowing waters falling within that territory. The outlet is a critical point to define a watershed because it sets the watershed line which generally corresponds to the ridge line. Based on point of outlets defined in our study area one have also defined the sub-watersheds following the Pfafstetter coding method.

The determination of flow directions of water was determined at every pixel from the DTM elevation values, knowing that the water follows the path defined by the line at the steepest slope. The latter is a very important phase in a fluid constrained by a surface. According to Charleux-Demargne, 2001, unidirectional or multidirectional but two dimensional algorithms are the most used in the determination of flow directions [22].

The majority of extraction methods use the 8 connexities or D8 one-way flow scheme algorithms. This algorithm determines the direction of flow at every pixel from the elevation values of its immediate neighbors and selects the downstream pixel following the maximum descent. The D8 algorithm takes therefore into account the eight neighboring pixels following the cardinal and diagonal directions of the central point considered [23, 24].

We then based on this algorithm to define the flow directions. For more precision, individual treatments were performed on local and flat depressions before making the final extraction directions of flows.

Then, from the obtained plane of flow directions, it was possible to calculate the accumulation threshold. The latter was calculated using the constant "Drop Stream" developed by Tarboton and Bras in 1991 and well performed by Tarboton alone in 2003 [25, 26].

It is to determine the altitude decrease between the beginning and the end of a river arm properly defined by Strahler orders [27]. Finally, we extracted the full river system on the study area, which allowed us to appreciate the entire river netting and perceive the classification of Strahler orders.

3. RESULTS AND DISCUSSION

Figure 2 shows the color gradient that starts with blue symbolizing the highest areas to the lower ones. Indeed the blue color which passes diagonally represents the highest floors and underlines a ridge or watershed line separating the southern basin from the North West one. This watershed line is of linear form in the given scene and gives birth to several water courses from one part to another.

One find that in the northern rivers originate near the crest line which regulates the flow from south west to the north east rapidly forming other courses of (N+1) order while in the south ridge line regulates courses from north west to south east, but the flow is slower than in the other part.

One might say that the northern basin is hydrologically more nervous or more precipitate, which means that one could touch on two aspects: the first is that the northern basin is experiencing a more dynamic hydrological regime than during the southern one the second aspect shows heterogeneity of the soil between the two basins. Our results, thus, discover two river systems that belong to two watersheds and put in the evidence the so strong topographic gradient that characterizes the morphology of the area.

The figure 3 emphasizes the direction of flows when the figure 4 shows clearly their accumulation.

The extraction of the limits of sub-watersheds schematized in figure 5 was mainly based on the presence of outlets, because according to Hocine et *al.,* 2007, treatment of flat areas and depressions significantly improves the quality of the DTM for the extraction of river system [28]. The figure 6 highlights the exposure slopes and the position of the outlets is obtained from the flow directions as seen in figure 7 which gives the water system of Strahler. Then, each outlet positioning error is resulting in poor estimation of watershed boundaries.
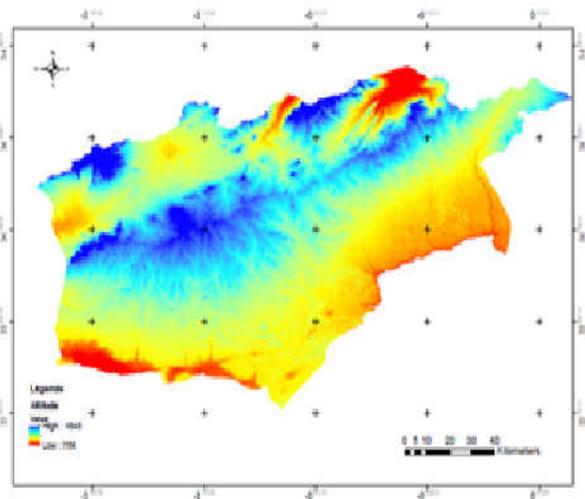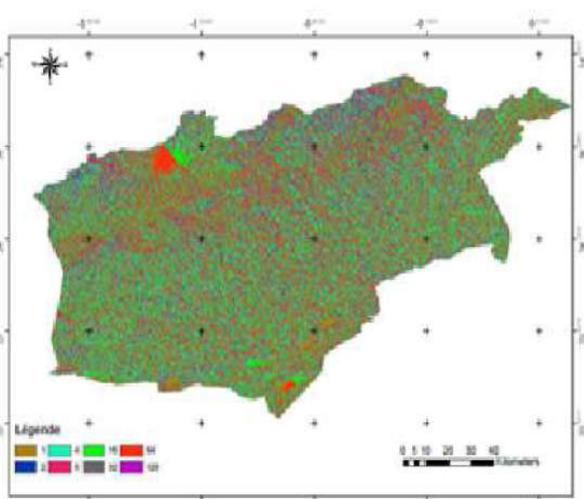
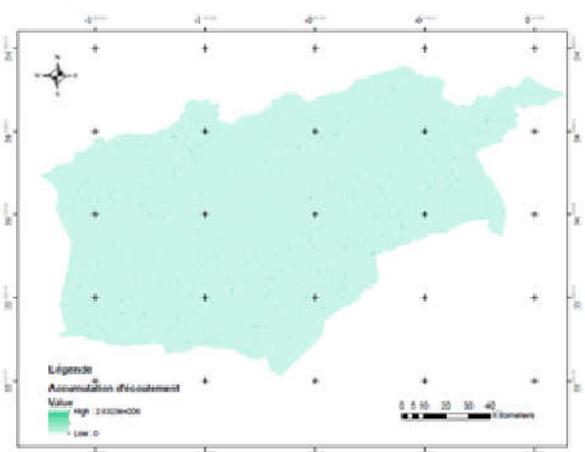**Fig.2.** Map of the digital model

Fig.3. Direction of flows
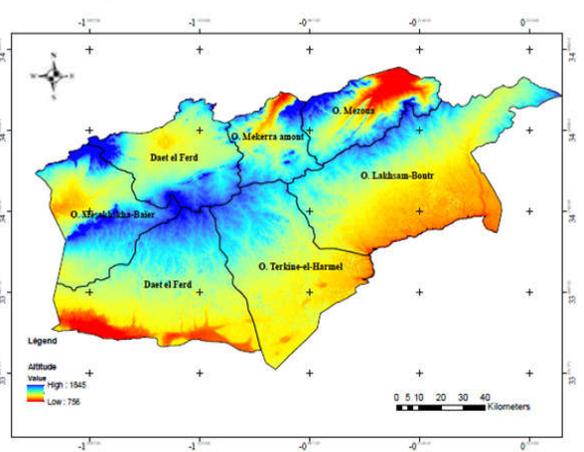

Fig.4. Maps of flows accumulation
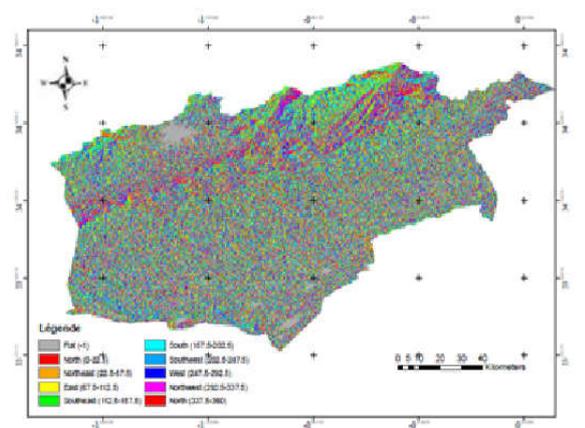

Fig.5. Limits of subwatersheds
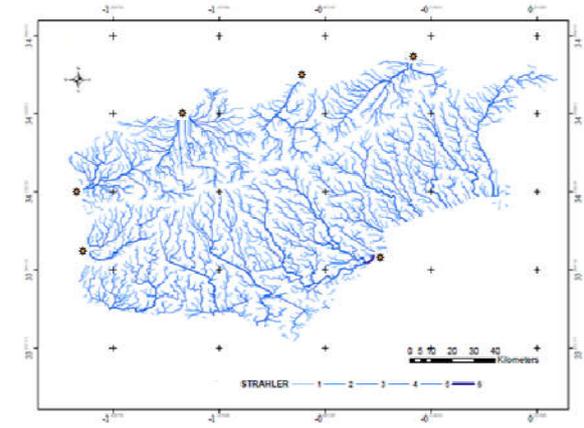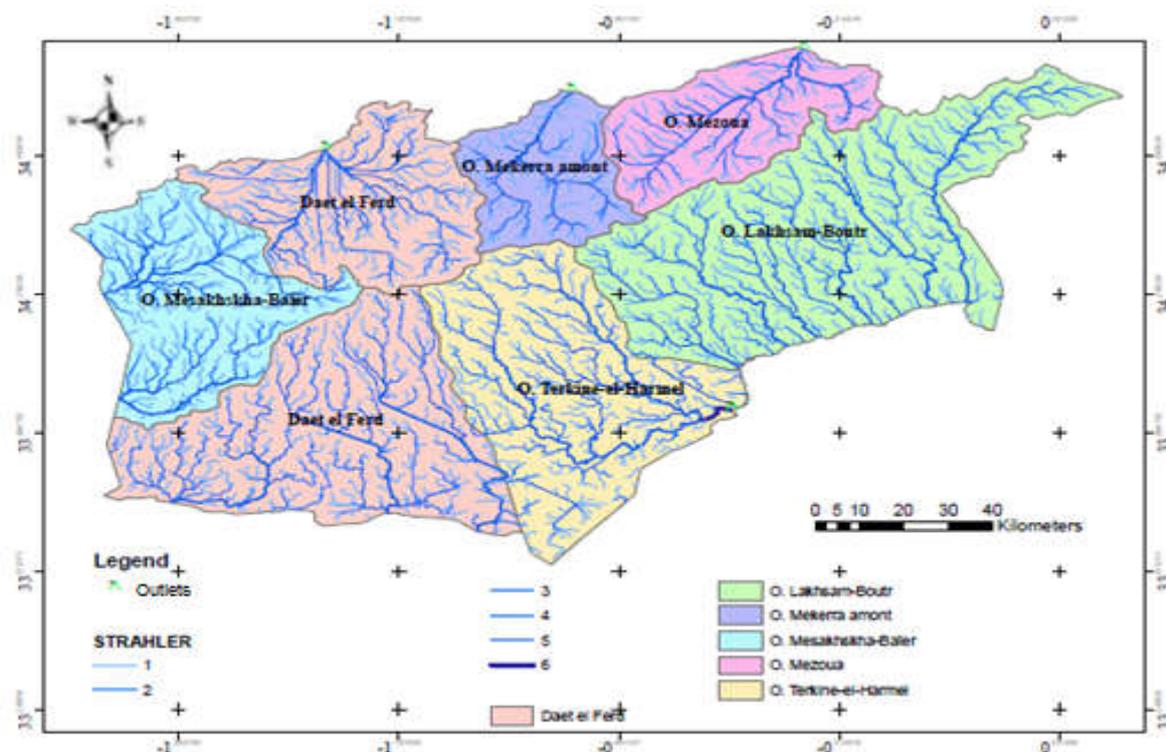

Fig.6. Map of exposure slopes

Fig.7. Water system of Strahler and outlets

Fig.8. Water system, Limits of subwatersheds and outlets obtained

The final result is therefore a natural river system in most of the region with some artificial streams is very marked by the presence of human action areas as shown in figure 8. On the other hand, the stagnation of the steppe population is justified by the abundant presence of water points and one have even noticed the extension of irrigated crops by more than 20% in this area. Accordingly, the digital terrain model used in this paper has to consider hydrological use. A flow algorithm in eight directions (D8) has allowed us to properly extract the water system of our study area. The treatments carried out on the flat areas and depressions have allowed us to eliminate morphological artifacts such as parasite depressions and favored the obtaining of a continuous tree network through the studied area.

4. CONCLUSION

Our study aimed to describe and map the surface water resources of the South of Oran, northwestern Algeria. With the most recent data we have at our disposal and with the latest computer methods available for automatic extraction of river network we developed a flow algorithm in eight directions which defined the water system.

This algorithm and directions of flows, the accumulation of runoff of surface water, the water system and the sub-watersheds limits offer significant advantage to the economy of the region, permits the optimization of water resources exploitation and can serve as a practical tool for sustainable development and above all respectful of ecosystems in this region which remains very fragile from an environmental point of view.

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