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DIGITAL MAPPING OF LANDSCAPES BASED ON SOIL MORPHOLOGY IN THE PLAIN OF LOWER-CHELIFF (ALGERIA): APPLICATION OF REMOTE-SENSING

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Abstract. The Plain of Lower-Cheliff is one of the most studied north Algerian areas in terms of soil and water dynamics either in space or in time but it is very poor in term of landscapes mainly those related to vegetation. Here in this brief study we used a digital elevation model to detect the soil morphology of our study area mainly slopes and altitudes then to extract and classify the different landscape patterns using the method of supervised classification applied on a satellite imagery of LANDSAT TM type to present the spatial distribution of the main morpho-landscpaes in a digital spatial map. The resulted classes from the image are mainly: cereal -crops, tree crops, garden-crops to the east side of the area also, halophytes and bare soils to the west side. The digital elevation model shows that the variation of elevation is not that important as the slope but it is still the one that controls the distribution of landscapes in the plain according to the overlay, elevation/landscapes: halophytes and bare soils locate in low altitudes commonly called depressions following the soil salinity concentration at this level, other crops locate in mid to high altitudes away from soil salinity that endangers agricultural practices in the area, finally we can say that the spatial distribution of any landscape in the area is directly related to soil dynamics and characteristics.

Keywords: Landscape, soil morphology, salinity, satellite image, digital map, Lower-Cheliff.

INTRODUCTION

The study of landscapes is regarded as an important information, for the evaluation of surface layers dynamics and the comprehension of the independent factors, which are responsible for any kind of degradation that can occur. The knowledge of these layers and their main component on a large scale remains always difficult and often not providing sufficient details to know their properties and to understand the operating mechanisms of the soil such as salinisation (Mulder et al,2011).

The plain of Lower-Cheliff located in the north west of Algeria is known with a variable dynamics of its surface layers under the direct influence of soil salinisation which occurs on different levels (Khan et al, 2001) (soil, vegetation) either throw irrigation (secondary salinisation) or coming from underground layers (primary salinisation).

The realized works in the area has all been unanimous to say that the soil salinisation which does not cease extending spatially and increase temporally, according to (Douaoui et al, 2006) is the leading cause of this degradation which appears by the deterioration of the vegetation cover and the water and soil resources (Fernandez et al, 2006).

McBratney et al, (2003) proposed a framework for the predictive digital mapping of the ground surface by considering the environmental variables (morphology, vegetation, lithology…). In the same direction, Boettigger et al, (2008) showed efficiently the utility of the satellite images to determine the characteristics of the surface layers named "landscapes" in arid regions with the presence of a moderate vegetation cover.

This work, aims to characterize and to map surface layers mainly landscape patterns; to know their spatial distribution in the area and their relationship to the digital data and the extracted parameters from the used digital elevation model (DEM).

MATERIAL AND METHODS

Material studied

We used two types of digital data downloaded from (http://earthexplorer.usgs.gov), the first is a satellite image of LANDSAT TM5 type with seven spectral bands covering the whole study area (Table 1) the second type is a digital elevation model which expresses the two morphologic data (elevation) for the studied region (figure 2). We validate the chosen patterns in the study throw a field mission. The image was taken during a vegetation season where the red color refers to the vegetal cover in the area (spring) 04/08/2013

Figure 1 - The LANDSAT TM 5 image of the study area

While most of the satellite data are provided with digital accounts geometrically corrected and to better map each targeted pattern in the area we proceed to an atmospheric correction in order to prevent any atmospheric noise (Browing & Duniway, 2011) and to convert the digital accounts into reflectance values.

Table 1 - Characteristics of the used satellite image

Scene ID	Band Combination	Acquisition Date	Resolution
LANDSAT TM5	Red → B4 (NIR) Green → B3 (R) Blue → B2 (G)	04/08/2013	28.5 meters
NIR: Near Infrared, R: Red, G : Green			

The used DEM was established in 08/11/2013 with 24.5 meter of resolution and was converted into elevation values in meter.

Study Area

The Lower-Cheliff known as "The Saline ground" (Douaoui et al, 2006) is located in the north west of Algeria at 220 km from the capital Algiers (figure 3), it is the west part of the grand Cheliff basin and extends on more than 50000 hectare.

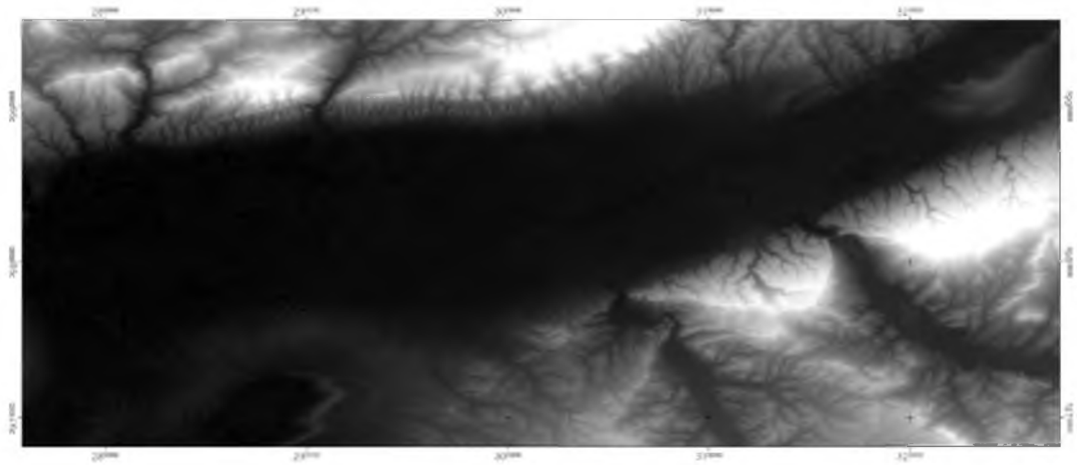

Figure 2 - The extracted DEM for the study area

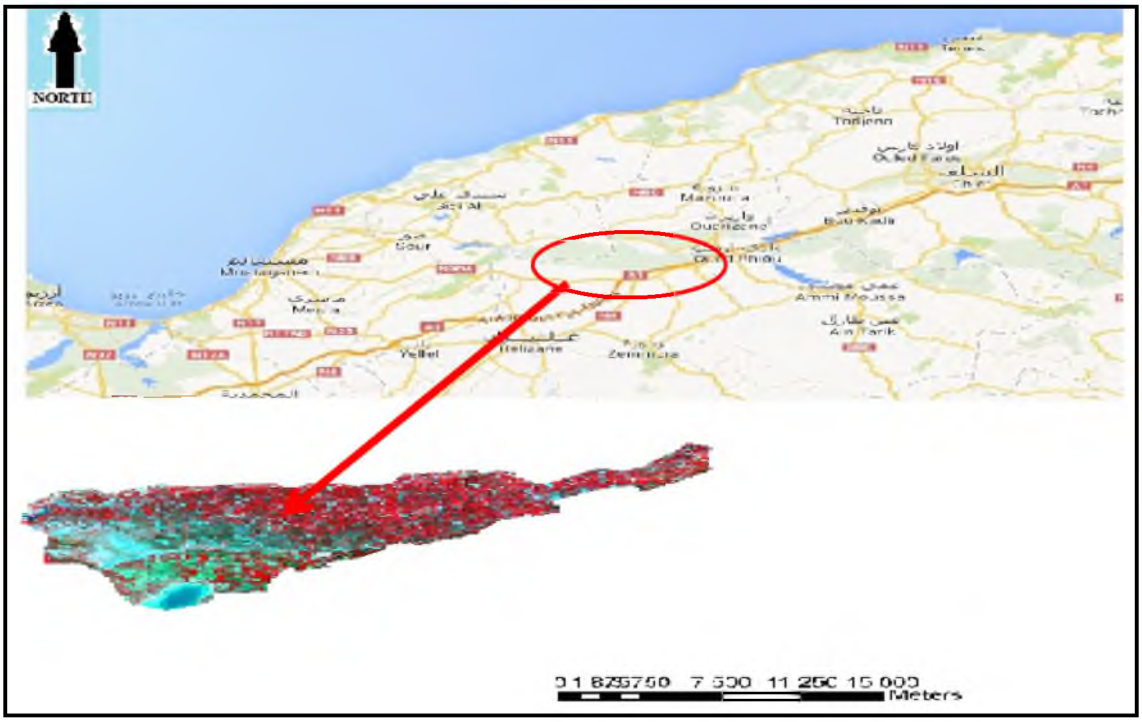

Figure 3 - The location and delimitation of the Study Area

Our area is characterized by a semi arid climate with hot and dry summers, cold and warm winters also by various types of soils which are in most clayey to the east of the plain with low percentage of loamy and sandy to loamy to the west side, cropping systems are focused in areas where salinisation is low or even null such as Ouarizane, Djediouia and some parts of H'madena, there are places where plants life is critically impossible such as the extremly saline depression of Gaa where we can find a stretched presence of halophytes, other zones know instable agricultural practices threaten also by the harsh weather there, the area lies on a large extension of degradable soils named bare soils under the continuous influence of salinity concentration in space and time (Mokhtari et al, 2012).

METHODS

Atmospheric correction

This correction is based on converting digital number of each pixel of the image into spectral radiance (USGS, 2001) then to convert the radiance values to surface reflectance in order to eliminate the atmospheric noise on the surface patterns:

$$L\lambda = \left(\frac{Lmax - Lmin}{Qcalmax - Qcalmin}\right) x\ (Qcal - Qcalmin) + Lmin \dots\dots\dots\dots (1)$$

where the LMINs and LMAXs are the spectral radiances for bands at digital numbers 1 and 255, respectively, and QCAL = digital number (Chander et al. 2009).

$$\rho = \frac{\pi . L_{\lambda} . d^2}{ESUN_{\lambda} . \cos(SZ)} \dots\dots\dots\dots\dots\dots\dots\dots\dots (2)$$

where

p = planetary TOA reflectance [unitless] (Chander et al. 2009)

Lλ= spectral radiance at the sensor's aperture in [W m −2 sr −1mm −1]

d^2= the square of the Earth-Sun distance in astronomical units = [1 − 0.01674 cos(0.9856 (JD-4))] 2, where JD is the Julian Day (day number of the year) of the image acquisition

ESUNλ= mean solar exo-atmospheric irradiance in [W m −2mm −1]

SZ = sun zenith angle in radians when the scene was recorded.

We processed the data throw ENVI 4.8 platform using specific tool for LANDSAT calibration.

Classification Process

We chose to use the supervised classification because of our previous knowledge of the field and because we are targeting landscape patterns we adopted the algorithm of "Maximum Likelihood" as recommended by Girard & Girard, 1999, while it deals with pixels that belong to the same pattern in a narrow error possibility, the validation was done by calculating the KAPPA coefficient which was more than 0.99 (99.17 % precision). This allowed us to have a sum of classes that cover the main surface layers in the area (Fig.5)

DEM processing

According to Arrighi et Soille, 1999, we need to extract the elevation from the used DEM using the "Spatial Analyst" tool in ArcGis software where we will have an independent map for elevation with values in meters and clipped as for the satellite image.

The Overlay image / DEM

To answer the problematic we needed to combine the results of classification scheme with the extracted morphologic parameters, this was done using ArcGis platform giving the viewer the possibility to see in 3D the spatial distribution of the morpho-landscapes in the area.

RESULTS AND DISCUSSION

Elevation extraction

The aspect plain was given to the area because of the low variation of morphology especially in term of elevation (figure 4) The plain of Lower-Cheliff has low altitudes with a predominance in the depression of Gaa (30-40 m) and some surfaces near to Hmadna (45-55 m), Djedioula and even Ouarizane (50-60 m). In the east of the plain and on its peripheries, elevation increases to reach the 140 m on the level of the hill of division. The Hill of Benziane reaches altitudes which vary between 70-120 m. In a general, Except the zone of the hill of Benziane, elevation is low in the western part of the plain and increases proportionally towards the east.

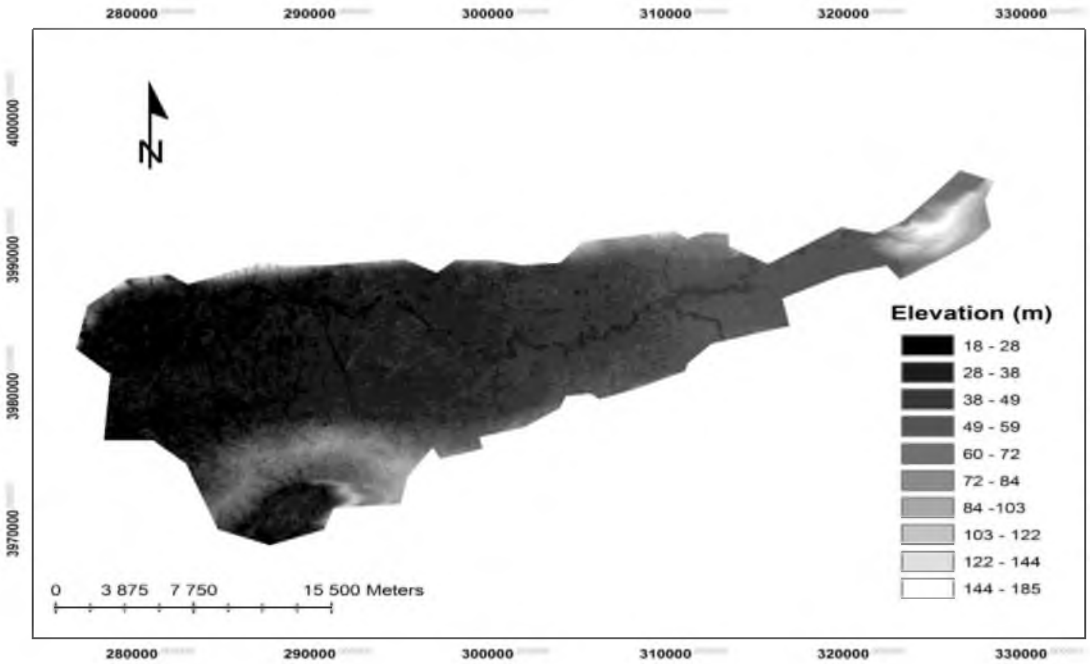

Figure 4 - Elevations map of the Lower Cheliff plain

Classified Map

Nine classes were obtained, where four classes represent the vegetation (Halophytes, Trees, cereals, garden), two classes for the agricultural vegetation (dense and average dense), two classes for the soil (Bare and plowed soils), two classes for water (the free water surface and the Cheliff wadi), and a class for the sebkha.

These classes are obtained during a spring period where all patterns of landscape can be detected especially vegetation.

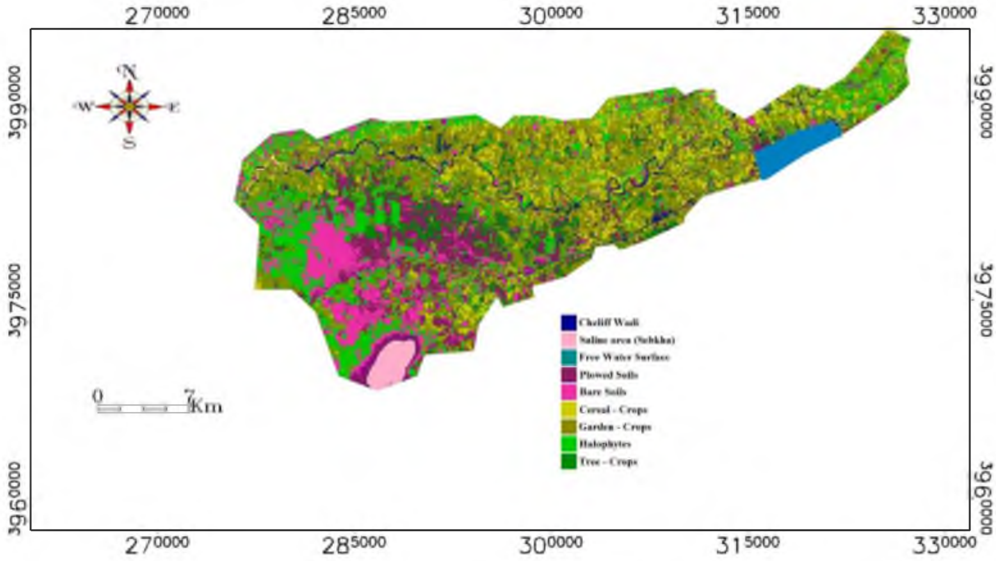

Figure 5 - Classification scheme of the main landscapes in the study area

Overlay DEM/Image

To see the natural distribution of the area based on terrain morphology we overlaid the digital elevation model on the satellite image (figure 6.1) giving a 3D visualization of the study ground there.

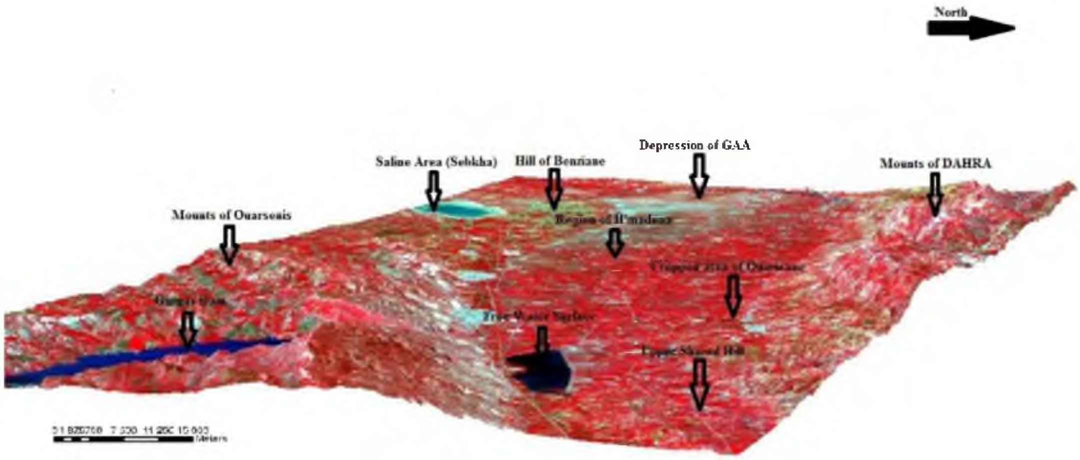

Figure 6.1 - 3D visualization of the study area morphology

Overlay Map/elevation

Most of the landscapes are on similar elevation levels such as bare soils and halophytes plants which occupy in general the very low altitudes called "depression" following the high levels of salinity in the area, in second position plowed soils and garden crops are mostly in mid altitudes where farmers find good conditions to practice there, the famous agricultural cropping systems such as Tree cropping and cereals take place in low and mid altitude where salinity is very low or null, the moderate altitudes in the area include an heterogeneous distribution between Trees, cereals, plowed soils and even a small part for bare soils (figure 6.2). The Free water surface in the plain called "Merdja" is the result of water collection due to soil structure which is clayey and compact, it is located in mid altitudes.

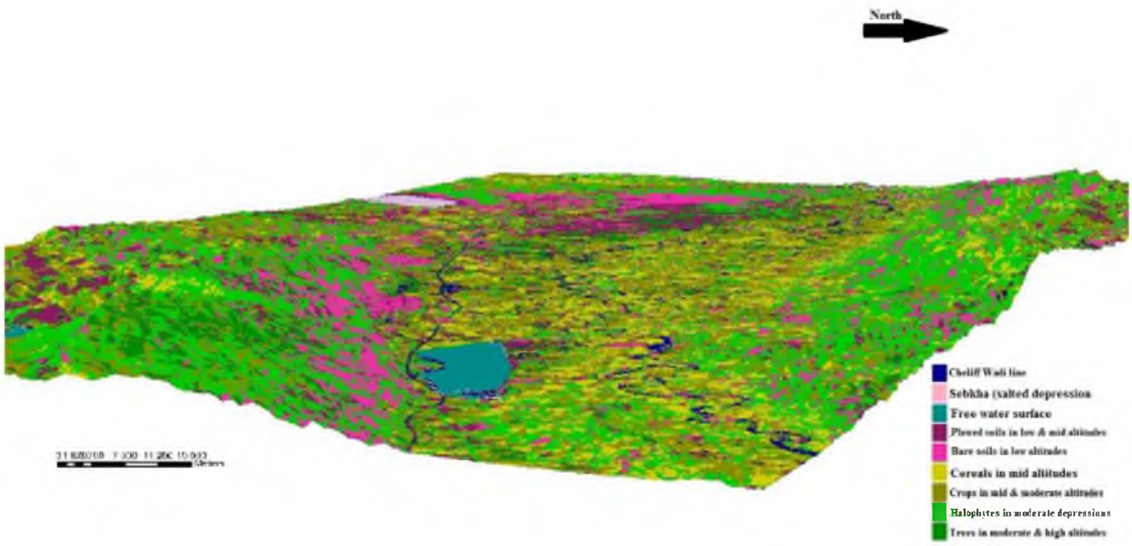

Figure 6.2 - Digital map of landscapes morphology in the area (3D Visualization)

CONCLUSION

The combined use of a satellite image and DEM was of big benefit by giving us the possibility to locate the main landscapes patterns in the area throw classification process then to see their distribution at different levels of elevation in the area, where we can define a limitation of their extension in term of altitude Z (table 2)

Table 2 - Limitation in altitude for landscape classes

Landscape Class	Altitude limitation (meter)
Plowed Soils	65 > Z > 40
Bare Soils	40 > Z > 18
Cereals	78 > Z > 35
Gardens	70 > Z > 55
Halophytes	55 > Z > 18
Tree	122 > Z > 65

This results can be extended by confronting the digital data either from the image or the DEM to field sampled data under the purpose of establishing a relationship between, the field, morphology and digital processing by creating a database that can help in studying the variability of the surface patterns in space and time and to see which influence has the topography on them.

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РЕЗЮМЕ

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СОЗДАНИЕ ЦИФРОВОЙ КАРТЫ ЛАНДШАФТОВ НА ОСНОВЕ МОРФОЛОГИИ ПОЧВ РАВНИННОЙ ЧАСТИ НИЖНЕГО ЧЕЛИФА (АЛЖИР) НА ОСНОВЕ ПРИМЕНЕНИЯ ДИСТАНЦИОННОГО ЗОНДИРОВАНИЯ

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Равнина Нижний Челиф является одной из наиболее изученных Северо-Алжирских районов с точки зрения почвенной и водной динамики в пространственном или временном аспектах, но недостаточно изучена в плане ландшафтов, главным образом связанных с растительностью. Здесь, в этом коротком исследовании, мы использовали цифровую модель рельефа для определения морфологии почвы на исследуемом участке, в основном, склоны и высоты, с тем, чтобы затем получить и классифицировать различные типы ландшафтов с использованием метода контролируемой классификации, применяемой на спутниковых изображений типа LANDSAT TM, чтобы представить пространственное распределение основных морфо-ландшафтов на цифровой пространственной карте. На основе анализа изображения выделены следующие классы: зерновые -с/х культуры, древесные культуры, садовые культуры в восточной части, солянки и голые почвы в западной части. Цифровая модель рельефа показывает, что изменение высоты не так важно, как уклоны, но оно по-прежнему контролирует распределение ландшафтов на равнине в соответствии с наложением сочетания высот / ландшафтов: солянки и голые почвы находятся в низких высотах, в так называемых депрессиях, следуя за степенью засоления почвы на этом уровне, другие культуры находятся в средней части на больших высотах, вдали от засоленных почв, которые ставят под угрозу сельскохозяйственные работы в этой области, и, наконец, мы можем сказать, что пространственное распределение любого ландшафта в районе, непосредственно связано с динамикой почвы и ее характеристиками.

Ключевые слова: ландшафт, морфология почвы, засоленность, спутниковое изображение, цифровая карта, Нижний Челиф.

ТҮЙІН

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ТӨМЕНГІ ЧЕЛИФТЕГІ (АЛЖИР) ЖАЗЫҚ ЖЕРЛЕРДІҢ ТОПЫРАГЫНЫҢ МОРФОЛОГИЯСЫ НЕГІЗІНДЕ ЛАНДШАФТАРДЫҢ САНДЫҚ ЖҮЙЕДЕГІ КАРТАЛАРЫН ҚҰРАСТЫРУ: ҚАШЫҚТЫҚТАН БАЙҚАУДЫ ПАЙДАЛАНУ

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Төменгі Челиф жазықтығы кеңістікті немесе уақытша буындардағы топырақ және су динамикасы тұрғысынан солтүстік Алжирдің барынша зерттелген аудандарының бірі, алайда өсімдіктермен байланысты ландшафтар тұрғысынан жеткілікті түрде зерттелмеген. Мұнда, қысқа зерттеуде біз бақыланатын учаскеде, негізінен жарлар мен құздардың топырағының морфологиясын анықтау үшін сандық жүйедегі үлгі қолдандық. Өйткеиі, бұл кейіннен LANDSAT TM типті спутниктік бейнелерде қолданылатын бақыланбалы жіктеу әдісін пайдалану арқылы ландшафтың түрлі үлгілерін алып, жіктеу, сандық жүйедеге кеңістік картасында негізгі морфо-ландшафтардың кеңістіктік бөлінуі туралы түсінік алу үшін қажет. Бейнелер нәтижесінде алынған санаттар негізінен мынадай: астық-ауыл шаруашылық дақылдар, ағаш мәдениеті, учаскенің шығыс жағындағы бау-бақша мәдениеті, батыс бөлігіндегі сораң және тақыр жерлер.

Бедердің сандық жүйедегі үлгісі еңіс секілді биіктіктің өзгеруі соншалықты маңызды емес екенін, бірақ ол үйінді, үстірт/ландшафтарға сәйкес жазықтықта ландшафтың үлестірілімін бұрынғыша бақылайтынын білдіреді: сораң және тақыр жерлер әдетте ойпат деп аталатын төмен биіктіктерде сортаң жерлерде орналасады, басқа дақылдар ортада жоғары биіктіктерде осы облыстың ауыл шаруашылық жұмыстарына қауіп келтіретін сортаң жерлерден жырақта орналасады. Аудандағы кез келген ландшафтың кеңістікті орналасуы топырақ динамикасымен және сипатымен тікелей байланысты.

Кілтті сөздер: ландшафт, топырақ морфологиясы, сортаңдану, спутниктік бейне, сандық жүйедегі карта, Төменгі Челиф.