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RESEARCH ARTICLE

MONITORING THE EVOLUTION OF THE LAND COVER OF OASIS THROUGH SATELLITE IMAGES. CASE: OASIS ZAGORA (MOROCCO)

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Abstract

The observation of environmental and climate change becomes an indispensable need for the management, monitoring and decision making in assessing the state of the Oases Systems which represents a world natural heritage that must be preserved and saved. The objective of this study is the detection of changes in land use in the Moroccan oases area, especially the dynamics of changing classes of vegetation, water and sand. Thus, an automated change detection and assessment process has been implemented based on a time series Landsat satellite imagery, covering the period of (1984-2015). The approach is to extract the information needed for change detection from satellite images, this process will be carried out based on the spectral index characterizing land cover (normalized difference vegetation index (NDVI), normalized difference water index (NDWI) and normalized difference iron index (NDII)) and later by realizing a diachronic analysis of the evolution of the territorial dynamics of Zagora oasis system.

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Introduction:-

The detection and monitoring of changes is a very important task in many environmental studies, especially the change in land-use, vegetation and water pattern are of major interest for landscape planning or climatologic studies (M. Schmidt et al., 2003). To ensure sustainable management of natural resources in the oasis environment, it is necessary to understand and quantify the processes of change of land use. It is also necessary to develop a better understanding of the causes of land use for effective against measures can be taken (Petit et al., 2001).

In this context, this study aims to implement an observation system changes and a territorial dynamics of oasis based on remote sensing, which is the most used in this type of research.

This system implements the following objectives:-

- ❖ Automate the chain of change detection to simplify the task of detection and to generalize to other areas.
- ❖ Observe and identify changes in the territory of the study and its main natural elements (water, vegetation, sand) through the satellite images of different periods.
- ❖ Measure the intensity of the phenomenon of desertification in the area following the development of the desertification sensitivity map.
- ❖ Produce relevant indicators to quantify and qualify the changes;
- ❖ Develop a specific GIS database that will include all the statistical and geographical information of the natural and human environment.

Study area's description:-

The oasis of Zagora province belongs to the southeast region of Morocco (Figure1), and extends over an area of 23 000km². The study is dedicated to the detection of changes in this region, accounting for a very frail element in the structure of ecosystems in Morocco, this due to its location 30 ° 19 '50 "North, 5 ° 50' 17" West and its hot desert climate (Koppen classification BWh.1900) typical of the Sahara with very long and extremely hot summers and short, moderately warm winters. The study area, which spans the province of Ouarzazate and Zagora, contains the largest dam in the area namely the Mansour Dahbi dam, that feeds the whole oasis area water resources.

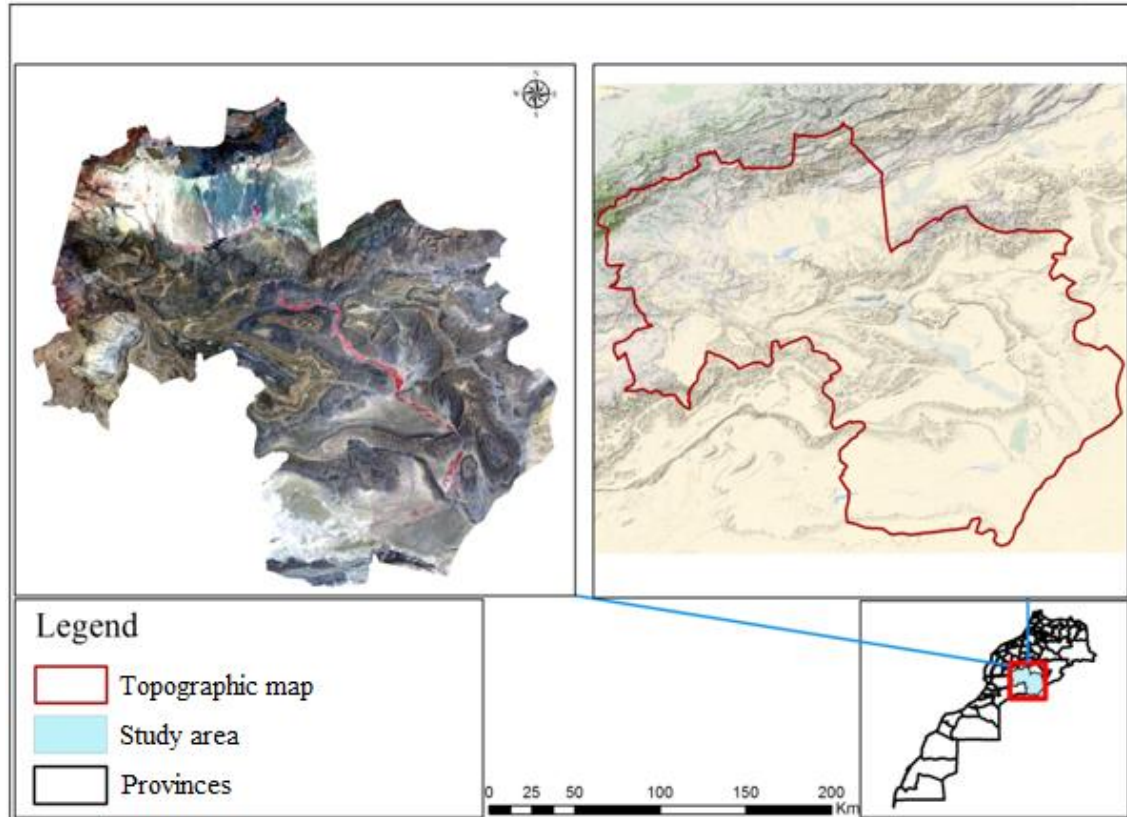


Figure 1:- Spatial localization of the study area

The climate is very dry all year since the annual average rainfall which is about 61 mm. In summer, the heat is extreme and takes a persistent nature: the maximum average temperatures are consistently above 40 ° C between late May and mid-September but rather revolve around 45 ° C during this period. In winter, maximum average temperatures remain above 20 ° C but the average minimum temperatures down to about 4 ° C overnight. The sky is clear and bright all year and overcast days are very rare, if they exist. The annual average daily temperature is around 24 ° C in Zagora (Table 1).

Table 1:- Zagora Climat, alt : 724 m (represents in °C)

Relevé météorologique de Zagora													
Mois	jan.	fév.	mars	avril	mai	juin	juil.	août	sep.	oct.	nov.	déc.	année
Température minimale moyenne (°C)	3,8	7,9	9,8	14,4	19,6	23,5	26,3	25,7	21,8	17,9	10,1	5,5	15,78
Température moyenne (°C)	12,1	16,1	18,8	22,7	28,4	32,2	34,9	34	30,3	26,2	18,9	13,2	24,06
Température maximale moyenne (°C)	20,3	24,3	27,8	30,9	37,2	40,8	43,5	42,2	38,8	34,4	27,7	20,9	32,34
Précipitations (mm)	4	3	5	1	2	1	1	3	6	13	15	7	61

Demographics:-

The rural majority provinces of Ouarzazate, and Zagora are considered with the prosperous regions northwest of Morocco, are generally characterized by low population density, a young population, a high reproductive rate and high mortality post native. The population growth in the Basin of Draa can be analyzed according to the national census data from 1994 and 2004 (Figure 2). The spatial distribution of the growth rate of the population is very heterogeneous. In some areas, the population growth has even reached a negative value. Apart from the influence of national and international migration, negative population growth are results of a regional migration. People migrate from the most marginalized regions to the municipalities increasingly urbanized zones, along the Draa and Dades rivers. These areas provide alternative incomes, particularly in the tourism sector and subsistence farming. Moreover, the most important point for regional economic development, is the urban center of Ouarzazate Tabount which recorded an annual population growth of 3.3% between 1994 and 2004. The 74 600 populations in 2004 represented 15% of the total population of the province of Ouarzazate. In addition to developing the tourism industry, the film industry - Ouarzazate is one of the most developed cities in this economic branch on the African continent - plays a crucial role in job creation (Direction of Statistics, 1995), (Haut-Commissariat au Plan, Centre de Lecture Automatique de Documents, 2005).

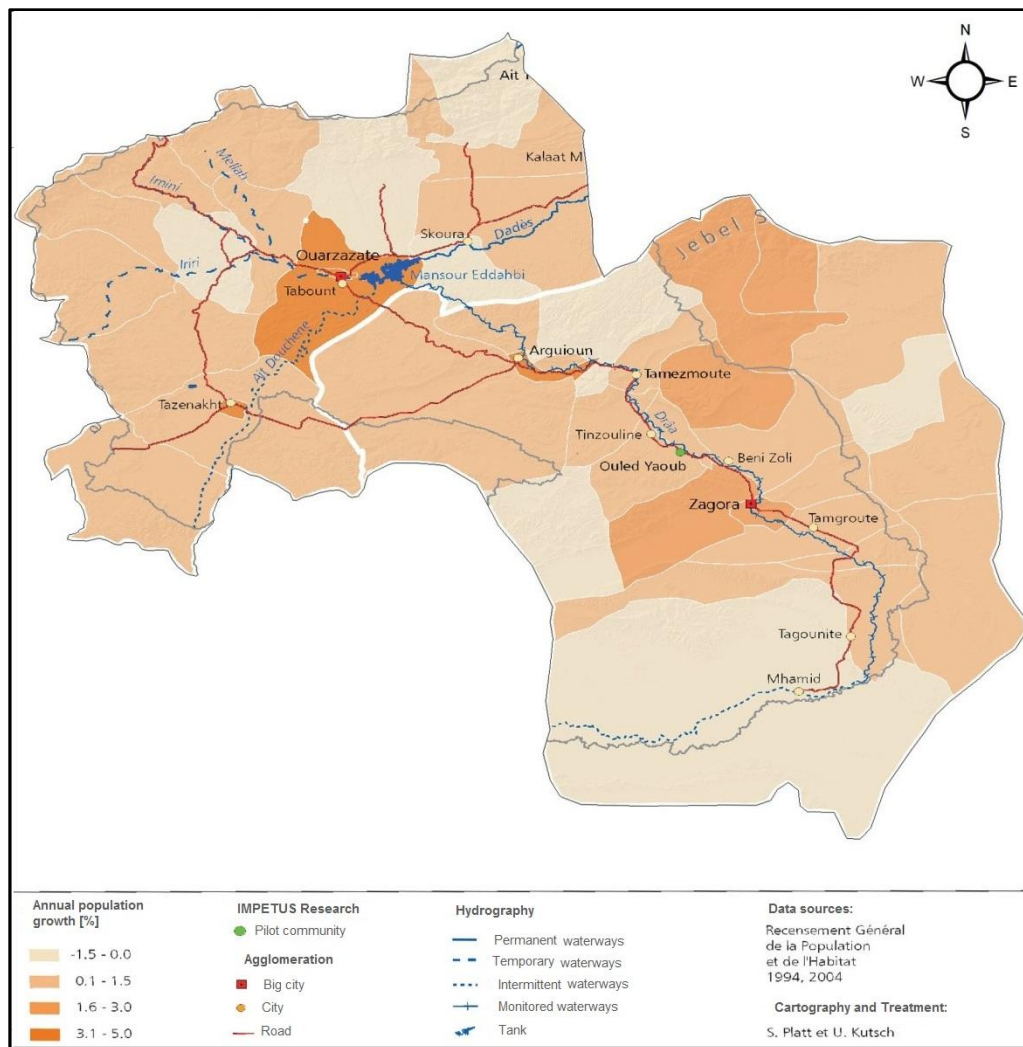


Figure 1 : Population distribution map in the province of Ouarzazate and Zagora.

Data and Materials:-

Data Acquisition:-

Landsat is the most appropriate for a remote sensing satellite project as change detection, it provides high-resolution images that are currently available on the Landsat archive accessible via free download sites like that of

the US Glovis Geological Survey, the University of Maryland and also. The advantage of it is that it features images of seventy years since the first satellite was launched in 1972 (MSS) and the last was launched in 2013 (Lands at8). It provides images, since 1972 until now, all the 16 days on the same area with a resolution of 30, each Land at image covers an area of 185*185km. (Table 2).

Table 2:- Data and data sources.

Data type	Year	Data provider
Lands at 5 TM	1984	U.S.G.S (GLOVIS)
Lands at 7 ETM+	2003	U.S.G.S (GLOVIS)
Lands at 5 TM	2010	U.S.G.S (GLOVIS)
Lands at 8 OLI	2015	U.S.G.S (GLOVIS)

Data preprocessing:-

Before exploiting satellite images in the different treatments that are needed, it was necessary to prepare and preprocess to eliminate defects of acquisition. In this respect, we can consider that the Lands at TM images have been largely fixes minimum pretreatments by the image provider (sensitivity between the detector elements of the sensor, panoramic effect, curvature and rotation of the Earth, etc.) but it is very clear that certain adjustments appear necessary.

To correlate the results with the terrestrial physical units, radiometric corrections are applied to both the sensor and the atmospheric effects. Various methods are used to convert digital values (DN) to the reflectance. The highest is the conversion method numeric (DN) to "So-Called apparent" or "at-satellite reflectance" by correction of sensor gains, the offsets, the solar radiation and the solar zenith angle, (Chavez, 1989), (Collins et al, 2000), (Bruzzone et al, 1997), (Price, 1987), (Masroor et al, 2013). However, these methods do not correct atmospheric effects can be significant (Collins et al, 2000). These atmospheric effects usually depend effects of Rayleigh scattering and Mie (Grover et al, 1999), (Tucker, 1979), (Sellers, 1985), (Turner and Malila, 1971). For this, various methods have been developed to remove these as the subtraction of dark objects (DOS) model (Chavez, 1989) – (Ahern et al, 1977), (Singh, 1986) the model Cos (t), the Apparent reflectance and Model others. The model Cos (t) was developed by Chavez (Collins et al, 2000) as an approximation technique which operates in such cases. It integrates DOS model elements (by haze correction) plus a procedure for estimating the effects of absorption by atmospheric gases and Rayleigh scattering.

The geometric correction: enables, among others, to give the image a geographical reference. So as not to complicate things, and since theoretically the images are already geo referenced and projected in UTM projection system, Zone 30 / spheroid: WGS 84 / Datum WGS 84, and since the study area is located in an area conflict on the cartographic map between zone 1 and 2 of the Lambert Conformal Conic system, we decided to keep them in first place in the projection system proposed by Lands at.

Data processing:-

With the spectra of training samples of water body, vegetation, and sand, we attempted to develop a normalized difference index to enhance sand information. A normalized difference index is typically applied to highlight the difference between the strongest and weakest spectral responses of a target sand cover. NDVI, as an example, was developed to highlight the difference of the spectral responses of vegetation at the red and near infrared bands. Unfortunately, such characteristically strong or weak spectral responses do not exist for sand due to its complex physical and chemical compositions, as well as regional differences. Therefore, the first task is to find out the band combinations to construct a normalized difference index for sand covers.

The first part describes the processing time series after reconstruction, which aims to extract information about changes. It comprises firstly applying a chain of image processing that aims to extract information and locate changes in the oasis; initially this process is used to extract the vegetation data based on the calculation of the NDVI, which is most used for the detection of changes in vegetation level (Tucker, 1979), (Sellers, 1985), (Singh, 1986), (Running et al, 1986) and (Lyon, 1998):

The Normalized Difference Vegetation Index highlights the difference between the visible band of the red and near infrared.

$$NDVI = \frac{NIR - RED}{NIR + RED}$$

This index is sensitive to the rigor and amount of vegetation. The NDVI values between -1 and +1, negative values corresponding to surfaces other than canopies, such as snow, water or clouds where the reflectance in the red is greater than that of near infrared. For bare soil reflectance being roughly the same magnitude in the red and near infrared, NDVI has values close to 0. The vegetation in turn, have positive NDVI values generally between 0.13 and 0.7. The highest values corresponding to the densest canopies.

The same method will be applied to define the water body except that the index used in this approach is the index of normalization of the difference in water "NDWI", it was developed by McFeeters in 1996 (McFeeters, 1996) under form of the following equation:

$$NDWI = \frac{GREEN - NIR}{GREEN + NIR}$$

Where the GREEN and represent NIR reflectance bands Green and Near Infrared. The NDVI–NDWI index (Shanlong, 2011) is used to enhance the contrast between water bodies and the surrounding surface features.

Then we define the area occupied by the sands, that the use of the iron index (IF) (SoeMyint and Kyaw, 2005) because the sand is rich in iron which gives it its red color that can be identified visually on Lands at images, bands red and blue combination serves as a better alternative as it can adequately enhance the sand information so we define the normalized difference iron index is as follows:

$$NDII = \frac{RED - BLUE}{RED + BLUE}$$

Recently we set a threshold empirically to extract each layer (Foliage, body of water, sands) and separate those from other different components of land use through visualization of the results of different indices.

Also to extract the degree of change from each theme (Change Positive Negative change or no change), we will rely on the difference image, this method is based on the subtraction of two index images from two different dates T1 and T2 from the same area.

$$DI = Im_{T2} - Im_{T1}$$

The second part is devoted to the methods used to validate the results obtained, both in the pretreatments as images treatment. The whole pre-treatment and treatment chain of the multi-time series of Lands at image is implemented with the aim of detecting changes in oasis landscapes.

Finally, the last part will focus to the presentation of results as thematic maps, GIS database, digraphs or registered models and finally extract the change for each interesting object in a table.

Results and Discussion:-

The water body:-

The NDVI–NDWI index was applied on the test study. The results indicated that the NDVI–NDWI index is superior to the single index of NDVI and NDWI, which is made to enhance the contrast between water bodies and the rest of the features. The study area is continental nature and the main bodies of water are often present dams, sometimes day as; and are more or less filled with the seasons and years of acquisition. The year's 2015 and 2010 been a wet years and bodies of water present have filled and occupy large areas compared with 2003 and 1984 (Figure 3). Also there is a rate of change always positive but showing a decreasing trend over time (table 3), with maximum rate of change of 139% between 1984 and 2003 because 1984 was an extremely dry year.

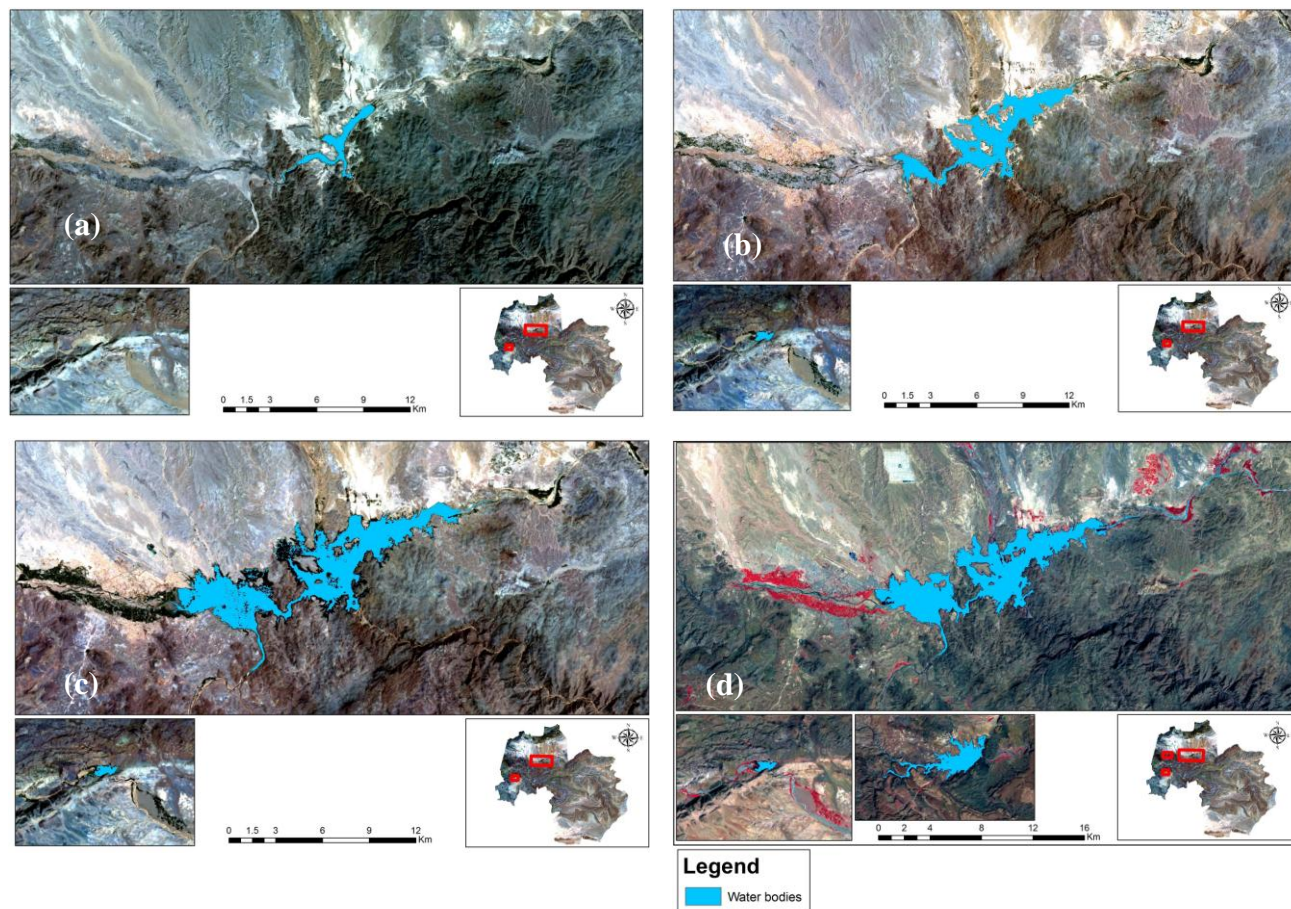


Figure 3: Serial time of water bodies in Ouarzazate and Zagora; a: 1984, b: 2003, c: 2010, d: 2015.

Table 3:- **Statistic** of water body changes.

Period	Initial Area (Km ²)	Final Area (Km ²)	Changed area (%)
1984-2003	7.4862	17.8866	139
2003-2010	17.8866	32.2155	80
2010-2015	32.2155	56.565	75.5

The vegetation area:-

The oasis vegetation is located mainly in the major rivers into the wadis and ZizRheris (Figure 5). Major crops include the Palmerai, vegetable crop, wheat or alfalfa. However, nowadays some crop production is also developed in outer space oasis.

As for water, discrimination vegetation is very easy thanks to its very particular spectral signature, which is characterized by a strong absorbance in the red and a high reflectance in the near infrared. Moreover, the chlorophyll activity can be very well quantified by the normalized difference vegetation index (NDVI). The results for the class vegetation are in perfect agreement with those of the sand class and shows that 2015 was better than the others because the vegetation is abundant (Figure 4). This result is in agreement with the results obtained for water bodies since 2015 was the wettest year. The rate of change (table 4) has fluctuating between moderately positive, this can be explained by the fact that Morocco is emerging from a very dry period in the 80s, slightly negative which corresponds to a decreasing precipitation in the years 2003 to 2010 largely positive. It results from a combination of

a slight increase in precipitation in period between 2010 and 2015 and the start of the national Green Morocco Plan provides through its Pillier II program, a united support of small holder agriculture.

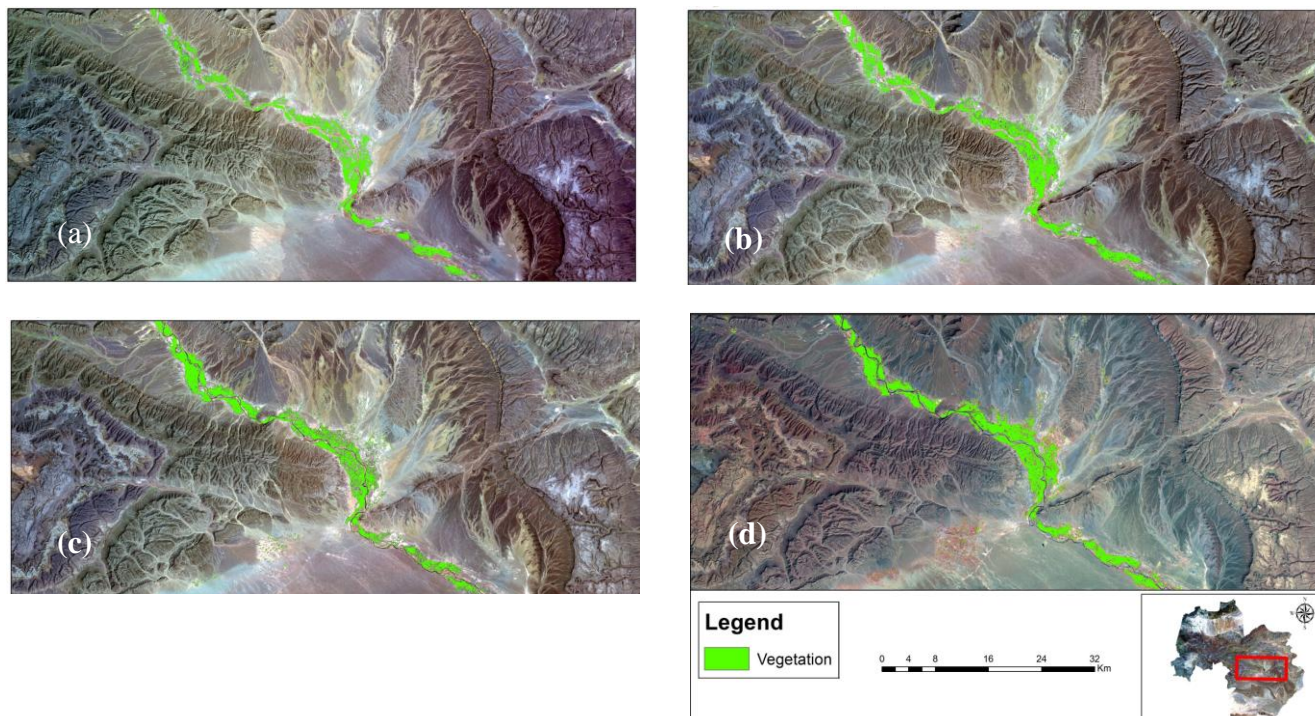


Figure 4: Serial time of vegetation area in Ouarzazate and Zagora; a: 1984, b: 2003, c: 2010, d: 2015.

Table 4:- Statistic of vegetation changes.

Period	Initial Area (Km ²)	Final Area (Km ²)	Changed area (%)
1984-2003	234.258304	292.112992	27.70
2003-2010	292.112992	268.152304	-8.20
2010-2015	268.152304	442.9881	65.20

The sand area:-

The sand often accumulates in the form of mobile sand dunes that cover a significant portion of the study area and constitutes a permanent threat to the oases indeed, the silting phenomenon intervenes directly in reducing areas of arable land and pastures. It is the result of wind erosion and the effect of the attack from the ground by the wind. The erosion mechanism is triggered when the wind causes firstly the fine parts of the soil, that is to say, silt, organic matter and fines and (Sabins, 1978). It deteriorates the soil structure, which becomes sandier, more sensitive to its action, and reduces its water retention capacity. The ground color changes from gray to white and then to red, as it leads to as tripping grounds (Bert et al.2010). The red color is the final stage of degradation in the sands of the process often travels from south to north. As known, the red color is the manifestation of the presence of iron easily identifiable element on Landsat-TM images. The location of the sands can be made from the supervised classification process Landsat-TM imagery, but mainly from the images of normalized difference iron index (NDII) which is the ratio of the bands

Red - blue / Red + blue (Vincent, 1972). Practically, things are more complex, since the spectral signature of objects depends on the surface elements, and it is enough that a thin cover of sand dust so that the object takes signatures and this does not consider the thickness of the object. Thus, in this work the partial located to the sands contain both still and quick and, which are prominent and vary locally. The sand dust for its part is much more mobile and will more or less migrate according to the surface condition. The sandy dust reflects the dynamic activity of the sand, which can vary with the seasons, where we observed that years 2015 (d) have been wetter than other time periods. The results can largely be explained by this fact, being given that wet sands are less dispersed than the dry

sands (Figure 5). Also the rate of change (Table 5) has fluctuating between moderately negative which can be explained by the fact that Morocco is emerging from a very dry period in the 80s, this progression is reasonably positive which corresponds to slightly comparable situations in years 2003 to 2010, and is largely negative in the period between 2010 and 2015 which results from increasing precipitation.

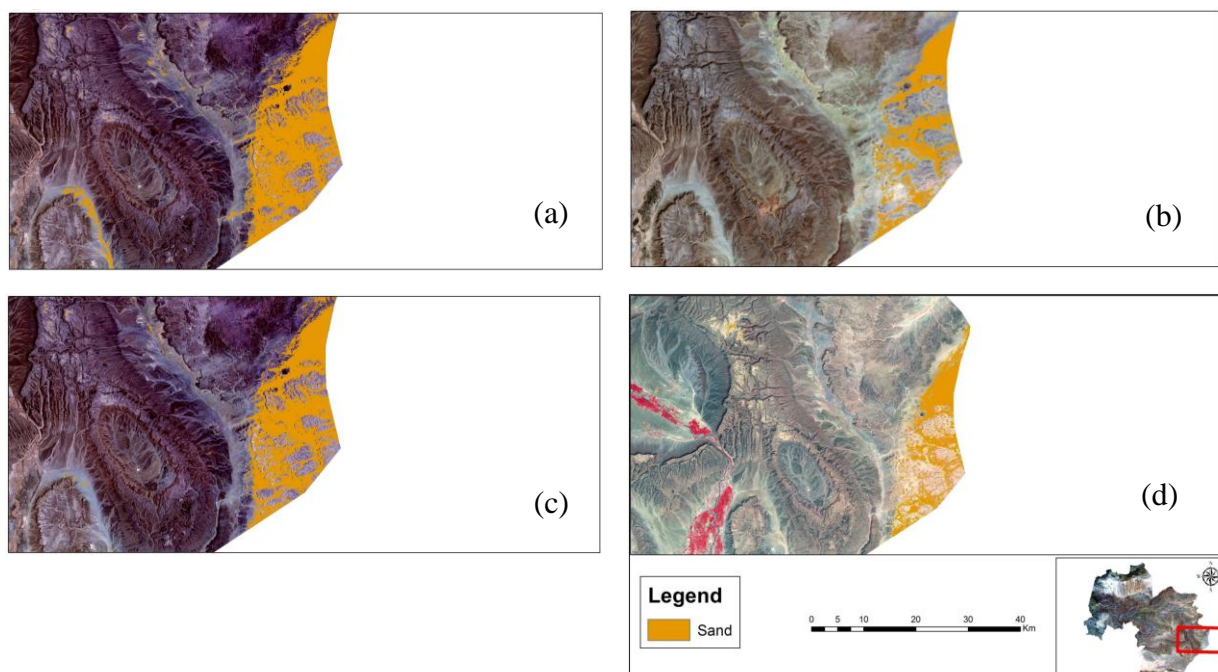


Figure 5: Serial time of the sand area in Ouarzazate and Zagora; a: 1984, b: 2003, c: 2010, d: 2015

Table 5:- Statistic of sand changes.

Period	Initial Area (Km ²)	Final Area (Km ²)	Changed area (%)
1984-2003	630.795584	512.212512	-19
2003-2010	512.212512	626.33792	22
2010-2015	626.33792	301.717792	-52

Changes in land use (Water, Vegetation, Sand):-

The NDVI is intended to measure the chlorophyll activity (Bacour et al, 2006), it shows a trend towards the increasing in crop production (Table 3). This enhancement should be seen in connection with the distribution of precipitation in treated years (Table 4). The period between both years 2010 and 2015 is the rainiest and renders the largest chlorophyll activity. However, the driest year 1984 is one that provides the lowest activity and this may also explain the less evolution of water bodies during this year. On the other hand, we can notice that in 1984 the sum of the surfaces occupied by the water is very low compared to 2010 and 2015 periods, possibly the appearance of new water bodies was observed in 2003 as reflected in Figures 5 (b), (c) and (d). All these factors point in relation to justify the reduction of areas occupied by the sands in 2010 compared to 1984. As well, rainfall directly affects vegetation cover which itself in turn plays a very important role against erosion (Table 5), and generates a vegetation expansion that serves to set and calibrate the fine parts of the soil. This, subsequently decreases the effect of transport and soil degradation, and ultimately reduces the rate of silting temporarily.

For explaining the constant progress of water bodies it is recommended to compare the vegetation growth area with the regression of sand dispersions. Figure 6 shows how the development of vegetation surfaces is correlated with water availability due to precipitation combined with a less sand dispersion. It also brings together convergent criteria, leading to the presence of a high level of soil moisture that causes fixing of the sand particles, resulting in an expansion in soil organic matter and improves retention of soil moisture, thus protecting valuable water resources.

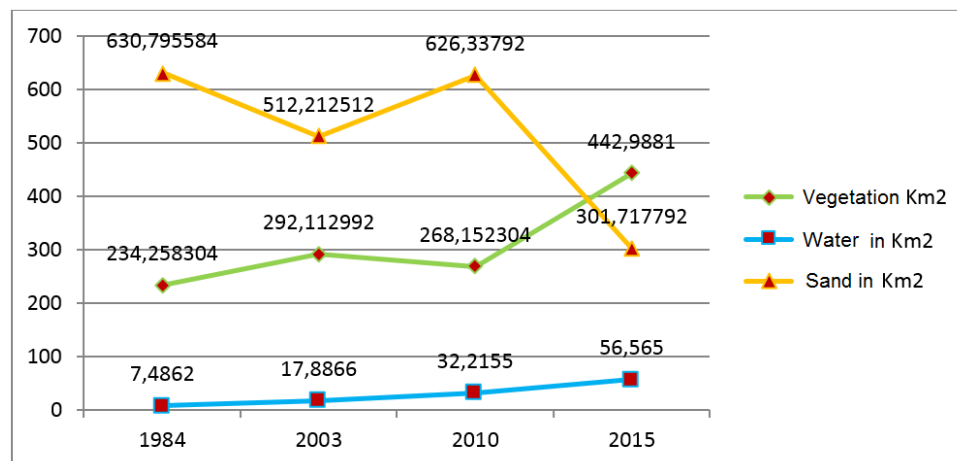


Figure 6: Evolution of the area occupied by the vegetation, water and sand (km²)

Conclusion:-

This study has been made to see the vegetation, water and sand evolution in monitoring and decision making in assess the state of the Oases Systems in Zagora regions. Obviously in nature we observe the influence of several factors simultaneously, but also changes related to climatic are known to be very slow, it's the reason why this study has been improved using a time series of Lands at imagery to capture the key phases of development during a period of 31 years from 1984 to 2015. We developed a simple method to locate changes in water body, sand area and vegetation cover. It could be stated that this analysis of LANDS AT data, recorded by the TM, ETM+ and OLI sensors is suitable to describe changes in the land-cover/land-use pattern during four decades. Although radiometric corrections are applied to both the sensor and the atmospheric effects to those data, the processing time series after reconstruction, which aims to extract information about changes, involved using spectral normalized indexes. The method will be further investigated to quantify the magnitude of changes within the class water body, sand and palms/agriculture area and in order to zoom the region of investigation to a local scale with very high spatial resolution imagery. Where the Normalized Difference Vegetation Index is sensitive to the rigor and amount of vegetation has demonstrated a development of the vegetation area. There is a strong movement to increase agricultural production, in south regions of Morocco, these results in a worsening ecological situation not only due to intensification of agriculture in oases but due as well to an extreme development of technologies for nature sustainable management. During such long-term changes one can observe in some years a decrease in plant biomass with temporary overgrazing. Fortunately under favorable moisture conditions the initial state of vegetation cover can be restored rapidly with the cessation of grazing.

In the same way the Normalized Difference Water Index has been applied to define an obvious development of the water bodies. This method has shown a constant progress of water surfaces all along those years. In the other hand sand areas has been spatially extracted by using a normalized difference iron index and has shown a regression of its surface especially during wet years such as 2010 and 2015. The sandy dust reflects the dynamic activity of the sand, which can vary with the season sand year's 2015, was wetter than other years. This is explained by a decrease in precipitation which leads not only to progressive desiccation of soil horizons, but also changes in surface and ground waters, these factors cause changes in vegetation cover and as a rule lead to desertification. Also a poor green area causes a desiccation of upper soil horizons in dry time periods that produce additional materials for the wind transfer of dust and sand. This explains the main reasons why the development of vegetation surfaces is correlated with water availability due to precipitation in addition with the factor of a less sand dispersion.

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