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# Integrated Remote Sensing and GIS Applications for Mapping diverse Landscapes and Potential Touristic Destination in Zarzis, Tunisia

***Faiza Khebour Allouche[1], Dalel Ouerchefani Bouzaida[2], Amal Laarif Souguir[3], and Abd-Alla Gad[4]***

[1]Assistant Professor, Departement of Horticultural Sciences and Landscape-ISA-CM - IRESA - University of Sousse, Tunisia

[2]Researcher on Eremology and Combating Desertification Laboratory IRA - Médenine, Tunisia

[3]Engineer of Landscape Architecture - ISA - Sousse, Tunisia

[4]National Authority for Remote Sensing and Space Sciences, Cairo, Egypt



**ABSTRACT:** This study aims to present the benefits of a new methodology based on geographic information systems and remote sensing techniques for the identification and classification of Mediterranean landscapes. The approach has been applied to a coastal region of South East Tunisia: the Zarzis region. It is based on the combination of different satellite Landsat-8 image processing, namely supervised and unsupervised classifications and calculation of radiometric indices. Thematic maps and validation of results by Google Earth images have permitted, in a second step, to offer a touristic destination and geolocation of few stations encompassing representative of the area landscapes. This study presents an innovative methodological approach based on remote sensing and GIS to map the types of landscapes in Zarzis region. This approach may be useful in landscaping projects and as an efficient tool to develop a touristic destination by highlighting each type of landscape.

**KEYWORDS:** GIS, remote sensing, indices, landscape, touristic destination.

## 1 INTRODUCTION

Tunisia is a southern Mediterranean country that is characterized by remarkable and exceptional landscapes diversity perfect for ecotourism activities. To enhance and preserve these valuable landscapes, there is an urgent need to first identify them. The variability of Tunisian ecosystems spanning mountainous regions, coastal areas and wetland, offer the visitors a range of colors, infinite seasonal varying landscape harmony, shaped by nature and man.

Southern Tunisia is among the Tunisian regions having natural and cultural potentiality. In order to highlight the natural wealth of southern Tunisia, the study focuses on Zarzis region, this remains an unknown destination. Located ten kilometers from the archipelago of Djerba, it is one of the “richest” regions both for the virtues of its "natural" landscapes and for its historic patrimony for centuries. The identification of the different landscapes of Zarzis by remote sensing tools will enhance the visibility of landscape diversity possessed by this region. The relationship between landscape and tourist attractions representations will be addressed through a theoretical study and the development of a methodological approach as remote sensing and GIS.

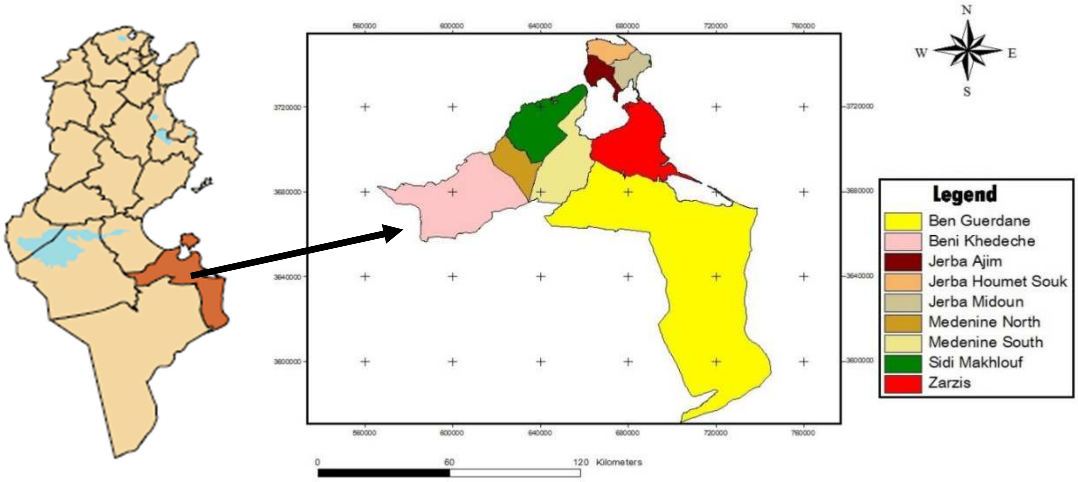



***Figure1. Location map of Study area***

According to Viviane (2007), the landscape consists of an objective party: the physical media landscape, a subjective, relative to the sensitivity of the observer and linked to his past, its cultural, moral influences and aesthetic, individual and societal criteria. In this context Zhixiao *et. al* (2011) defined the concept landscape as "The landscape is not the simple addition of disparate geographic elements". That is, a certain portion of space, the result of the dynamic combination, so unstable, physical, biological and human elements that is dialectically interacting each other to make the landscape a unique and indivisible whole constantly changing". The definition of the European Landscape Convention refers to the landscape as "an area perceived by people, whose character is the result of the action of natural and / or human interrelations" also appears to share this approach that the landscape does not reside or just in the subject, nor only in the subject but in the interface between the two (Passaro and De Joanna, 2014). Moreover, in this definition, the landscape is not compared to the territory, but on a perception of the territory, the distinction is thus made between landscape and resources that compose (soil, forests, buildings, *etc.*).

Being perceived as an area within aesthetic dimensions, socio-economic, cultural or ecological, landscape services can produce several orders. It may thus be represented as a space for recreation, a supplier of history, legend and typical images, a space of agricultural or forestry use, a natural ecosystem, a reservoir of genetic diversity (biodiversity) *etc.* (Chander *et al.* (2009) and Updike & Com (2010)).

According to Michelin (2005), it is essential to address both the functional dimensions, technical, social and cultural landscape in order to integrate it in a development project. According Fabienne *et al,* (2007), representations of the landscape are the aesthetic matrix that governs our appreciation of it and the perception of a landscape is none other than the optical operation of our brain combined with socio-cultural images. The tourist attraction can be defined as a perimeter for recreation that are the subject of a stronger attraction than others, leading to a concentration of attendance at these points.

## 2 STUDY ZONE

The study area belongs to the governorate of Medenine, located at the South-east of Tunisia. It occupies a privileged geographical position in the middle of the Mediterranean basin and covers an area of 9.167 km² (5.9 % of Tunisia total area and 10 % of the southern region). The island of Djerba and Zarzis are the two regions of the Governorate that allowed the region to be an international touristic destination. Zarzis is located about 80 km from the borders with Libya. It has a very wide coastline, occupying almost 867 square kilometers, or 9.5 % of the governorate area. Its location reflects a strategic importance as one of the most important diversified economic area (touristic, agricultural, industrial, Fish culture, *etc.*). However, the urban environment is inhabited by 70 % of the population and occupies 34 % of Zarzis area of (Figure1). In addition to its touristic potential, the area is also known by the diversification of its industrial, craft, agricultural and fishing and the diversification of natural resources such as water resources, rangelands, historical and cultural patrimony. Its development is based primarily on tree crops, livestock, fisheries and aquaculture.

The physical environment of Zarzis is composed of the coastal plain of the Jeffara representing a transition zone between the Saharien and the Mediterranean parts. This region is classified in the lower arid bioclimatic stage that undergoes the interaction of Saharan winds, dry, warm and more humid Mediterranean winds. Belonging to the southeast of Tunisia, Zarzis is considered among the areas affected by desertification and drought.

Agricultural activity in the area of Zarzis is the most dominant activity, despite the difficulties that limit the development of this sector such as low rainfall and soil type. It is based mainly on olive trees. Arable land is mainly occupied by the tree and the rest of the area is occupied by cereals, vegetables and legumes that are traditional crops with low yields. Industrial activity in the delegation of Zarzis is based mainly on the food industry in particular as regards olive growing and processing of seafood, and the building materials industry, ceramics and glasses. The business park, the commercial port, the Djerba-Zarzis airport and the road network in the region of Zarzis, facilitate export trade and exchange of food products with neighboring countries, resulting the vitality of the food industry (Laroussi, 2011). The Southern region has experienced very rapid development of the tourism sector, with its long coastline of 480 km, its desert areas, cultural, craft traditions and archaeological wealth. However, the tourism sector is among the most dominant activities in Zarzis region, because it has many natural advantages that make it one of the most important tourist cities of southern Tunisia. It collects various geographical units with a mosaic landscape, where you can admire the specific economic, agricultural, archaeological (e.g. Roman ruins and mosques), cultural (marriage traditions, traditional crafts, culinary traditions). Zarzis Tourism is mainly seaside tourism, with 50 km of beaches and mild hotel infrastructure. A large number of companies in the Zarzis region are oriented towards tourism activities such as car rental agencies, travel agencies, banks, crafts, *etc.*

## 3 MATERIALS AND METHODS

Analysis of satellite imagery is intended to provide an initial mapping on a very general typology of landscapes. Thus, basing on a methodological approach using satellite image processing principles, various steps were applied.

### 3.1 DATA COLLECTION

The satellite image Landsat 8 (Path 190-Row 37) with OLI sensor taken on April the 2$^{nd}$, 2014, having a relatively good spatial resolution (30 m) is used. Moreover, the images available via Google Earth Pro have also been used for the work of photo-interpretation requiring high spatial resolution, particularly for supervised classification. Other digital data were used as the vector layers of agricultural map of the governorate of Medenine provided by the ministry of agriculture.

The Landsat image is radio metrically corrected, using ENVI 4.6 software. These radiometric corrections are applied to the image to reassign each pixel the nearest possible value to that measured in the field (Emran, 2005). The proposed software that offers a wide range of multi-image and hyperspectral analysis tools automatically corrects the image radiometric reflectance "Top of atmosphere" from the metadata file that accompanies Landsat images (Bendenidina, 2008). However, no spectral filtering has been made since sought to highlight all of the existing landscape in this area of study. For example, marine environments, which have distinct spectral characteristics related to the presence of water, were taken into account, such as saline, the sebkha, *etc.*

Vector layers were retrieved from the database of the agricultural map of the governorate of Medenine (CRDA Medenine, 2009). They were used in the creation of thematic maps of the Zarzis region.

### 3.2 IMAGE PROCESSING

According to Girard *et al.* (1999), the interaction between radiation and matter is one of the remote sensing images interpretation bases. Indeed, an object at a given time in a given location, viewed from a certain angle and receiving a given solar radiation has its own spectral behavior. Thus, the spectral signature of the components of a given landscape varies in space and time. The aim was thus to highlight the major types of landscapes in Zarzis area through remote sensing, to obtain a mapping of major landscape units that characterize this region.

Image processing in remote sensing is of major interest to study the components of a landscape such as soil or plant and characterize large landscapes (Chaari, 2013). Unsupervised image processing, prepared in advance, was achieved via Envi 4.6 software in order to have an overview of the landscape organization at Zarzis region of. The pre-zoning typology is based solely on the analysis of reflectance and signal spectral characteristics emitted by the various components of the studied areas. However, to have a more precise zoning of landscape units and a more precise landscape typology, a second treatment was privileged: the supervised treatment. Validating areas of interest (AOI) was conducted through Google Earth helps to check the ground truth compared with data from the automatic satellite images processing. Once the control plots (plots or training) type of occupancy is checked, a spatial demarcation and allocation type of occupation will be enrolled in Envi4.6.

Two classification tests were carried out in the case of clustering, with the first six classes (minimum of 5 and maximum 6) and the second with 12 classes (minimum 11 and maximum 12). At this stage, it is necessary to define the number and type of classes. We try to identify relatively homogeneous image samples that are representative of different landscape types in the study area. The selection of the data is based on field data validation knowledge performed by Google Earth. Digital information for each band and each pixel of these sets are used so that the system can define classes and then recognize the regions with properties similar to each class.

### 3.3 Calculation of radiometric indices

The indices are multivariate analyzes, that is to say, treatment developed from multiple channels. This is often mathematical operations either to reduce the amount of information and / or highlight specific topics (vegetation, soils ...).

#### 3.3.1 Normalized moisture Index (INH)

The use of this index is justified by the observation that increasing the water content of a soil induces a stronger decrease in the luminance of wavelengths in the shorter wavelengths. The formula used for calculation of the Index Normalized Moisture Index (INH) is the following

**INH = (MIR Verde) / (MIR + Green)**

Where MIR: middle infrared band

#### 3.3.2 Normalized difference vegetation index (NDVI)

The NDVI is a function of the reflectance in the red and near infrared (Gilabert *et al.,* 2002). Indeed, the spectral response of vegetation cover shows a high reflectance in the near infrared and low reflectance in the red. These wavelength areas are therefore widely used as the reflectance difference in these two spectral bands depending on the characteristics of the vegetation chlorophyll (Laporterie, 2002). A relationship between these two bands is used to calculate a vegetation index, NDVI (Normalized Difference of Vegetation Index). The calculation of the NDVI is made from a normalized difference between near infrared and red channels since this index is a function of chlorophyll activity of plants. At first, a colored composition with TM2, TM3, TM4 channels is achieved by assigning the color blue to the TM2 band; green to the TM3 band; red color to the TM4 band. Within this combination of channels, vegetation appears red because it is more reflective in green or in the red, compared with other landscape components namely water, soils and rocks.

NIR = near infrared band

R = red tape

The formula used to calculate the vegetation index is the next available under the tool "Band Math" from the "Basic Tools" menu:

$$NDVI = (b1-b2) / (b1 + b2)$$

#### 3.3.3 Brightness Index

The brightness value is one of the most common indicators of soil conditions. It reflects changes of clarity in bare soil. The transition from dark colors to light colors is accompanied by a simultaneous increase in radiometric values in both red and near infrared channels (Baret & Hanocq 1993). Among the advantages of this index is that it allows the passage of three variables (the bands) to one (an index) and according to Dubucq (1989), it is the most significant parameter determining the behavior of soil regarding sand or salt presence.

The formula used to calculate the brightness index is as follows:

$$IB = \sqrt{((b1^2) + (b2^2) + (b3^2) + (b4^2))}$$

Where b1 = band 3, b2 = band 4, b3 = b4 = band 5 and band 6

The following formula is then used:

Sqrt ((float (b1) ^ 2) + (float (b2) ^ 2) + (float (b3) ^ 2) + (float (b4) ^ 2))

#### 3.4 VALIDATION

Mapping the landscape was derived from satellite images treatments coupled with validations on Google Earth. Field work is essential to geotag stop stations proposed in the tourist circuit. It is to locate, characterize and make the diagnosis of different backgrounds. Taking photos for each station is programmed. A Magellan GPS and a digital camera were used for these purposes, where data collection is based on meetings with resource personnel's ability to provide data on the stations. These meetings are done in administration and in the field and the retrieved information will be useful in the proposal of ecotourism circuit.

The occupation vector layers of soil and soil science recovered will be analyzed based on the input attribute tables. Thematic maps, derived from satellite images classification and computed indices, (e.g. NDVI and IB) will serve us to map the landscape of Zarzis.

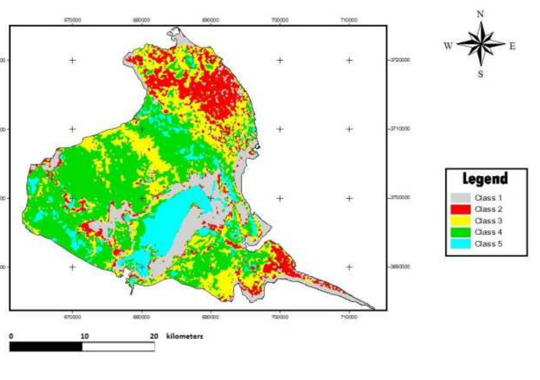
## 4 RESULTS AND DISCUSSION

#### 4.1 MAPPING ZARZIS REGION ENVIRONMENTS

Figure 2 shows that the area of this region is mostly occupied by olive groves and paths. These groves are associated with vegetable crops intercropped in northeast, southwest and southeast of the region. The courses are located around sebkha and the most natural environments are occupied by olive trees on isohumic soils or by steppes on sandy soils. Sebkha marks a halomorphic environment that occupies center and south of the area and the rest of the superficies is urbanized or cultivated. Poorly developed soils are scattered east, south-east, west and southwest of the region. Isohumic soils are soils rich in organic materials that form in temperate dry climate region. They give very fertile agricultural land, which is the occupation of the land by olive trees and other crops. The saline soils are soils containing high amounts of salts and occupy a large portion of Zarzis area (Figure 3).

#### 4.2 SUPERVISED AND UNSUPERVISED CLASSIFICATION OF SATELLITE IMAGES

Unsupervised classification highlights five environment classes in Zarzis region (Figure 4). Class 1 includes the communities located beside sea and sabkha "El Melah". The concentration of Class 2 in the northeastern Zarzis region and its southeastern dispersion are linked to the presence of cultivated areas. Class 3 is related to the presence of urbanized and less cultivated area. Class 4 corresponds to areas cultivated or occupied by natural vegetation. Class 5 is a wetlands area (sebkha, lake and water). However Figure 5 shows 4 environmental classes resulting from a supervised classification. Class 1 contains urban environments concentrated in the east. Class 2 includes the cultivated environment and olives. Class 3 includes sandy and salts accumulation environments. Class 4 corresponds to wetlands.



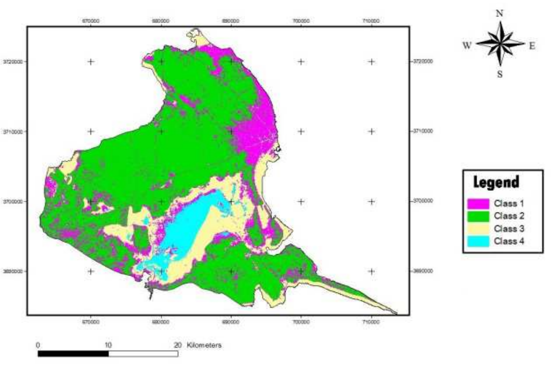




*Figure 4. Unsupervised classification map of Zarzis* *Figure 5. Supervised classification map of Zarzis*

### 4.3 THE RADIOMETRIC INDEXES

#### 4.3.1 MAP OF NORMALIZED MOISTURE INDEX (INH)

The humidity index is indicated in three INH classes: strong [-0.9783, -0.4688], medium [-0.4688, 0.0408] and low [0.0408, 0.3805]. Figure 6 shows that the low INH corresponds to the areas marked by the absence of water. Medium INH class is localized around the sebkha and saline areas at north, east and south. The strong INH is represented by El Melah sebkha and salt. According to the spatial distribution of INH classes, 75 % of Zarzis area is characterized low humidity index environments. While 14 % are wetlands and only 11 % are slightly damp.

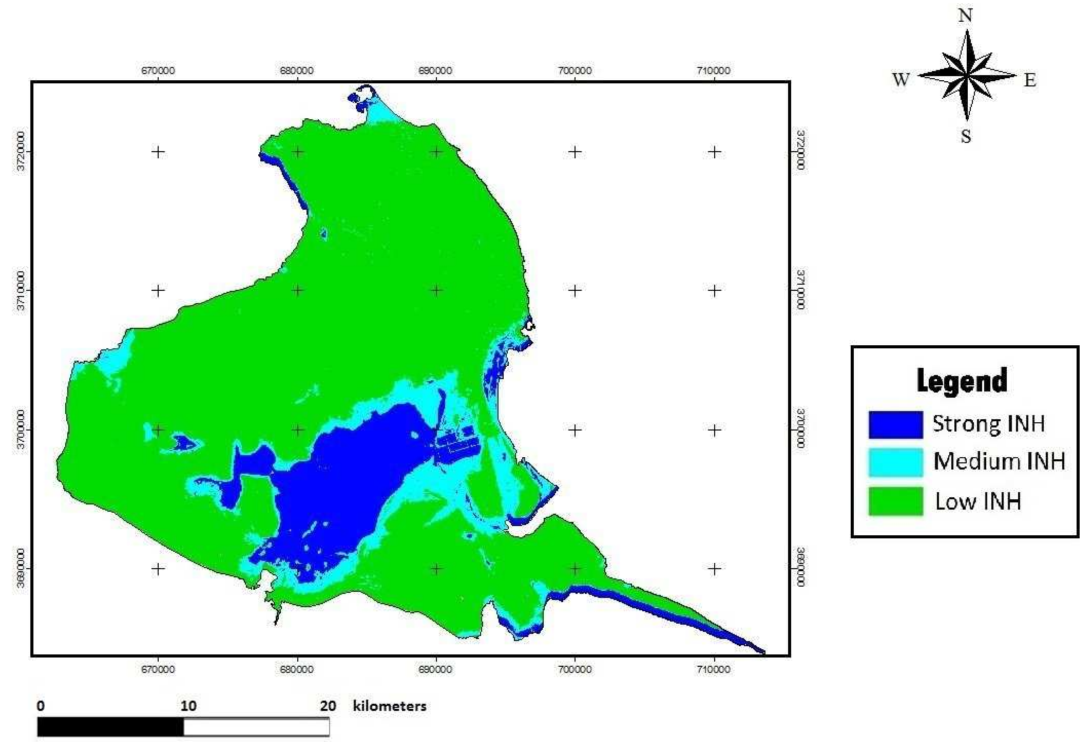



*Figure 6. Moisture index map of Zarzis*

#### 4.3.2 MAP OF THE NORMALIZED DIFFERENCE VEGETATION INDEX (NDVI)

The vegetation index is classified into five classes: high NDVI [0.5550, 0.2186] ; NDVI strong enough [0.2186, 0.0505] ; average NDVI [0.0505, -0.1177]; low NDVI [-0.1177, -0.4540] and very low NDVI [-0.4540, -0.7904]. The very low NDVI is concentrated in the center of the region, at the El Maleh sebkha and saline areas. It is also scattered on the northwest, east and southeast coast. This low value is due to the lack of vegetation. Low NDVI is concentrated at the sebkha, some tasks are noted especially on the south side of the salt and along the south-east beach. It can be explained by the presence of salt harvesting vegetation in this part. Average NDVI is mainly located south, southwest of the sebkha which explains a greater presence of vegetation. Strong enough NDVI plays a very important part of the region (85 %), almost all over land surface except the sebkha and some coastal parts. This index shows the presence of vegetation such as olive, steppe and other crops. High NDVI is found in small patches scattered mainly in the east and north. The spatial distribution of this class is related to the presence of large vegetation (Figure 7).

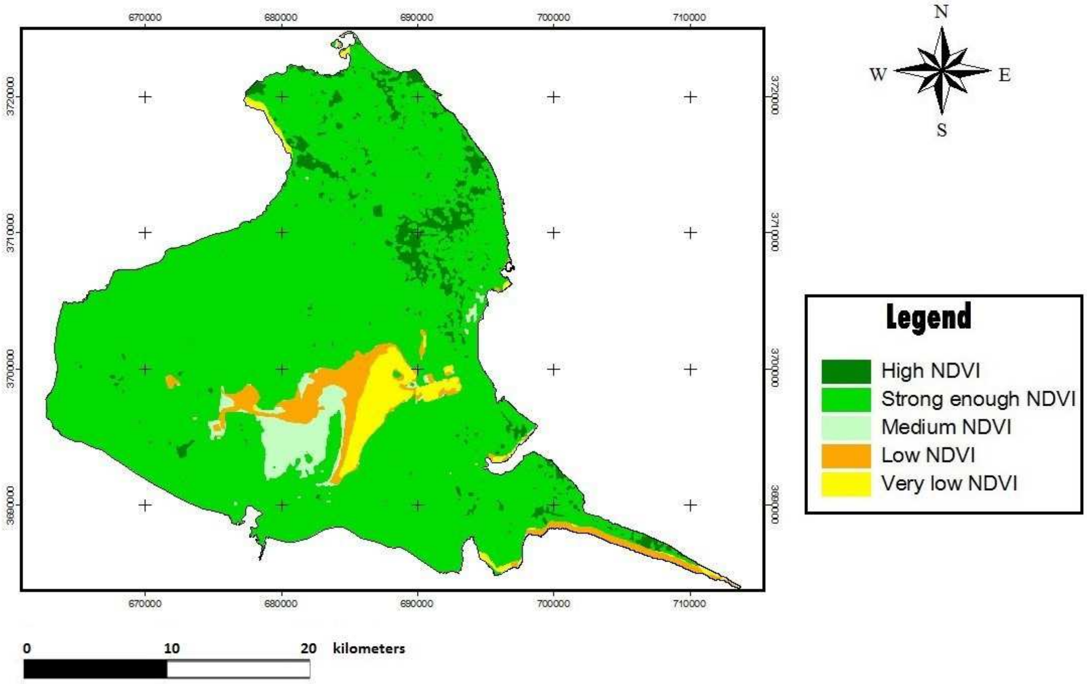



*Figure 7. Vegetation index map of Zarzis*

The very low classes, low and middle are related to the presence of Sebkha and salt while strong enough NDVI is explained by the presence of olive trees and other crops. However, high NDVI in the east can be explained by Souihel Oasis which is the most urbanized. The presence of average NDVI is due to a transition between absence and presence of vegetation on one hand and by the nature of the plant species which in this case is related to the halophilic vegetation.

#### 4.3.3 Mapping Brightness Index (IB)

Figure 8 shows that the study area is occupied by five IB classes. Areas of low IB [0.3038, 0.1013] almost predominantly in the Sebkha and scattered along the South-east and north-west coast. The mean IB [0.5064, 0.3038] areas are located arounds the sebkha and scattered to the north, west and south. This average is probably attributed to the presence of salts in soils. The distribution of IB strong enough [0.6077, 0.5064] opposes the foregoing, it is more condensed in north-east and south-east. This class is related to the spatial distribution of habitats. The strong IB [0.7089, 0.6077] is almost half (48%) of the total area region and can be explained by the increased silting covering the study area. The strong IB [0.8102, 0.7089] is located on the west side beach in the area, successively oriented to northwest and southeast. Thus, a concentration southwest side probably related to gypsum. The majority of Zarzis environments have high IB. While the average and the strong enough IB areas are almost equal in size (21 % and 22 %).

The least present media are those low-IB and IB strong. Comparing the map of the vegetation index and that of the gloss value, a first component which is determined by the vegetation index opposing brightness indices. It can be concluded that the floors covered oppose the bare and shiny floors. A second component which is determined by the brightness index associated with the vegetation index is a minor component determined by soils with low gloss value, with low vegetation index and very weak. This is the case of the Sebkha and the coast of the south east area.

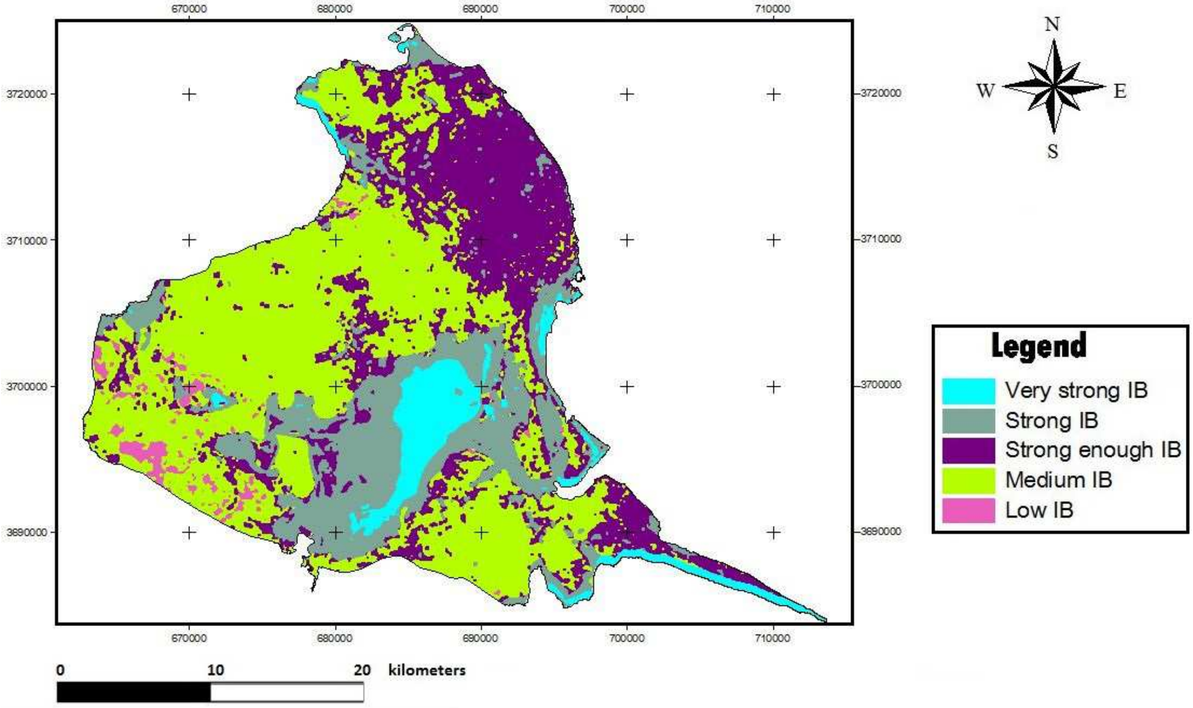



*Figure 8. Gloss index map of Zarzis*

### 4.4 MAPPING ZARZIS LANDSCAPES

Figure 9 shows that the Zarzis region is characterized by five landscape types. The coastal landscape stretches almost 80 km. The urban landscape, concentrated on the east and the north sides, occupies 34 % of the total area. Wet landscape (14 %) mark perfectly Sebkha locating (Sebkha El Melah and Sebkha Ain Maider). Natural landscape (11 %) includes steppes and rangelands. Olive landscape (39 %) and sanded olive landscape (8 %) occupy the largest superficies of Zarzis region.

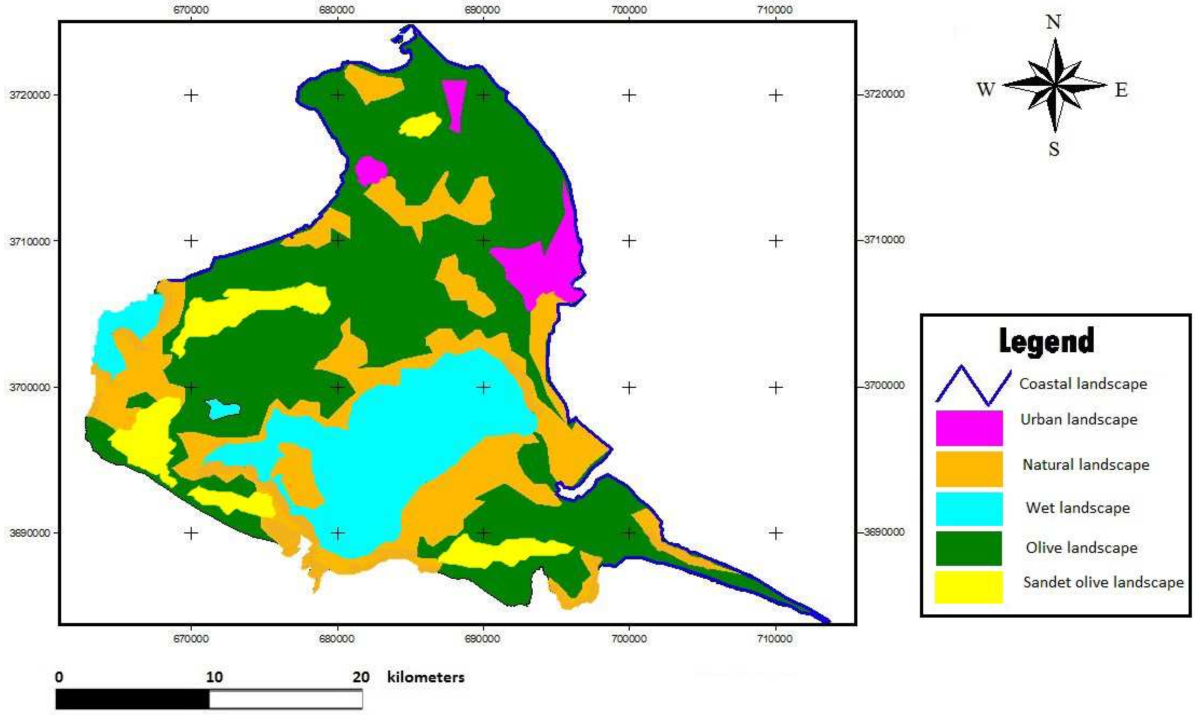



*Figure 9. Zarzis landscapes map*

## 5 TOURISTIC DESTINATION PROPOSITION INCLUDING LANDSCAPES

Given the importance deduced in mapping great landscapes types of Zarzis region, a proposal for a few stations to integrate into a tourist destination is presented including a station by landscape type.

- **Rsifett** (680436, 3714265) is a small village very old, located in Zarzis in the south edge of the "golf Boughrara" pool and on the main road Medenine Djerba linking El Kantara to Khallfallah. The components that mark this resort are the pool closed by the Roman road and the small fishing port. Among the best-known cultural activities is the annual Festival Rsifett which is a small entertainment festival, local folklore and the best product dish sea that attracts national and international visitors. Rsifett is a very nice place, hospitality and friendship with nature and well-being, still a virgin, with little urbanization, olive trees, wild bushes, travelers birds, flamingos, sunset on beautiful seabed ... the scenic attraction, ecological and bream dishes, wolves, grouper, squid, shrimp, are all factors that interest many visitors.
- **Ghrabet** (32671464 ; 3697406) : Sandy olive landscape of Grabet is marked by olive groves located in the sand dunes. A mixed landscape between natural and cultivated important phenomenon resulting from silting. It is characterized by the duality of multicolored sand dunes and olive groves: the golden yellow sand and green olives. However, access is not easy since there is no main road to access.
- **The Saline** (692270 ; 3699220) is built next to "Sebkha El Melah"; it extends over twenty kilometers and the salt layer can reach 20 meters in places. To exploit this resource, it is necessary to bring in seawater on the Sebkha. The salt stock dissolves and brine thus obtained is brought on saunantes tables where salt crystallizes with sun and wind. The color pink salts due to salt-tolerant algae, evapotranspiration ponds and harvesting salt and salt mountain that looks like a Ski track forming an attractive wet landscape.
- **Sakit Sola** (694086; 3714553) is located on the east of Zarzis region in Souihel and corresponds to a blank space, with a plunging panoramic sea views. Sakit Sola is rich in fauna and flora and characterized by olives tree, agave, and acacia and is a cultural and natural heritage of Zarzis region. Besides its natural beauty, this area is rich in historical elements, which Roman delimitations stones and small caves were found. In this place visitors can visit to the Eco museum, an ecoartistic

space called "Memory of the sea and the man". It is an exhibition space that recounts memory and history of the region for millennia.

## 6 CONCLUSION

The successive use of remote sensing and GIS has allowed the study and characterization of different environments of Zarzis area and to develop a map of the greatest landscapes of this region. This allowed assessing the contribution of remote sensing and mapping for the landscapes classification . The unsupervised classification provided a general classification of environments while supervised classification was less lighter but less accurate. Radiometric indices are calculated for the study of moisture, density of vegetation and bare soil in the area. Then by crossing all maps that landscapes of Zarzis are defined. This approach " remote sensing and mapping" aimed to develop new methodologies using surface imaging as an aid to the decision to give results that can be used to support the development of a touristic destination that highlights the potential landscape of Zarzis region.

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