

Using the Archydro tool for watershed delineation Case of the Kherzet Youcef mine, North-eastern Algeria

Cheddad Souhila (✉ cheddadsouha@gmail.com)

Laboratory water and environment, University of Science and Technology Houari Boumedian

Haouchine Abdelhamid

Laboratory water and environment, University of Science and Technology Houari Boumedian

Research Article

Keywords: Archydro, spatial analyst, DEM, flow direction, flow accumulation, Kherzet Youcef deposit

Posted Date: November 9th, 2021

DOI: <https://doi.org/10.21203/rs.3.rs-1056465/v1>

License:  This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Abstract

This research article is attempted on the study of the morphological characteristics of the oued Loussif sub-watershed, located in the Wilaya of Sétif, Algeria. This study is part of a more general study on the hydrogeological study of the Kherzet Youcef deposit.

In all fields interested in the study of spatial phenomena, a need for automation is emerging, especially for geographical structures of the 'network' type, given their systemic organization of space that is not explained in databases of geographical data. In order to meet this need for automation, the use of Geographic Information Systems has proven to be cost-effective.

Morphological characteristics such as flow accumulation, flow direction and stream network were extracted on the basis of the digital elevation model (DEM), and the results were interpreted and analyzed. The geographic information system (GIS) based approach with the use of DME facilitates the understanding of the different morphological features represented in the thematic matrix data maps, and the correlation between flow accumulations, flow direction, stream order and stream network has been well explored.

The study represents the morphological characteristics extracted from the DEM. The software used to perform the global analysis was ESRI ArcGIS version 10.8 with the ESRI Spatial Analyst and ArcHydro extension. Morphological features are effective in understanding the spatial distribution of the watercourse network and identifying potential groundwater locations.

1. Introduction

The management and preservation of water resources is a major global concern (Mutin 2009, Louise 2007), and especially in countries with arid and semi-arid climates where the water heritage is constantly being tested, taking into account the growth of water needs (industrial development, population growth...).

The drainage basin study is vital in hydrological examinations. Understanding the hydrological establishment of rivers is a key elementary fact for decision-making in several areas: environmental planning and the use of water resources in the river watershed. The essential geographic boundaries of watersheds, sub-watersheds, and stream system help to assess data for watershed management activities.

Morphology plays a major role in understanding the controls of the variability of the fluvial process. The assessment of morphological parameters includes the upstream and downstream, the order of the watercourse, the direction of the flow, the accumulation of the flow, the connection of the watercourse and the network of watercourses that can be interpreted using a digital elevation model (DEM).

In the early days, topographic maps were the main sources of information for the origin of watershed features in hydrological models; currently, DEM is very important in hydrological studies, topographic characterization because it provides fast, economical and consistent information. (Hema et al., 2021)

We propose a methodology for the extraction and delimitation of watersheds using a geographic information system. Specifically, we will use a GIS to process SRTM data. From the digital elevation models, we will extract a representation of the hydrological network. This will make it possible to delimit and characterize the various basins, which are a key element of any hydrological management (Hema et al., 2021, Ahmed 2018).

Automatic DEM extraction data have largely replaced manual demarcation of stream networks and watershed boundaries from topographic maps (Visharolia et al., 2017). Some research has suggested that the flow networks present in the topographic sheets and also in the satellite images correspond to the DEM data of the delimited flow network (Bhagwat et al., 2011).

To analyze spatial morphometric parameters, it is essential to delineate the flow network (Qadir et al., 2020). DEM derivatives have a wide range of applications in the field of engineering, such as uplift mining, cut and fill analysis, land reclamation, and slope determination to understand the geomorphology of the area (Arunkumar et al., 2018). Remote sensing (RS) and GIS have yielded key results in delineating geography and landforms (Arbind Verma et al., 2017, Vittala et al., 2004, Arunkumar et al., 2019).

2. Material And Methodology

2.1. Presentation of study area

The Kherzet Youcef deposit is located southwest of the Ain Azel depression (North-eastern Algeria). This depression is part of a vast hydrological basin that stretches over more than 9580 Km² from the Ain Beida region in the East to that of El Eulma in the West. The national water resources agency assigned it the number 07, under the name of the Constantin highlands (Fig. 1). The plain of Ain Azel occupies the westernmost sub-watershed (s/BV), coded 07-01, chott El Beida.

At the scale of the sub-watershed Chott Beida, the hydrographic network has been disorganized by the combined effect of the tectonic phases of the Late Pliocene and the drying of the climate. This explains the existence of endorheic phenomena in the High Plains, once crossed by upper branches of the Wadi Rumel in particular Wadi Dehamcha and Wadi Dehab.

It is not very dense, and corresponds to a set of short and temporary wadis that drain most of the slopes, and get lost in the detrital formations of the plain. The exhaust points correspond to the chotts and sebkha, which are very common in this region (Fig. 2).

2.2. Methodology

The extraction of morphological aspects using geospatial technology is the key objective of this study. This study also shows the interest of the use of GIS in the process of extraction of hydrological networks and the delimitation of the watershed.

The methodology adopted consists in exploiting and interpreting the SRTM altimetric data an arc (a spatial resolution of 30m) in order to map the watershed boundary and the hydrographic network. This data was uploaded to the website of the US Geological Survey. The spatial reference of the Word Geodetic system 1984 (WGS) and UTM 31N.

This methodology will also allow us to describe the various topographic parameters (slope, ridge, length of the watercourse...) and then a delimitation of the slopes of the basins.

In the bibliography, many authors are interested in this approach, the study of which requires the vectorization of the topographic background of the various areas of interest in order to generate the NCDs. According to Hingrey et al. (2009), this mode of production leads to inaccuracies in some areas, hence the importance of remote sensing.

However, our approach has the merit of being simple and inexpensive. Indeed, the only support required will be SRTM data, which is available on the Internet. With the help of the Archydro extension, the basic parameters of the watershed are derived. The flowchart of the methodology is shown in Fig. 3. The results obtained using SRTM DEM are the flow direction, the flow accumulation and the flow network using the Arcgis GIS software, version 10.8.

3. Results And Discussion

The Achydro module integrated into the ArcGIS 10 solution. * provides solutions to various water management problems (Maid, 2002). It has two components: the first concerns the management of the geospatial database related to water resources and the second groups all the tools for analysis and data integration.

First of all, we proceed to the correction of soil anomalies, in order to avoid either calculation errors related to altimetric artifacts, or the generation of interruptions in the waterway. The well filling function is used to eliminate depressions in the MNA.

The process of delineating the watershed and extracting the hydrological network of an MNT is as follows:

3.1. Validation of the MNT

First of all, we carried out a validation of the DEM:

- - We generated level curves from the DEM, then superimposed them with those of the topographic map, (Fig. 4)

- - We also digitized the side points and entered the values of the altitudes on the attribute table. At these same points, we extracted the altitude values on the MNT (thanks to the command: extract the values of the points). The statistics on the values of the altitudes are shown in Fig. 5.

Overall, the elevation values are proches.de slight differences were recorded.

3.2. MNT correction

First of all, we proceed to the correction of soil anomalies, in order to avoid either calculation errors related to altimetric artifacts, or the generation of interruptions in the waterway. The function of filling the cuvettes is used to eliminate depressions in the MNT.

3.3. Determination of the direction of flow

This method assumes that topography is a good indicator of the gravitational potentials involved in surface flow processes (Crave, 1995). The program then uses the algorithm D8 (Jenson and Domingue, 1988) which determines the direction of the flow using the maximum slope gradient (unidirectional diagram) (Fig. 6). This is to calculate the direction of the flow in each cell. It corresponds to the path with the greatest slope (Charleux, 2001).

3.4. Determination of the accumulation of the flow

The result of this operation is a grid representing the cumulative number of upstream cells (in the direction of the gravitational flow) flowing in a given cell (Fig. 7). The calculation requires the determination of a threshold corresponding to the minimum drainage area and a well-defined cumulative number of cells. The result represents a hydrographic network with a number of cells at least equal to the threshold set from the beginning. Fig. 3c shows that the cells located at the mouths assume high values, a predictable result since they receive all the water generated by the basins.

3.5. Classification of the hydrographic network

The hydrographic network obtained was validated by superimposing it on the topographic map (Fig. 8). We notice that the two networks overlap almost perfectly.

The resulting hydrographic network has a unique identification, it is coded in order 1. However, a classification of branches is based on the number of tributaries by applying the Strahler method (Fig. 9). This classification makes it possible to unambiguously describe the development of the drainage network of a basin from upstream to downstream (Bentekhici, 2006). Once classified, the modeled network is converted into a vector. Switching from raster mode to vector mode is an integrated operation and one of the key concepts of the Arc Hydro model.

4. Conclusion

The exploitation of the SRTM datasets allowed the extraction of the hydrological network. The modeled drainage map shows a flow that is moving mainly from the Southwest to the Northeast.

SRTM data covering the Ain Azel Plain region is integrated into a GIS.

We then proceeded to a morphometric characterization of the different hydrological units (calculation of the indices of shape, relief, drainage density...).

To validate the methodology, we cross the results obtained with the digitized network from a topographic map covering the study area. It should be noted that the network modeled under Arc hydro coincides with most of the main rivers, by means of some local differences of a metric nature. These differences may be related to the resolution of the SRTM data (1 arc second).

This study also demonstrated the acceptable accuracy of the SRTM data and the possibility of using them to conduct hydrological studies in Algeria.

References

- **Ahmad I.** (2018). Digital elevation model (DEM) coupled with geographic information system (GIS): an approach towards erosion modeling of Gumara watershed, Ethiopia. *Environ Monit Assess* 190, 568. <https://doi.org/10.1007/s10661-018-6888-8>
- **Arbind Verma K, Madan Jha K** (2017) Extraction of watershed characteristics using gis and digital elevation model. *Int J Eng Sci Invention* 6. pp1–6
- **Arunkumar Y, Kappadi PK, Hafeezunnisa** (2019) Crop pattern change and crop water requirement judgment using remote sensing and GIS techniques: research on Tungabhadra Dam Right Canal, vol 8, pp 652-657. <https://doi.org/10.35940/ijrte.B1120.0782S319>
- **Arunkumar Y, Dodamani BM, Dwarakish G.S.** (2018). Shoreline analysis using Landsat-8 satellite image. *ISH J Hydraulic Eng* 1–9. <https://doi.org/10.1080/09715010.2018.1556569>
- **Bhagwat TN, Shetty A, Hegde V.S.** (2011). Spatial variation in drainage characteristics and geomorphic instantaneous unit hydrograph (GIUH); implications for watershed management—a case study of the Varada River basin, Northern Karnataka. *Catena* 87:52–59. <https://doi.org/10.1016/j.catena.2011.05.007>
- **Jenson S.K et Domingue J.O.** (1998). Extraction de structures topographiques à partir de données numériques d'élévation. *Génie photogrammétrique et télédétection*, pp. 1593-1600.
- **Hema H. C., Govindaiah S., Suresha K. J., Arunkumar Yadav.** (2021). Morphological Characteristics of the Kanakapura Watershed, Arkavathi River Basin, Karnataka, India—Using GIS and DEM. *Sustainability Trends and challenges in Civil engineering*. PP 991- 1001.
- **Hingrey B. et al** (2009). *Hydrologie 2 - Une science pour l'ingénieur*, Volume 2. 600 pages.
- **Louise R.** (2007). *L'eau, source de conflits*. *Lex Electronica*, vol. 12 n ° 2.
- **Maidment D. R.** (2003). *Arc hydro: SIG pour les ressources en eau*, volume1. ESRI, Inc.
- **Mutin G.** (2009). *Le monde arabe face au défi des problèmes de l'eau et des conflits*. hal- version 2, novembre 2009.

- **Qadir A, Yasir M, Abir IA, Akhtar N, San LH.** (2020). Quantitative morphometric analysis using remote sensing and GIS techniques for Mandakini River Basin. IOP Conf Ser Earth Environ Sci 540. PP 1–10
- **Visharolia US, Shrimali NJ, Prakash I.** (2017). Watershed delineation of Purna River using geographical information system (GIS). Int J Adv Eng Res Develop 4. Pp690–695.
- **Vittala SS, Govindaiah S, Gowda HH.** (2004) Morphometric analysis of sub-watersheds in the Pavagada area of Tumkur district, South India using remote sensing and GIS techniques. J Ind Soc Remote Sens 32. Pp351–362. <https://doi.org/10.1007/BF03030860>CrossRefGoogle Scholar

Declarations

Competing interests: The authors declare no competing interests.

Figures

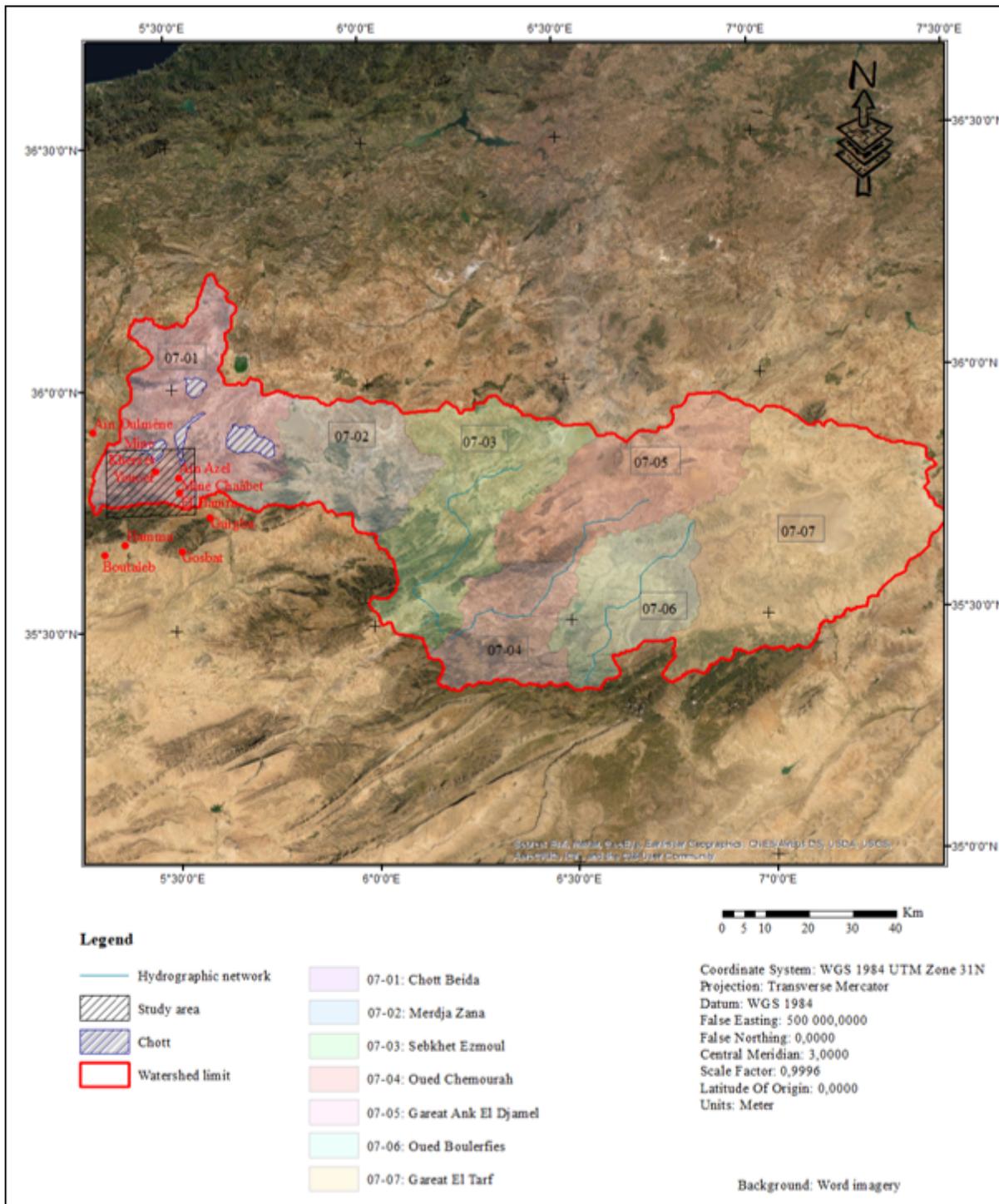


Figure 1

Constantines highlands

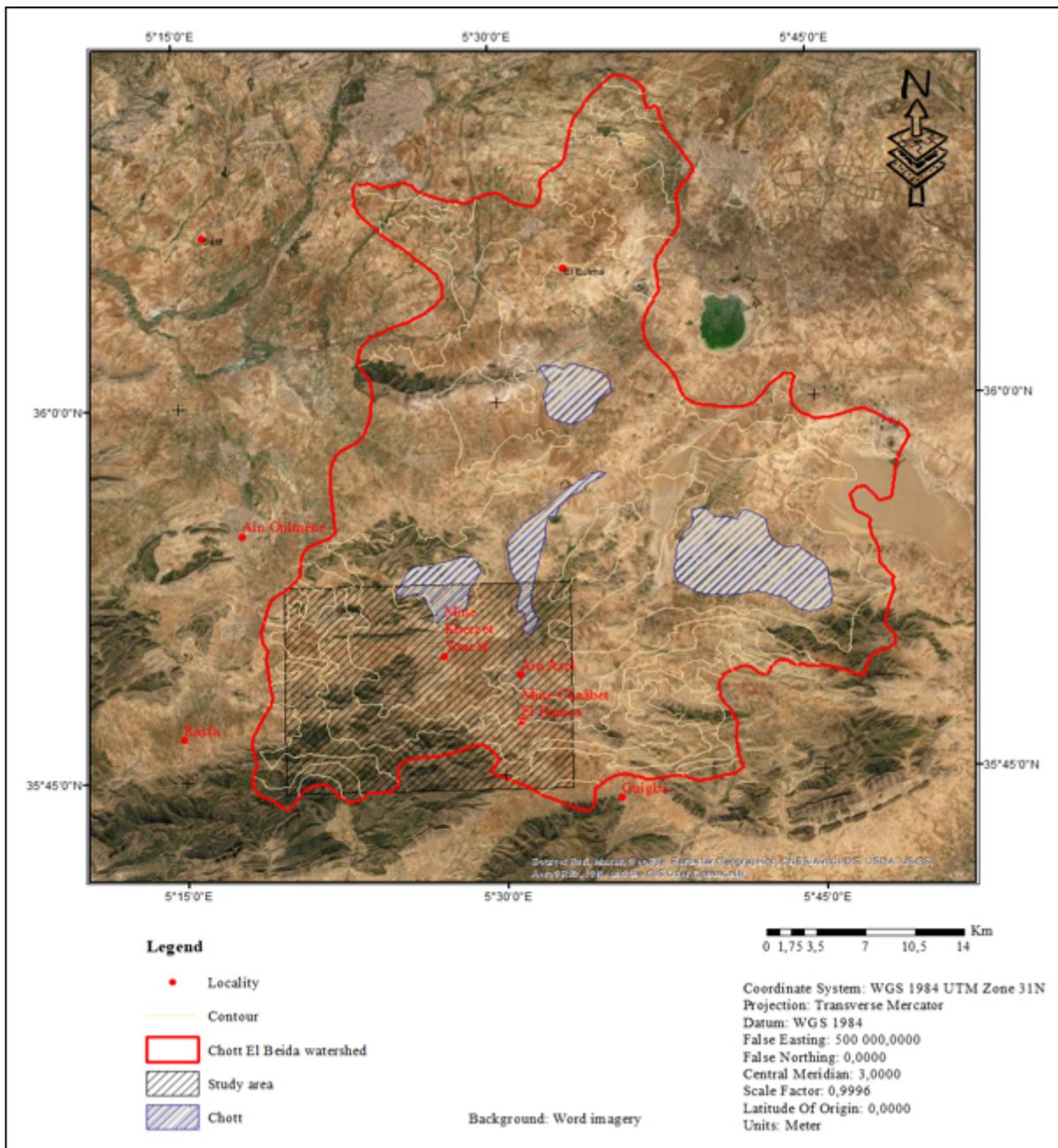


Figure 2

Chott El Beida sub-watershed

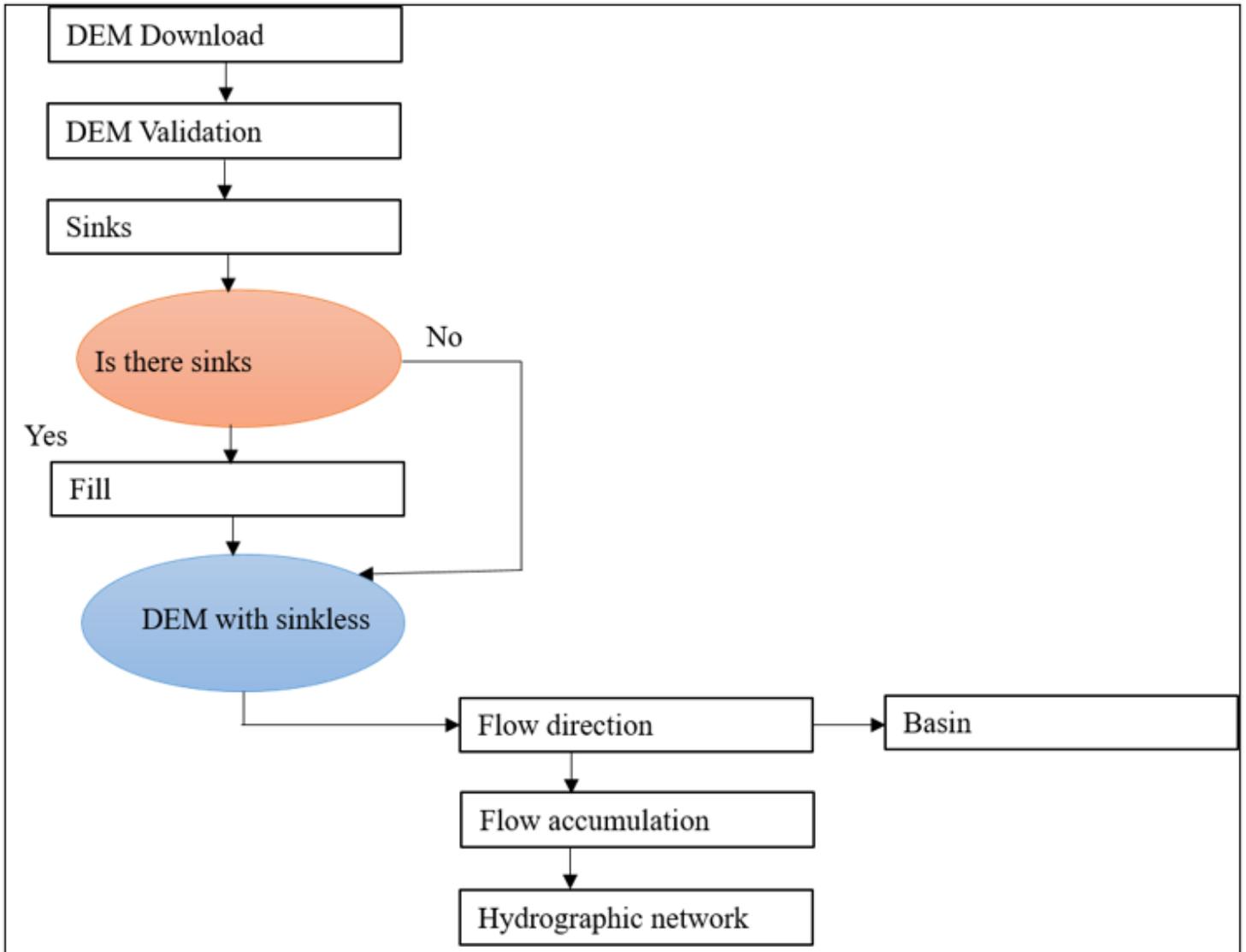


Figure 3

Flowchart methodology

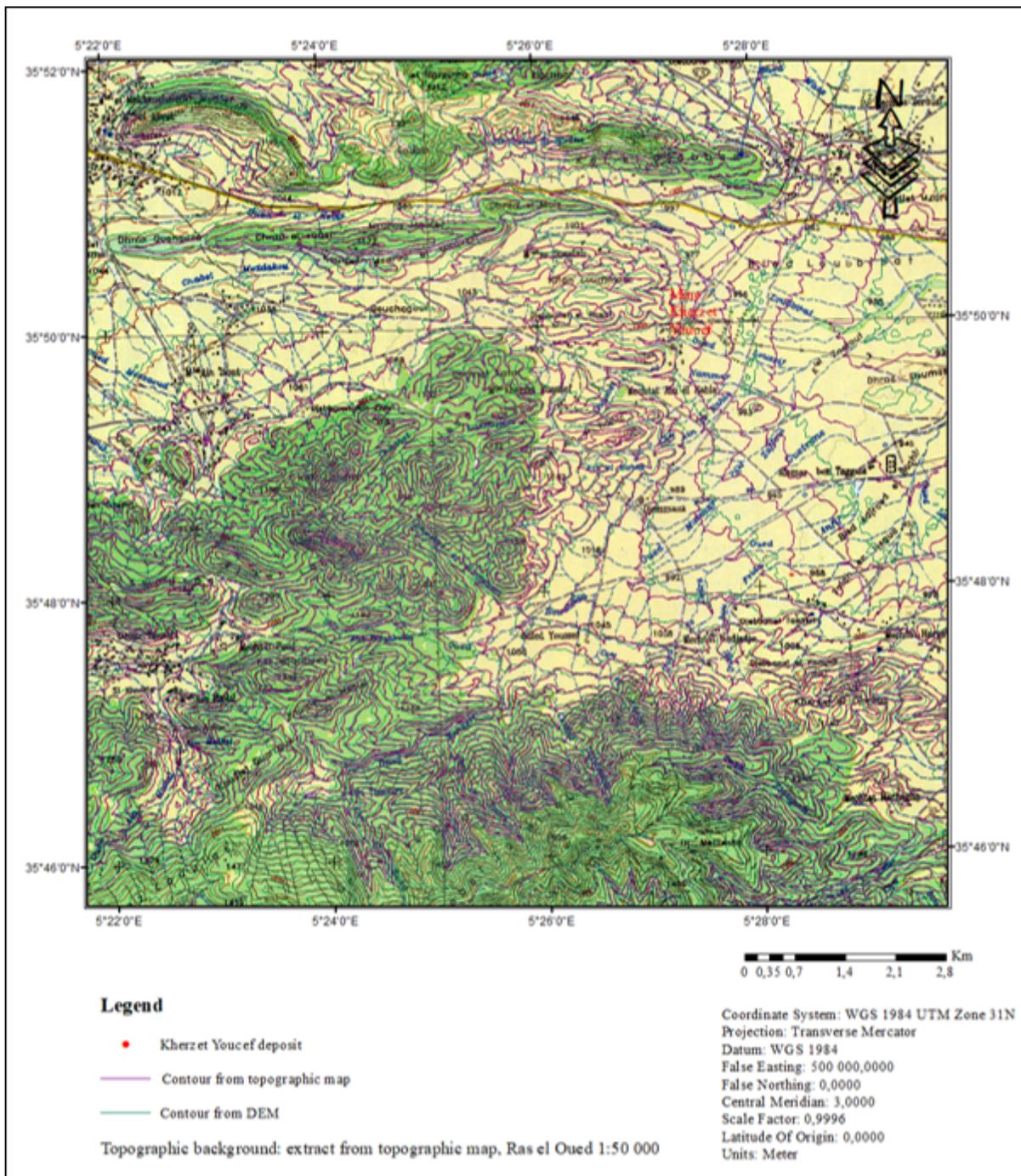
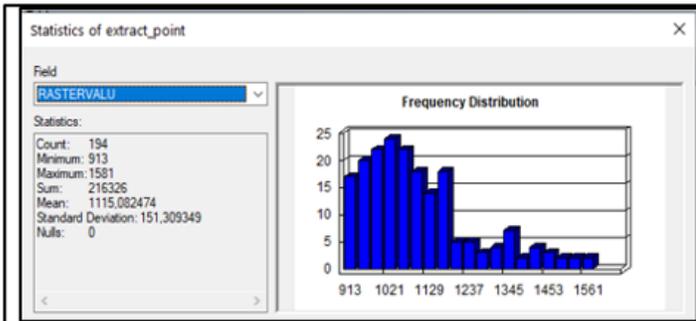
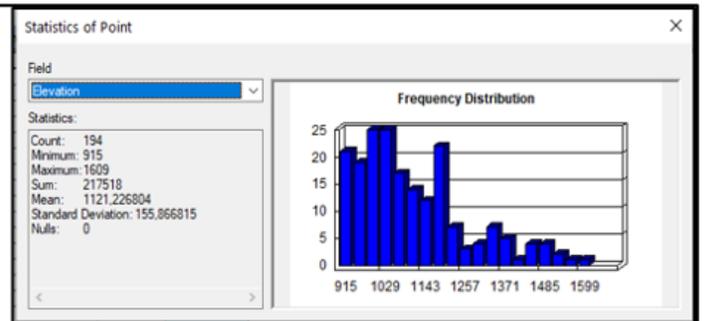


Figure 4

DEM validation



A. Statistique sur les altitudes des points extraits du MNT



B. Statistique sur les altitudes digitalisés sur la carte topographique

Figure 5

Comparison of altitude statistics to validate the DEM

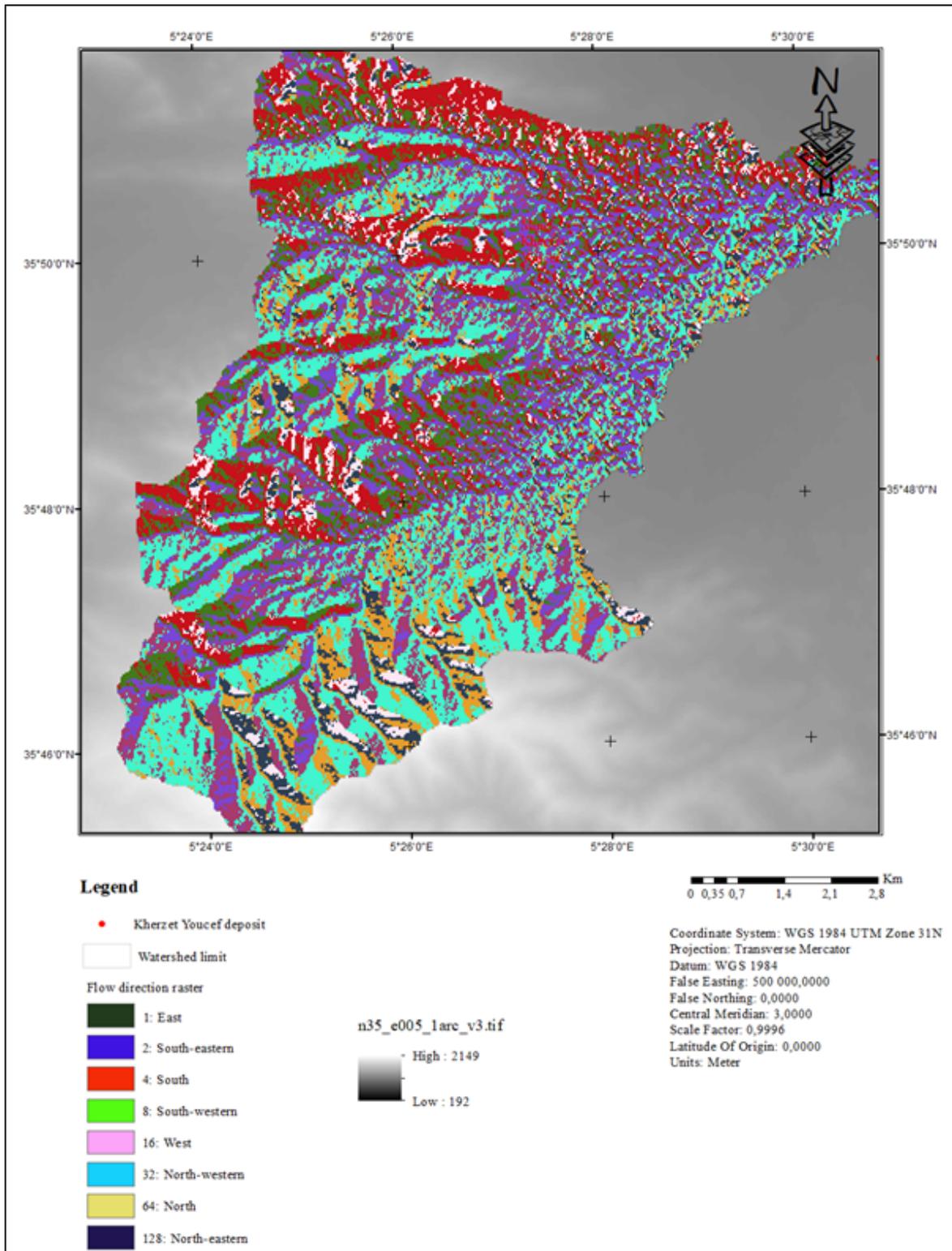


Figure 6

Flow direction raster

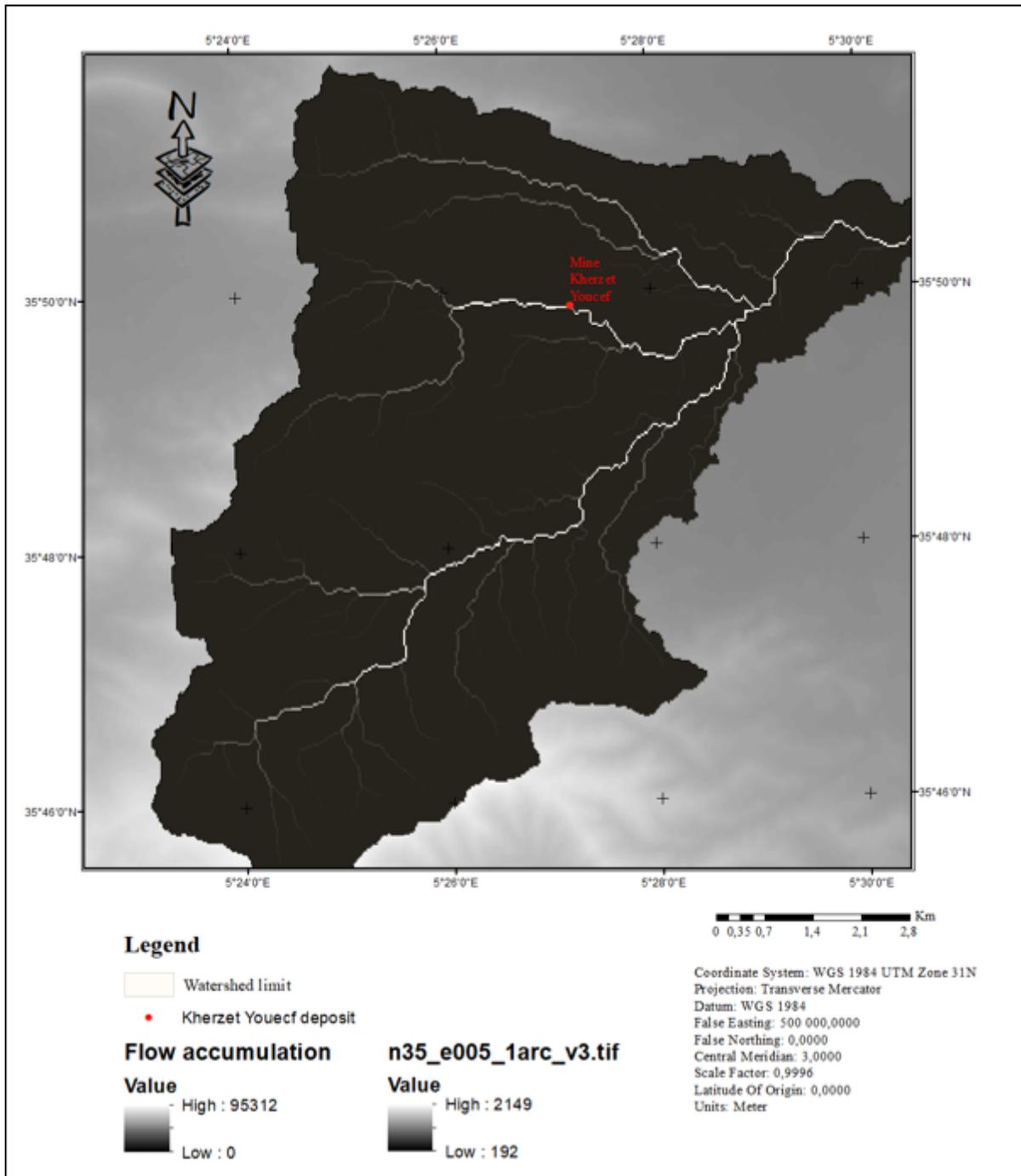


Figure 7

Flow accumulation raster

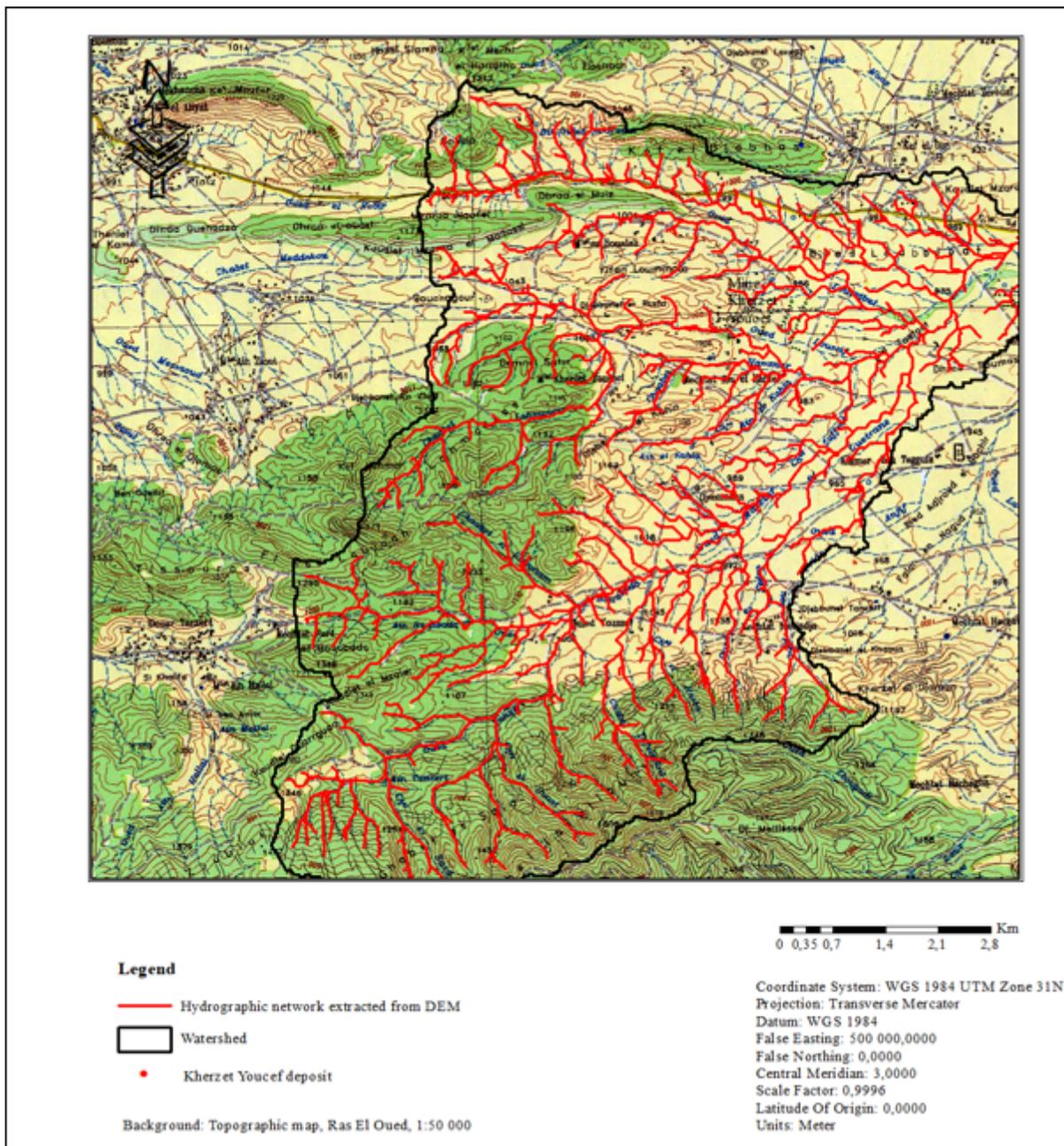


Figure 8

Hydrographic network validation

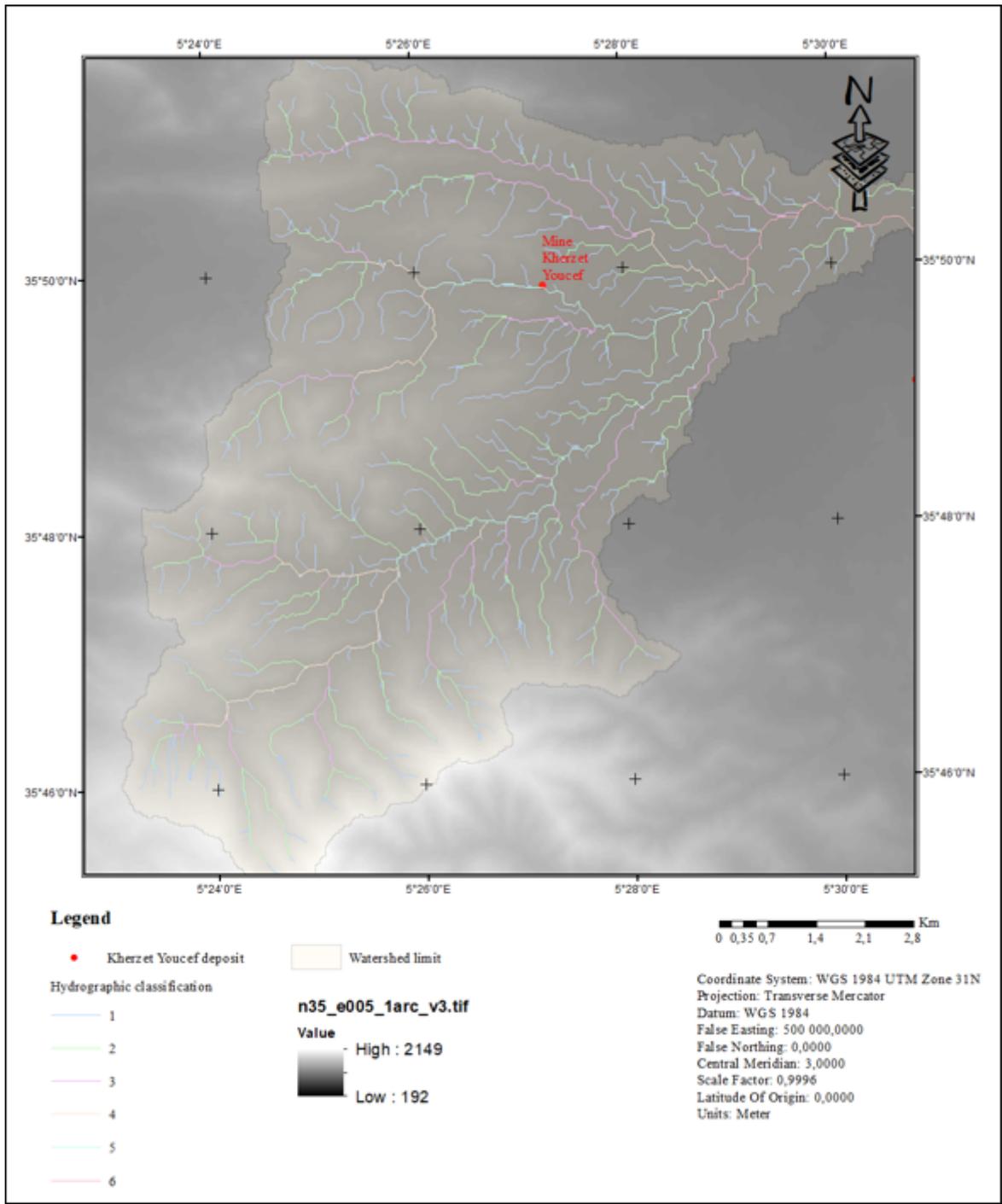


Figure 9

Hydrographic network classification