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GIS Based Remote Sensing Data to Monitor Biodiversity in the Cultural Parks of Ahaggar and Tassil Najjer (Southeast of Algeria)

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ABSTRACT

The exponential rise in the natural risk related to the climate changes and important impacts resulting to the human activities with strongly threatening the biological richness of the protected sites in arid and semi-arid regions in Algeria. Indeed, the accelerated degradation of the ecosystems has brought to the fore the necessity to use powerful tools and efficient follow-up of the biodiversity and management systems. Consequently, using geomatic tools (Geographic Information System, remote sensing data, Global Positioning System) are completely justified to have a powerful spatial decision aid system. This paper presents a geographic information system (GIS) based remote sensing data approach to monitoring biodiversity in the cultural parks of Ahaggar and Tassili Najjer in the southeast of Algeria. This approach, which gathers several tools, makes it possible to quantify the vegetation in terms of occupied surface and to describe the vegetation cover. Also, it is possible to detect change over extended periods on wide areas. This approach also allows the creation of land cover maps which are based on the combination of multiple classifications of remote sensing data and the different indices such as: vegetation indices, sol indices...etc. In addition, the objective of this research is to enable decision-makers to evaluate the state of the biodiversity by the availability of reliable and update land cover map.
KEYWORDS: Change detection, vegetation, Arid land, Spatial analysis, Geodatabase.

1. INTRODUCTION

Monitoring biodiversity by satellite remote sensing (RS) is an important task in Algeria, arid and semi arid regions of the world. We used a full year 2010 of Landsat images with 30 m spatial resolution to produce a land cover map with special emphasis on the detection of sparse vegetation and the important reducing of the vegetation cover as indicators of areas at risk of degradation [1].

GIS is a powerful tool. It can be used to perform a variety of quantitative analysis. It is the "glue" that holds all the data together, and which allows the display, analysis and measurement of the different information coming from different sources [2]. However, GIS can be used to develop useful models to try to find new resources based on statistical analysis of the relationship between environmental and cultural data (crossing layers, buffer zone, arithmetic and logic operation on data in raster format, etc.).

In the words of Lo and Yeung [3], "GIS empowers us to solve environmental problems of a changing world faced by humankind in the new millennium". RS and GIS technologies will indeed play a crucial role in the development of effective decision support systems or expert systems for the sustainable development and management of vital but shrinking water resources.

Integration of RS within a GIS database can decrease the cost, reduce the time, and increase the detail of information gathered from soil survey [4]. This integration approach has significant potential for regional applications for the management of cultural and environmental heritage. Various researchers around the world are using these tools today. Some of these applications include the location of new features such as archaeological sites, road segments, extraction of river network and fields, to determine land use and current land cover.

The aim of this review was to integrate the remotely sensed data in a GIS to (1) produce the land cover map for multiple areas and (2) detect change in vegetation cover over a long period in the Cultural Parks of Ahaggar and Tassili Najjer, southeast of Algeria. Moreover, we aim to offer to the decision makers a tool which enable it to evaluate the current state of vegetation diversity in a short time and for a wide area where the access is often difficult, by offering a multiple land cover maps up to date, reliable and rich in information.

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2. REVIEW OF LITERATURE

A several research has been carried out on the use of remote sensing tools and GIS for multiple subjects such as: monitoring biodiversity, creating land cover maps and change detection. Some of them are mentioned here: Ziadat and colleagues [5] investigated the use of Landsat TM images and topographic data to assist in differentiating areas, which represent soil-mapping units, at a detailed level. Alrehaili Ayman [6] described the combined used of the remote sensed data and geographical information system to estimate artificial recharge of groundwater below the dam lakes in the Kingdom of Saudi Arabia. Seyad Armin and colleagues [7] used IRS images to extract various land used in Takistan for a full year, the results indicated the kind and percent of various land uses with high precision and lowest energy and time. The normalized difference vegetation index (NDVI) is often sensitive to the soil background and atmospheric effects. Farooq Ahmad [8] examined the use of different vegetation indices; transformed normalized difference vegetation index (TNDVI), enhanced vegetation index (EVI), SAVI and MSAVI2 were quantitatively evaluated using Landsat ETM+ dataset over the Cholistan Desert to find the best vegetation index for use in sparsely vegetated semi-arid and arid tracts of Pakistan. Maliheh and Abdollah [9] used the remote sensing data (MSS, TM and ETM+ sensors) to detect changes of geomorphic units within of Mighan basin over 30 years. This approach allowed the calculation of the increased and decreased areas for several units. Iman Meer and colleagues [10] studied the seasonal and temporal variations within the flora canopy based on the normalized difference vegetation index (NDVI) data from MODIS (Moderated Satellite Image) satellite images. Because of the vegetation's cover is dense in these areas, the NDVI index was sufficient to attain significant results. Mohammad Hamed and Moussa [11] used Landsat5 TM and Landsat8 to map the spatiotemporal changes of land use/land cover in Tehran City. Authors retained that the increased population growth and rapid immigration rate to the city were the probable reasons for expansion of built-up areas and decreased area of vegetation cover. Seif and Mohamadi [12] used the TM, ETM+ and OLI data sensors to detect changes of geomorphic units within of Daghesorkh playa in Isfahan provonce of Iran over 27 years (1986-2013).

3. MATERIALS AND METHODS

4.1 Study areas

Algerian biodiversity (natural and agricultural) is immensely rich, with approximately 16,000 known species overall. Known marine biodiversity amounts to 3,183 species and between 720 genera and 655 families. Marine flora is estimated to comprise 713 species, and up to 4,150 when littoral and island vegetation and marine and littoral ornithological fauna are considered. Mountain biodiversity is also very rich (*https://www.cbd.int/countries/profile/default.shtml?country=dz#facts*, accessed on November, 1st 2016). Further, Algeria's Sahara hosts a large diversity of ecosystems [13], most of which are still unknown.

In this case, our choice was made on three zones located within the cultural parks of Ahaggar and Tassili. Thus the choice is justified by several reasons : The floristic and faunistic characteristics which were mentioned (cited) in several works [14] ; [15]; [16] ; [17]; field missions carried out within the framework of this work (Tamanrasset and the North-Ouest part of the Tassili park) [18]. The sites presented in Fig.1 are the following:

(1) Site of Tamanrasset: geographically situated between 5° to 6° east longitude and 22°.356 to 23° .536 north latitude over an area of 13440 square kilometers, this part belongs to the Ahaggar park and more particularly the zone of Taessa (mounts of Atakor in north to the capital of Tamanrasset province in the south) [19].

(2) Site of Djanet: is situated between 8°.389 to 9°.892 east longitude and 24°.378 to 25°.319 north latitude over an area of 10920 square kilometers, this site covers the North-Est part of the commune of Djanet including the town of Djanet, it is part of the plateau of Meddak which gathers important wadis like: Tamrit wadi, Adjemdjoum wadi, wadi Tissouanet (Tichouinet), Taoulaoulat wadi (towards Tissouar) and obviously others.

(3) Site of Illizi: situated between 8°.410 to 9°.423 east longitude and 25°.800 to 26°.780 north latitude over an area of 11000 km².

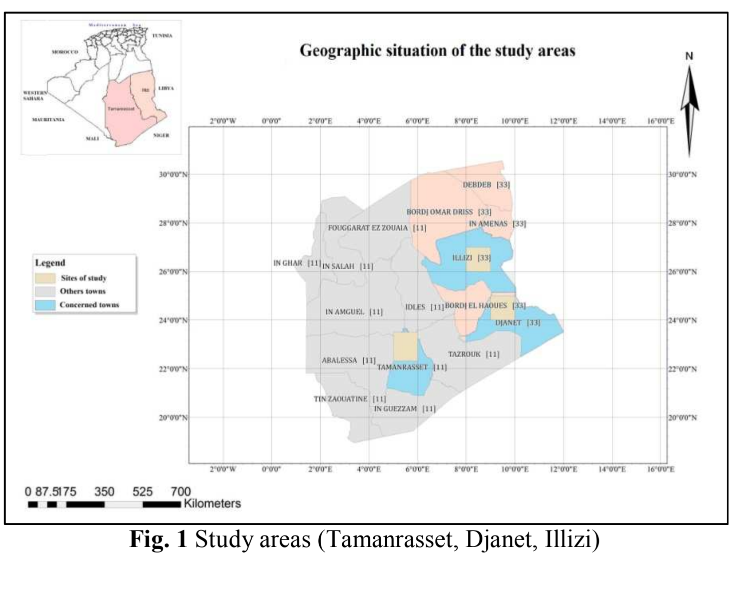


Fig. 1 Study areas (Tamanrasset, Djanet, Illizi)

4.2 Methodological approaches

As in most of the thematic studies by RS techniques, identification and monitoring (follow-up) of vegetation's cover is based on the spectral response of surfaces in different wavelengths (concept of spectral signatures of objects). We recall that the spectral signature of a surface corresponds to the reflectance curve of the area according to wavelengths of the electromagnetic spectrum, in given conditions.

The spectral properties of the vegetation cover depend at the same time on the nature of the vegetation which composes them, of their physiological state, and of their water content, but also the underlying soil which affected especially the spectral measurement vegetation if it is sparse (scattered).

The use of RS in vegetation mapping is facilitated by its multiple benefits:

- Satellite images are permanent records, providing useful information in various wavelengths
- Large area coverage enables regional surveys on a variety of themes and identification of large features.
- Repetitive coverage allows monitoring of dynamic themes like water, agriculture, etc.
- Data acquisition at different scales and resolution is often easy.
- A single remotely sensed image can be analyzed and interpreted for different purposes and applications.
- Remotely sensed data are characterized by its ability for fast processing using a computer.
- RS is unobstructed if the sensor is passively recording the electromagnetic energy reflected from or emitted by the phenomena of interste. Thus, passive RS does not disturb the object or area of interest.
- The images are analyzed in the laboratory, thus reducing the amount of fieldwork.
- Map revision at medium to small scales is economical and faster.
- Color composite can be produced from three individual band images, which provide better details about the area than a single band image or aerial photograph.
- Floods over a large region or the forest fire can be located from above, and rescue planning can be immediately arranged.
- The data generated by RS techniques can be used for: lan-use planning, forest development, geological surveys, urban planning, disaster management.
- Chep and rapid method of constructing base maps in the absence of detailed land surveys.

There are two RS recording modes:

- The active RS makes use of active remote sensors. These sensors provide their own source of illumination and they emit radiations that are directed towards the target body that is to be investigated. Active remote sensors emit energy in order to scan the objects and areas and they then detect and measure the radiations that are reflected or are backscattered from the target body.
- The passive RS makes use of passive remote sensors. The sensors are used to detect natural radiations that are emitted by the object or by its surrounding areas. The most common source of energy that is measured in this case is reflected sunlight. For this mode, four types of sensors are used: TM (Thematic Mapper), ETM + (Enhanced Thematic Mapper Plus) which are embedded in the Landsat satellite, MSS (Multispectral Scanner) is embedded in the SPOT satellite and HRV (High Resolution Visible).

Data collection

a. Topographic maps

Eight (08) maps of 1/250000 of scale were used to provide the cover for the study area. Topographic maps represent a support on which several types of information are stored (places, toponymy, hydrography, etc.) which are used within the framework of the present research, in more, these maps are necessary for other operations such as geometrical correction of the satellite images. The different maps are presented in Table 1:

Table 01 Topographic maps

Maps codification	Cover area	Source
NF31-4, NF31-8	region of Tamanrasset	*http://loadmap.net/en/m25586*
NG32-6, NG32-7	region of Illizi	
NG32-10, NG32-11, NG32-14, NG32-15	region of Djanet	

b. Satellite images

The data adopted to achieve our objective, focused on images acquired by the TM sensors (Tematic Mapper) of Landsat satellite. The selection of these images is usually based on their availability (ensures repetitive acquisition of observations over the Earth's land mass), as well as the multispectral resolution they offer. Landsat, sun-synchronous satellite's scanning system, offers images arranged the one close to the other with a recovery rate of 20%, which gives the possibility to a mosaic of scenes to ensure continuous coverage. It is with our that in our case the three areas are dispersed of such kind that each area is located completely on a scene. Indeed, six scenes of TM sensor with 30 meters of resolution, captured at different dates were implied in this study. Each scene is characterized by a serial number corresponding to the number of line (row) and column (path), and its acquisition date and time. Further information is presented in Table 2 :

Table 02 Characteristic of the satellites images which cover the study area

Study area	Regions	Satellite/Sensor	Path/Row	Date	Time	Quality
SA1	Tamanrasset	LANDSAT TM5	192/44	09/05/1990	09:24	Good
		LANDSAT TM5		04/05/2010	09:55	Good
SA2	Djanet	LANDSAT TM5	190/43	05/23/1986	09:16	Good
		LANDSAT TM7		05/24/2001	09:41	Good
		LANDSAT TM5		01/17/2010	09:42:47	Good
SA3	Illizi	LANDSAT TM5	190/42	01/17/2010	09:43:23	Good

For areas of Tamanrasset and Djanet, we have used different dates over a period of 10 to 20 years, of which the goal is to detect and monitor the development or degradation of vegetation cover. While only one date was selected for the Illizi area because the purpose of the work is to compare between different vegetation indices. The months of acquisition of these data are between January, April, May and September as shown in Table 2. The images, acquired during this period, are of good quality and are characterized by the absence of clouds[1], sandstorms and any other atmospheric obstacle, which allows an easy detection of the objects.

- **Spatial resolution (pixels)**

Choosing a good spatial resolution is based on the studied phenomenon, so the resolution is not too lower or too higher to that of the detected object and is based especially on the availability and the good quality images. The images, which we use in the present study, are characterized by its medium resolution (30×30 meters). This resolution can be regarded as sufficient for the vegetation monitoring in Saharan areas since most of the plant species are distributed along the wadis. Indeed, the beds of wadi and the zone of spreading (alluvial region) where the grounds show the most favorable pedological characteristics for maintains plant species, constitute the habitat most favorable for the development of the vegetation [17].

- **Spectral resolution (spectral band)**

The TM Landsat sensor offers to take good spectral resolution in panchromatic (ETM +) and in multispectral (seven spectral bands: three in the visible spectral bands, three bands in the near-infrared and one band in the thermal infrared spectral bands of the electromagnetic spectrum). The thermal infrared spectral band (TM6) is not used in our case because it does not provide more information for our case; moreover, it has a different spatial resolution (120×120 meters) from the other bands (30×30 meters), which makes difficult the combination with the other bands.

Table 03 Spectral and spatial characteristic of the Landsat TM sensor

Bands	Wavelength (µm)	Resolution (meters)	Spectrum
Band 1	0.48500	30m x 30m	Blue
Band 2	0.56000	30m x 30m	Green
Band 3	0.66000	30m x 30m	Red
Band 4	0.83000	30m x 30m	Visible near infrared
Band 5	1.65000	30m x 30m	Short infrared
Band 7	2.22000	30m x 30m	Short infrared
Band 6	11.45	120m x 120m	Thermal infrared

The richness of the TM sensor in spectral bands makes it possible to combine the data resulting from several bands, in different spectral intervals, in order to extract relevant information about the land cover and land use. Girard separates the use of the spectral bands while proposing the bands of visible and the infrared to detect the terrestrial phenomena, and the thermal bands, which have a certain penetration (ultra high frequencies or infrareds) for the phenomena affecting the depths [20].

c. Pretreatment of raw data

The images acquired by various sensors and provided from RS data broadcasting organizations are not directly usable. Any project integrating remotely sensed data (satellite images) previously requires a set of digital treatments to improve the quality of information and to correct any ambiguity or error. However, these treatments require the use of appropriate hardware to have the control of specialized models and software in this matter. Several commercial software, was developed specifically for the treatment and analysis of RS data. Thus, our choice was made on the use of the ENVI software (the Environnement for Visualizing Images) which offers the possibility of visualization and complete image analysis. The choice of this tool can be justified by several reasons:

- The personal experience opposite the use of this tool,
- The user-friendliness and the simplicity of its use,
- The multitude of modules of integrated treatments,
- The possibility of exporting/importing to/from several GIS formats (ArcView, ArcGis database, Etc)

The pretreatment of the satellite images is a primordial operation in order to ensure an optimal use of the data sources and thereafter to make a better interpretation of the results. The pretreatments operations gather the various corrections such as: geometrical and radiometric corrections.

- **Geometrical corrections**

Images recorded by the RS system of a given territory, contain geometric distortions due to several parameters (the rotation of the earth, the camera angle, the roundness of the earth, the satellite's orbit and satellite movements). To be able to use these images, their geometrical distortions should be corrected. The geometrical corrections indicate primarily the setting in space conformity of an image with a reference map. We have used polynomial modeling, global method, which is based on the knowledge of a given number of homologous points between the image to correct and the map of reference (Ground Control Points GCPs). These points are used to calculate, according to a model polynomial of order 1, the coordinates of the homologous points in the image.

The 1st order polynomial method gives more satisfactory results [20], in spite of the fact that it is less accurate than the polynomial method of the 2nd and 3rd order. However, it makes it possible to have a more homogeneous document.

To complete the geometric corrections, a resampling operation is required. Each point (x, y) of the corrected image does not have exactly the same numerical value of the original point (q', p') in the raw image. So resampling is to assign to each

[1] We note the presence of clouds and sand winds on the scenes corresponding to the year 1990 for March, January, April, August, October. This characteristic makes the image unusable, the reason for which we retained that of September.

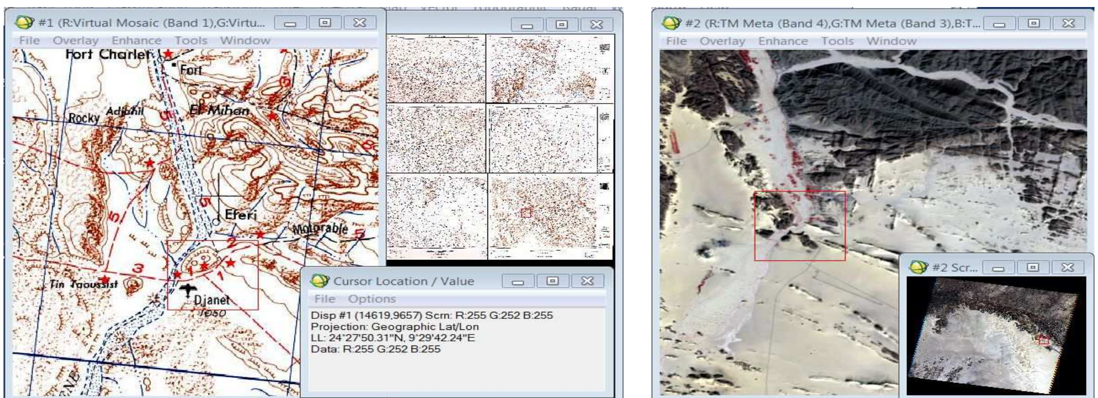
point of the corrected image a numerical value determined by interpolation between the values of neighboring pixels of the raw image, the nearest neighbor method that is applied in our case. Using the 1st order polynomial method with sufficient number of ground control points from topographic maps at 1/250000 of scal, we got georeferenced images which allows us to construct a mosaic and establish a simultaneous connection between maps and corrected images (Fig.2).

- **Radiometric corrections**

Radiometric corrections consist in converting digital accounts of the image (grayscale) into brightness ($w.m^{-2}.sr^{-1}.\mu m^{-1}$) at the satellite sensor then to extract from this new variable the atmospheric disturbing effects in order to lead finally to a physical measurement of reflectance from the target surface. These corrections are generally applied to decrease the effect of the related distortions:

- with the angle of sweeping of the couple sensor and vector;
- with the satellite orbit;
- with the difference of solar irradiance due to the shooting date and that prejudice in the case of diachronic study [21];
- with the atmospheric disturbances which appear in the presence of elements accentuating the diffusion phenomena (particles and aerosols) and the absorption phenomenon (water).

In this case, the angle of scanning remains weak. It can be assimilated with a constant angle. The LANDSAT orbits are heliosynchronous and consequently no distortion due to the orbit will be notice. In addition, the images have been corrected to the atmospheric effects since they are captured on multiple dates.



The image on the right is well georeferenced by report to the maps. The red square represents the town of Djanet. Also, the wadi which crosses the image top in bottom is well oriented (the two windows are automatically dependant under ENVI.

Fig. 2 Mosaic and relationship between topographic maps and images

d. Digital processing of the satellite images

Changes in spectral properties of soils related to their color and their brightness disturb considerably the detection of the dispersed vegetation in heterogeneous environments, using the vegetation indices. A new generation of vegetation index (TNDVI, PVI, SAVI, MSAVI, TSAVI, TSARVI) was developed to minimize these effects.

For this study, the different treatments can be arranged as follows: (1) enhancement, (2) transformation, (3) classification and (5) the different analysis of the image.

Enhancement functions are used to improve the appearance of the imagery in order to make easy the visual interpretation and analysis. Indeed, this process includes several techniques such as dynamic improvement that serves to increase the tonal distinction between the different elements, the application of different spatial filters to enhance the specific spatial patterns in an image. In general, enhancement techniques are applicable per band.

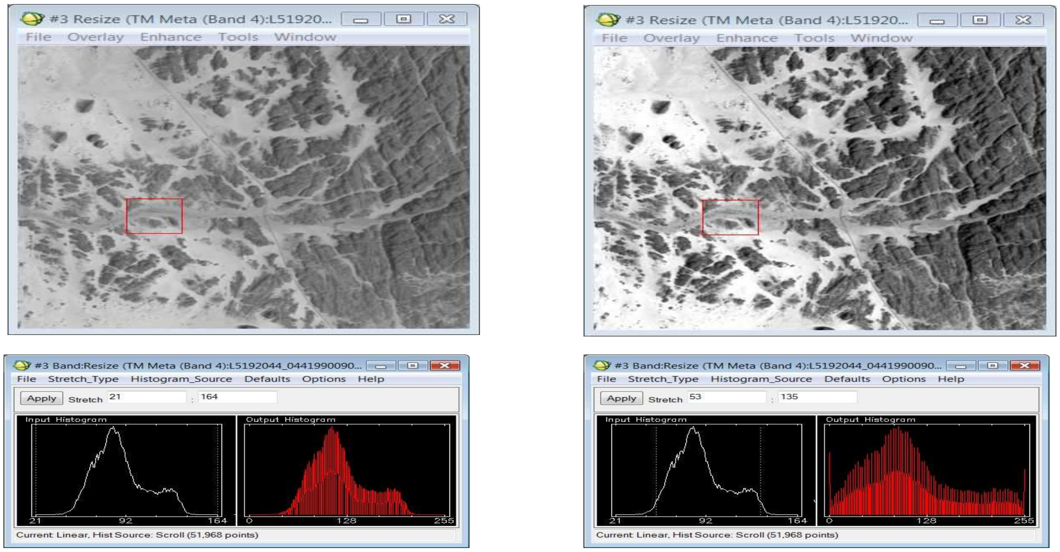
The transformations of images are represented by the different arithmetic operations (addition, subtraction, multiplication, division) applied to multiple spectral bands. Their goal is to combine and transform the original bands in new images (neocanal) which show more clearly some elements of the scene.

The classification and analysis operations are used to digitally identify and classify all pixels of satellite image to establish different thematic maps.

e. Dynamic improvement

The dynamic enhancements consist in modifying the radiometry of each pixel of band, knowing that the data are coded on 256 levels. These data almost never cover the extent of the available 256 values represented by the histograms of each band [20]. Dynamic spreading allows the maximum use of this range. Thus a thresholding operation by eliminating the pixel values initially lower or equal to a certain threshold according to the case, can be used.

Indeed, the main objective of the dynamic improvement of the image is to build the most contrast image to allow the optimization of information (Fig. 3 shows clearly the difference in sharpness for the same band before and after i mproving its dynamics).



a: before DI b: after DI

Fig. 2 Dynamic improvement (bande TM4), region of Tamanrasset

Vegetation mapping

The dynamic monitoring of biodiversity requires the collection, processing and rapid analysis of information [22], [23]. In this context, the Landsat TM images were selected for their synoptic character over a wide area, their repetitiveness and their availability over a long period.

A series of color composites had established with the creation of new image from georeferenced, orthorectified and improved radiometric images: brightness index (BI), normalized difference vegetation index (NDVI), transformed normalized difference vegetation index (TNDVI), soil-adjusted vegetation index (SAVI), modified soil-adjusted vegetation index (MSAVI2) [24] and principal component analysis (PCA).

The idea is to combine between all these techniques to discriminate the various classes in particular the vegetation which is very weak with an important degradation [25], the presence of sources of water which are frequently temporal, the type of ground which changes from one place to another (sandy, rocky) [26].

The study of the state of vegetation and its development over a period more than 20 years has made it possible to detect the positive and negative changes in wide and different areas. Supervised and unsupervised classifications, by applying the adequate algorithms to the imagery TM of Landsat with the integration of GPS data (field work), have makes it possible to eliminate the undesirable classes and finally to lead to a land cover map.

Geographic Information Systems (GIS) allow for relevant, reliable and updated information (hydrological network, water points, settlements, boundaries, etc.), validate the analysis of spatial data, offer different tools for editing maps [27]. The methodological approach presented in Fig. 4 shows the combined use of RS and GIS tools.

The different neocanal are given in Table 4 :

Table 04 Indices used in this study

	Site of Tamanrasset	**Site of Djanet**	**Site of Illizi**
NDVI	1990 and 2010	1986 and 2010	2010
Change detection	Period (1990-2010)	Period (1986-2010)	-
TNDVI	1990 and 2010	1986 and 2010	2010
SAVI	1990 and 2010	1986 and 2010	2010
MSAVI2	1990 and 2010	1986 and 2010	2010
False Color Composites	(TM4, TM3, TM2) (TM1, TM4, TM7)	(TM4, TM3, TM2)	(TM4, TM3, TM2)

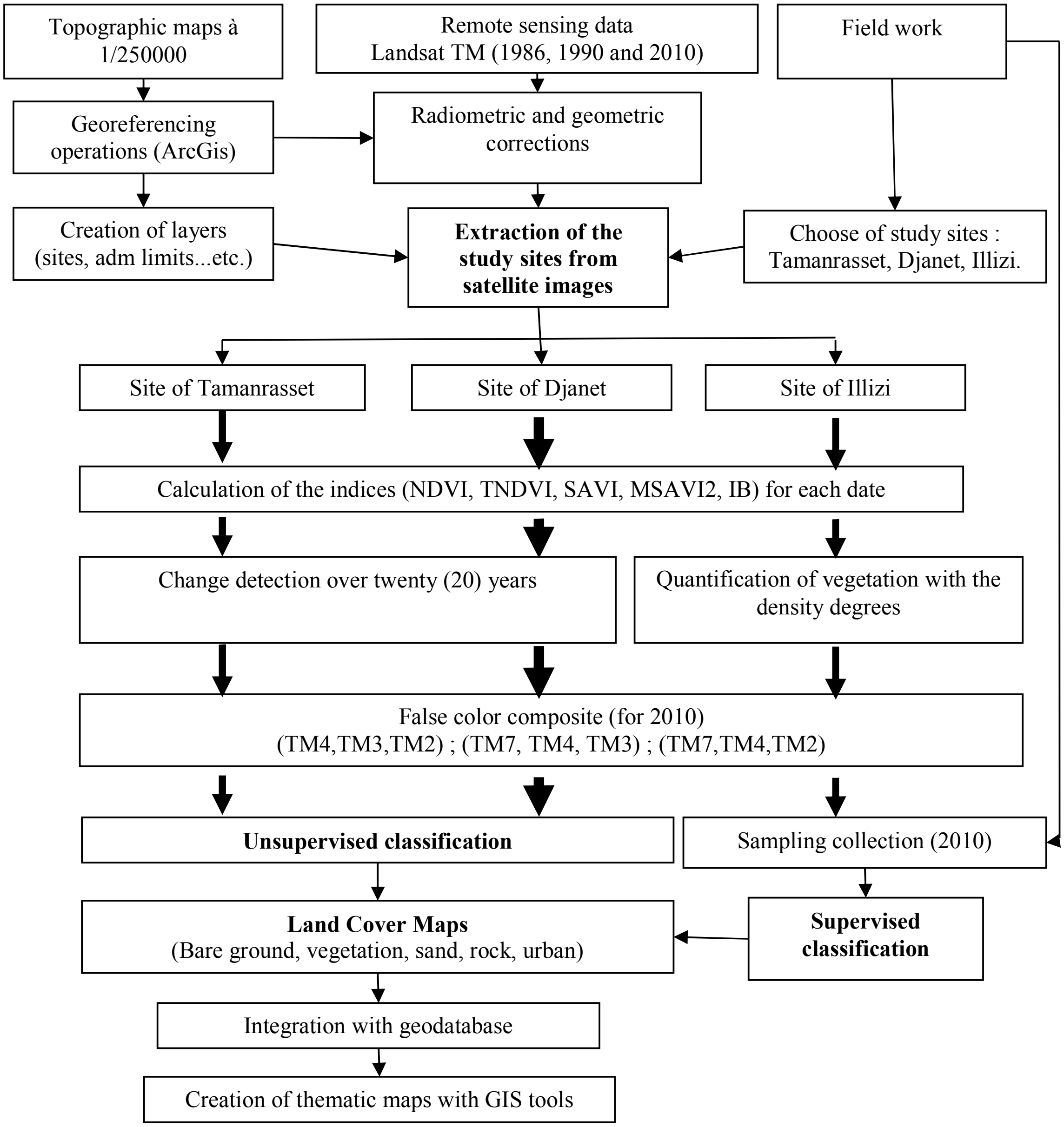


Fig. 3 Flow Chart showing the methodological approach

3 RESULTS

4.1 Site of Tamanrasset

Color composite image

We have used TM1, TM2, TM3, TM4 and TM7 bands to establish two false color composites (FCC); (TM1, TM4, TM7) and (TM4, TM3, TM2). Beforehand, an operation of the photo-interpretation was necessary to help determine existed soil types while being also based on the spectral signature samples, geographic location and geometric form. The mosaic of topographic maps in Fig. 2 was used as a complement to the FCC.

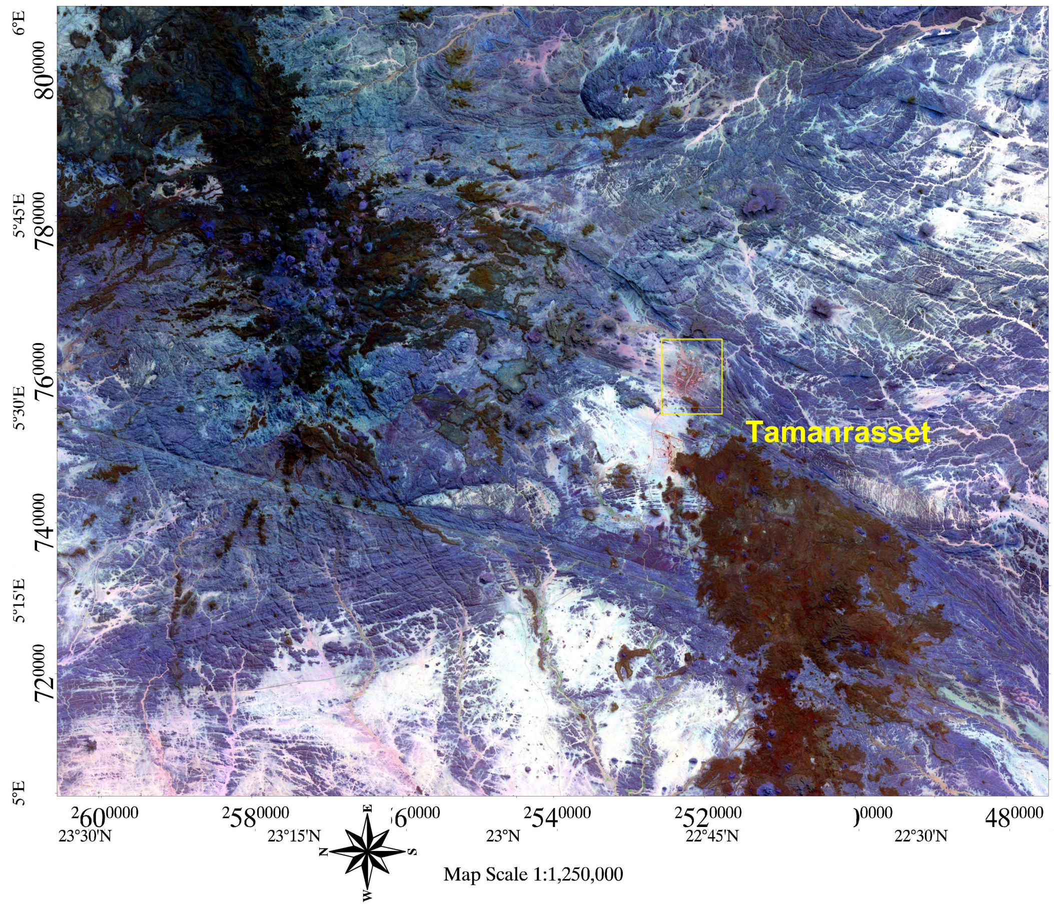


Fig. 4 False color composite image (TM1, TM4, TM7)

Vegetation index and its derived indices

The normalized difference vegetation index makes it possible to visualize on a single channel the dynamic responses related to the density of vegetative cover, by optimizing contrasts between the visible and the infrared bands. This index is included between -1 and +1, the more this index is high and more the area corresponding to the soil has a strong chlorophyllian activity.

After enhancement of the NDVI result, we present in Fig. 4 the vegetation distribution in 1990 and 2010. Indeed, this vegetation cover is characterized by a weak vegetation (99% in 1990 and 98% in 2010 of bare ground, according to the calculated NDVI) which usually located in the wadis beds. However, the NDVI index is saturated for the area with high biomass regions and it is sensitive to a certain number of disturbing factors such as atmospheric effects, cloud, ground effects and anisotropic effects etc.

Consequently, a number of derived index from the NDVI index were proposed in the literature to give solutions for these limitations [28]. Tucker presented a transformed index of vegetation (TNDVI) by adding a constant of 0,5 to NDVI and by taking the square root. It always has a positive value and the variance of the report/ratio is proportional to median values. [29].

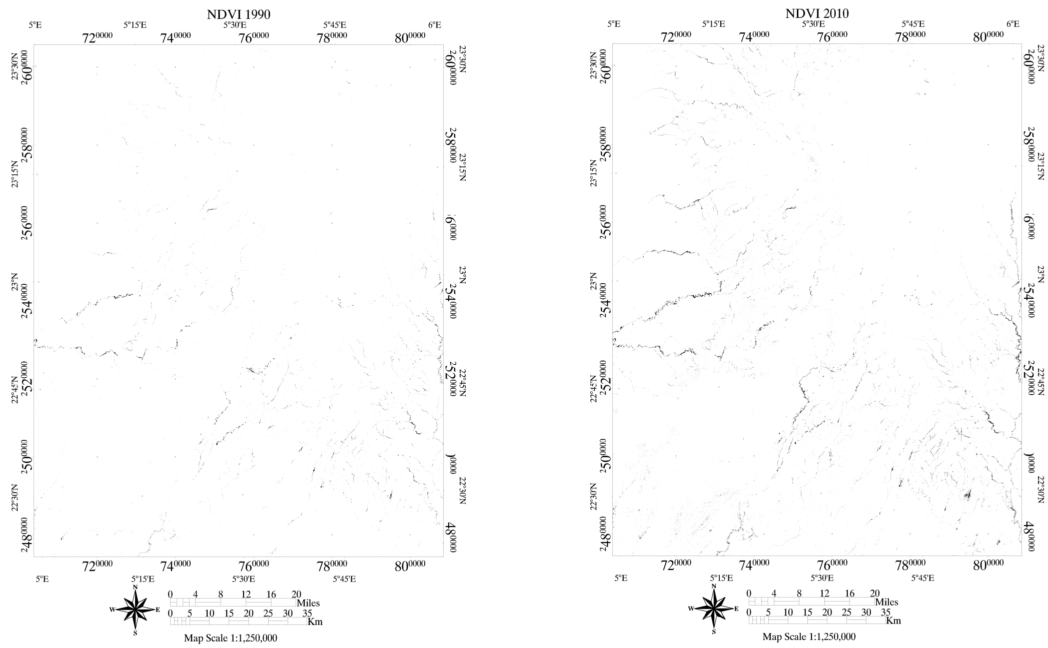


Fig. 05 The normalized vegetation index (1990 et 2010)

The TNDVI shows slight better correlation between the quantities of biomass and the pixel value [30] ; [31] ; [28]. In order to reduce the impact of ground change on the NDVI values in areas with low vegetation cover, Huete [28] proposed a vegetation index adjusted to the soil (SAVI) by introducing a correction factor L. The SAVI index presents an important step towards creating a simple model for describing the dynamics of soil-vegetation system from RS data [32].

The MSAVI2 index [24], presents the modified adjusted vegetation index to the soil, its aims are to answer some NDVI limits when applied to areas with a high degree of exposure of soil. The problem with the SAVI index is that it must specify the correction factor of the soil brightness (L) which ranges from 0 for very high coverage vegetation to 1 for very low vegetation cover. Most researchers use the value 0.5, which design an intermediate vegetation cover [32].

Brightness index

The brightness index is built from the red and infrared bands, it represents the average of the image brightnesses. This index is sensitive to the brightness of soil moisture and the presence of salts in surface. Depending on the brightness index value, we deduce that the wet soil or covered with water or vegetation have small values and then appear very dark (black), while higher values represent bare ground with little moisture or with low vegetative cover, these areas appear clear (white). In fact, the brightness index is used to distinguish shadow areas from the sunny one [20].
Here in Table 5, we present the calculation formulas for the associated indices:

Table 05 Formulas of the used vegetation indices

Indices	Formulas	References
NDVI	$(TM4-TM3)/(TM4+TM3)$	Rousse et al., 1973
TNDVI	$\sqrt{(TM4-TM3)/(TM4+TM3)}+0.5$	Tucker, 1979
SAVI	$(1+L)*(TM4-TM3)/(TM4+TM3+L)$; L=0.5	Huete, 1988
MSAVI2	$0.5*((2*TM4+1-\sqrt{(2*TM4+1)^2-8*(TM4-TM3)})$	[24]
IB	$\sqrt{(TM4)^2+(TM3)^2}$	Robin, 1995
	with : TM4: Near Infrared canal and TM3: Red canal	

In addition to these five indices, a principal component analysis (PCA) was performed. The application of the principal components analysis to six spectral bands of TM sensor, based on a linear combination, allows to have three uncorrelated PCA. Then the information is mainly concentrated around the neocanaux PCA1, PCA2 and PCA3. This study did not absolutely require calculations of the PCA. Indeed using the ENVI software allows the consideration of an unlimited number of bands or neocanal in the supervised classification.

Change detection

Once the satellite images were corrected, we have to apply an approach that is based on the use of multi-temporal sensing data (TM of 1990 and TM of 2010) in order to detect the different changes in the same area.

This approach is based on the calculation, for each date, the vegetation indices after bringing the original images to the same radiometric and geometric reference [33]. Indeed, the resulting image pixel values represent the class numbers according to the difference in value between the two years. While five classes are defined by specifying their intervals: the different classes are (1) decreased, (2) little decreased, (3) no change, (4) little_increased and (5) increased, which represent respectively (1) a big negative difference, (2) a small negative difference, (3) for no difference, (4) a small positive difference and (5) a big positive difference.

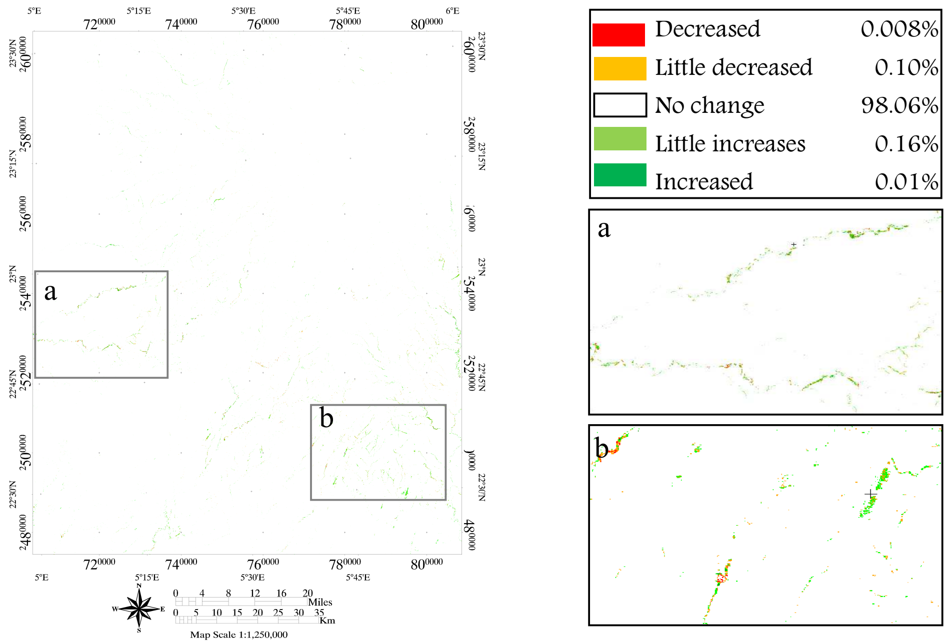


Fig. 06 Change detection by the NDVI index (1990-2010)

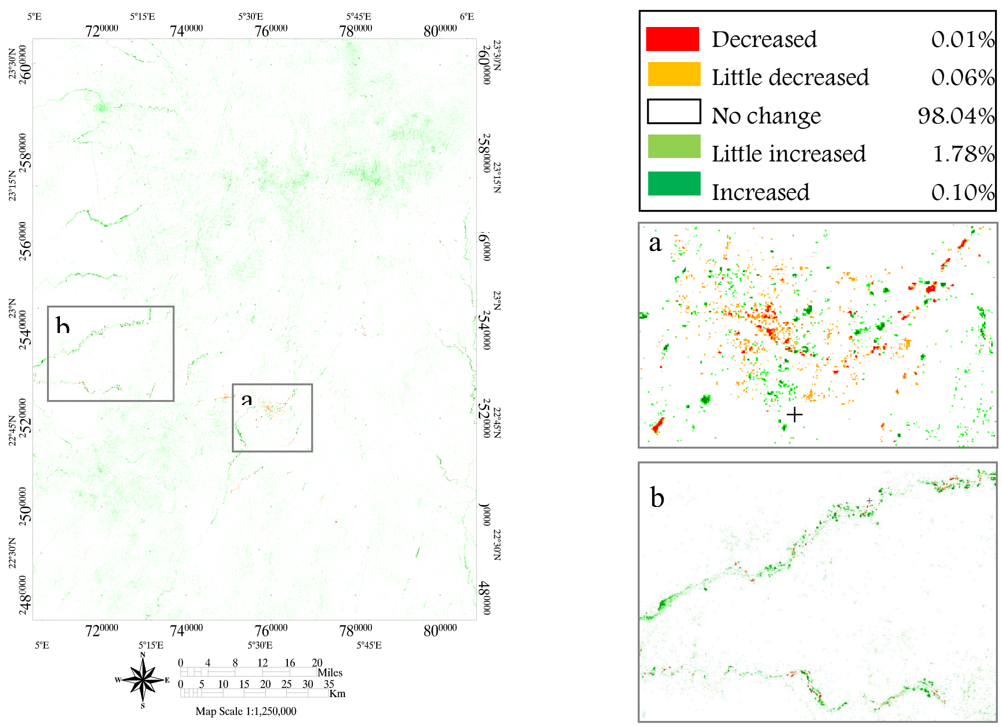


Fig. 07 Change detection by the MSAVI2 index (1990-2010)

The detected changes using the SAVI and TNDVI index are shown respectively in Fig. 9 and Fig. 10. Adding that for TNDVI, a change to digital accounts of the pixels was conducted in order to avoid the error values (the square root of a negative number) the ridge that this index represents the square root of NDVI over value of "0.5". Thus, all pixels with the error value, which corresponds to a negative NDVI were replaced by zero.

Consequently, the minimum value of the TNDVI index for both dates was "0.5". Because margins (min, max) of indices were different, a threshold adjustment corresponds to the five classes was needed for each index.

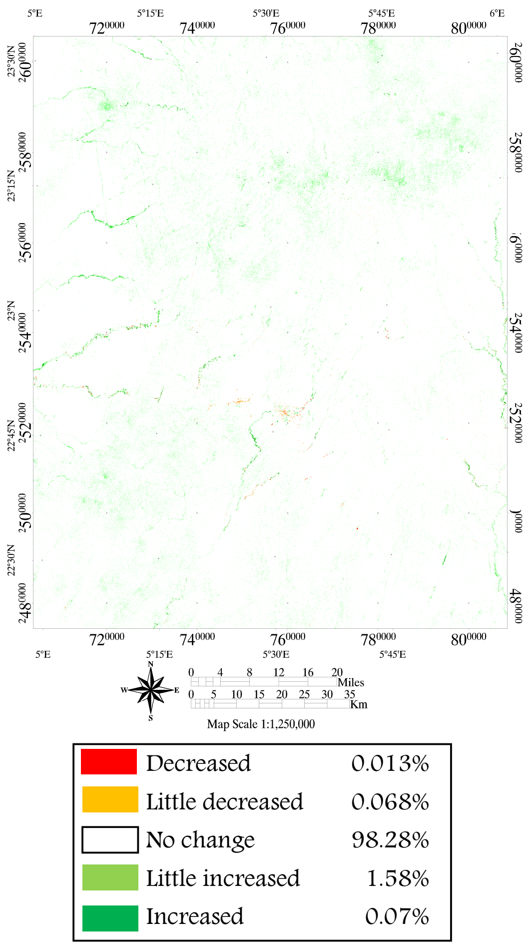


Fig. 08 Change detection by the SAVI index (1990-2010)

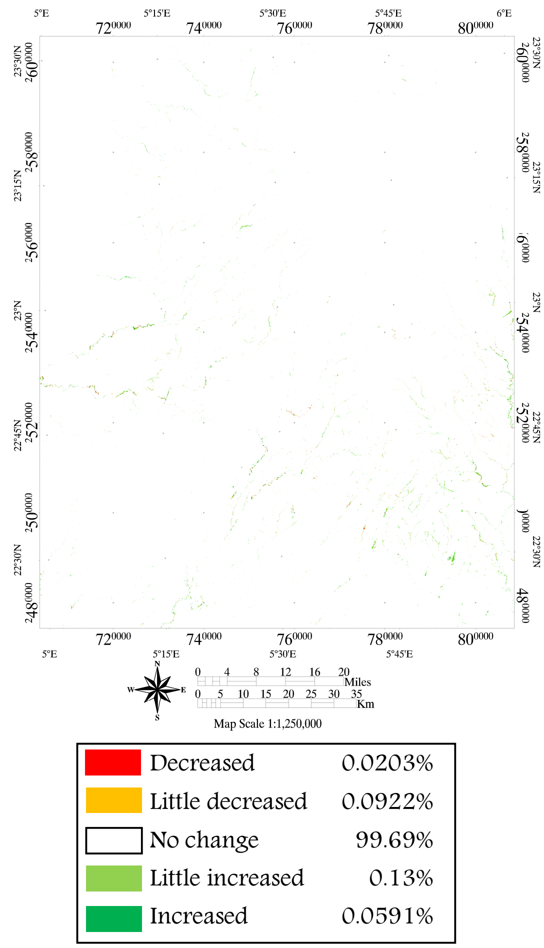


Fig. 09 Change detection by the TNDVI index (1990-2010)

Fig. 11 presents a comparative analysis of the four vegetation indices quantitatively evaluated in this research. According to the results, the vegetation index NDVI showed minimal degradation of the vegetation cover while for MSAVI2, the SAVI and the TNDVI the results were the same, presented respectively in Fig. 8, Fig.9 and Fig.10. The MSAVI2, SAVI and TNDVI indices showed almost the same percentage for the class "little decreased" lightly different for the NDVI (Fig. 7). For the "little increased" class the NDVI index showed a too low value against other indices which have recorded almost similar values. For the 'increased' class, the MSAVI2 and the TNDVI showed a maximum increase, which is not the case for the NDVI.

However, all indices have shown with the same percentage for surfaces that have not changed. The modeling process is effective to estimate land cover from satellite images, even using a limited number of data [34]. Overall, the MSAVI2, SAVI and TNDVI indices showed almost the same results for all classes, the reason why we recommend their use to detect vegetation change in the case of regions which are characterized by a dispersed vegetation cover where the reflectance of soil were strongly influenced the spectral response of objects.

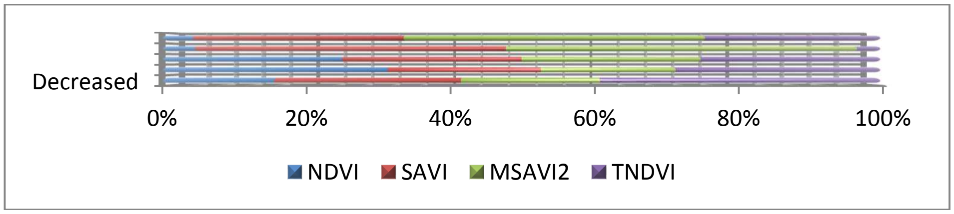


Fig. 10 Comparative analysis of the vegetation indices

Classification

Unsupervised classification based on K-Means method was used for the selected channel (Fig. 12). The image thus classified highlighted the following topics (themes): bare soil, rocky surfaces, sandy surfaces, mountainous areas, urban zone and vegetation cover. It should be noted that the use of K-means method has appeared at first time eleven (11) classes. After several iterations of combinations of classes by referring each time to multiple supports: color composite (visual interpretation), already computed indices, the data field and in some cases the radiometric values of the objects; we came up with the first four themes (bare ground, rock, sand and mountains). While for vegetation, a supervised or unsupervised classification does not give good results that reflect reality at the causse of degraded and sparse vegetation cover in this region. For this purpose, we appealed to the MSAVI2 vegetation index to integrate[2] it into this classification. Urbanized areas were delimited[3] manually on the basis, of the visible boundaries of the town of Tamanrasset.

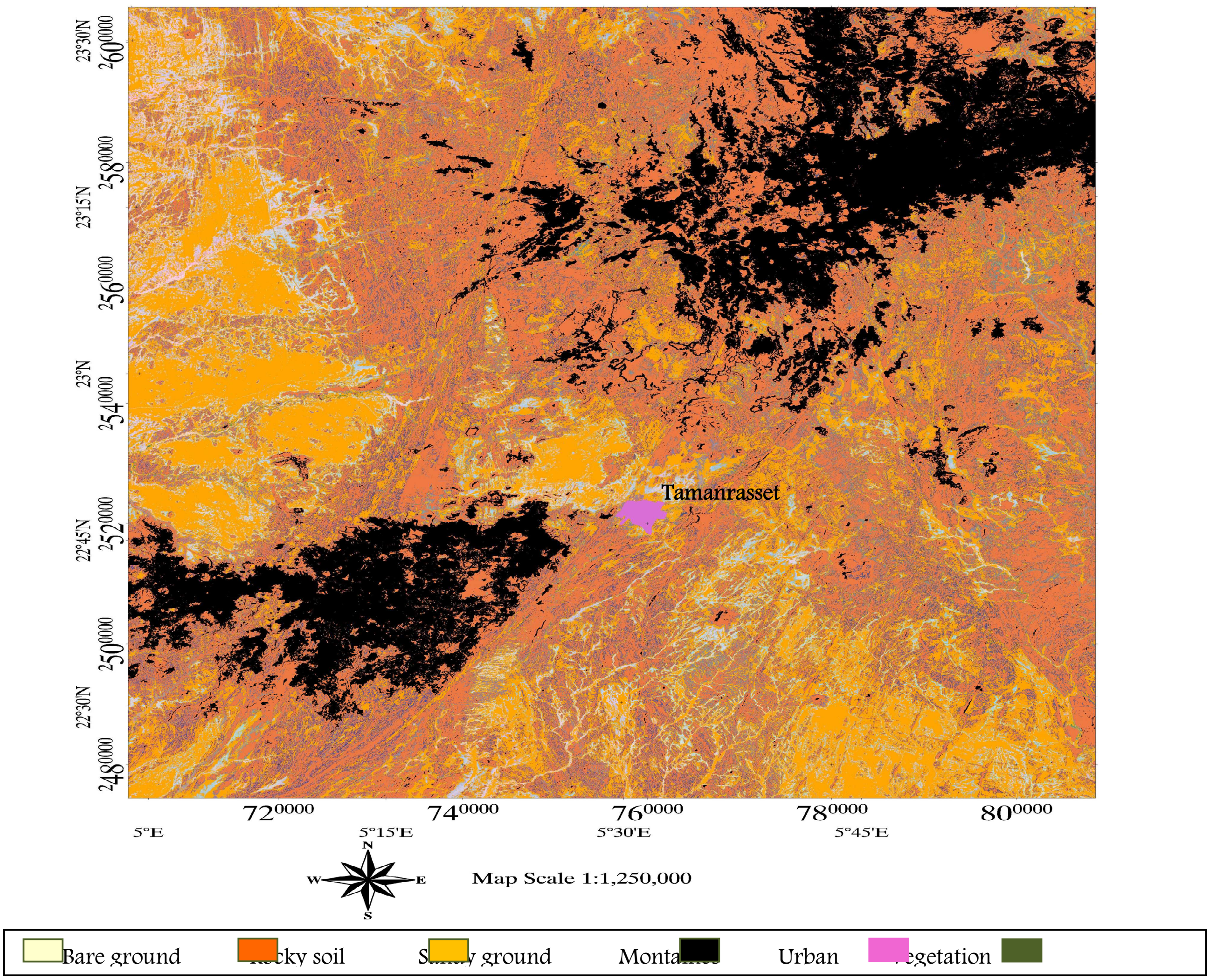


Fig. 011 Land cover map in 2010 (unsupervised classification)

[2]We have used only the values of the MSAVI2 that are higher than 0.02, this value is justified by comparing the MSAVI2 with several colored composition, it affirms that a pixel with a value greater than 0.02 of the MSAVI2 is a sufficient indicator to confirm the presence of vegetation.

[3] For K-Means method, the urbanized area of Tamanrasset belongs to several classes; in fact, it is a mixture of soil, sand, rock, concrete, bitumen.

4.2 Site of Djanet

Monitoring (follow-up) of the vegetation

The calculation of a series of index for the study of vegetation, especially in areas with low vegetation cover, contributed to the localization of vegetation on the one hand, and gave explanations for the overlapping areas in the other hand. The calculation of neocanal for all indexes was made for two different years 1986 and 2010 based on the use of Landsat TM satellite images (path/row:190/43). Consequently, the acquisition of multidates data has allowed the detection of changes in land cover over more than twenty years.

Change detection

Fig. 13 presents a comparative analysis of the four vegetation indices applied in our case. According to the results presented in Table 6, the vegetation index NDVI showed minimal degradation of vegetation cover, the SAVI index gave the greatest value and the intermediate values were assigned by the MSAVI2 and TNDVI. However, if we merge the two categories (decreased and little decreased) that characterize the degradation case, we find almost the same ratio (about 0.60%).

Table 6 Change detection with the four indices (by %)

Djanet	Decreased	Little decreased	No change	Little increased	Increased
NDVI	0.0186	0.61172	96.5631	2.4051	0.3782
SAVI	0.3674	0.5398	96.3046	2.2868	0.5014
MSAVI2	0.2448	0.4691	96.4025	2.497	0.3865
TNDVI	0.1369	0.4331	97.2995	1.6113	0.5209

For "little increased" class, the TNDVI index showed a low value in regards to the other indices which recorded almost similar values. For the "increased" class, an average of 0.40% was recorded for all indices.

Areas that have not undergone changes, were marked by a value of 97.2% for the TNDVI index and with an average of 96.5% for the other indices.

The obtained results seem coherent which affirms the effectiveness of the adopted methodology, which is based on the comparison between several indices.

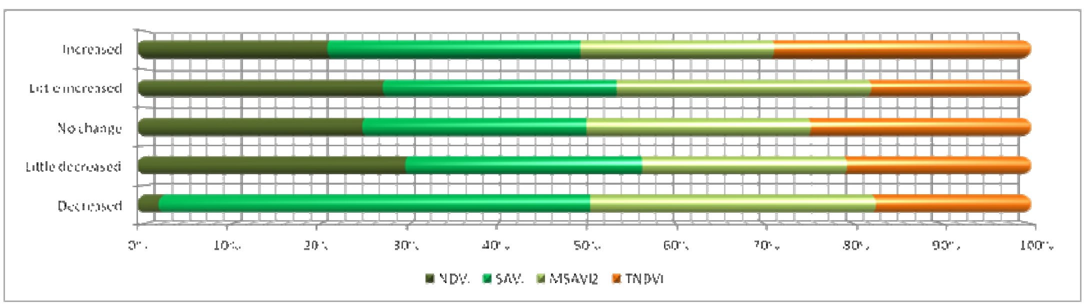


Fig. 012 Change detection 1986-2010 (Djanet)

Classification

Unsupervised classification for the year 2010 based on the K-Means method, was used for the second study site (Djanet region). Fig. 14 shows the different themes that are the same as the first study site : bare soil, rocky terrain, sandy, the mountains in the region, urban (city of Djanet) and vegetation cover. The results obtained from this model were the subject of several treatment steps in order to better purify the classes thus obtained. The land cover ontained is the result of the combination of several information : photo-interpretation of colored compositions (color, shape, location, spectral response of objects), calculated indices (brightness, redness, and vegetation), principal components analysis, Google Earth image.

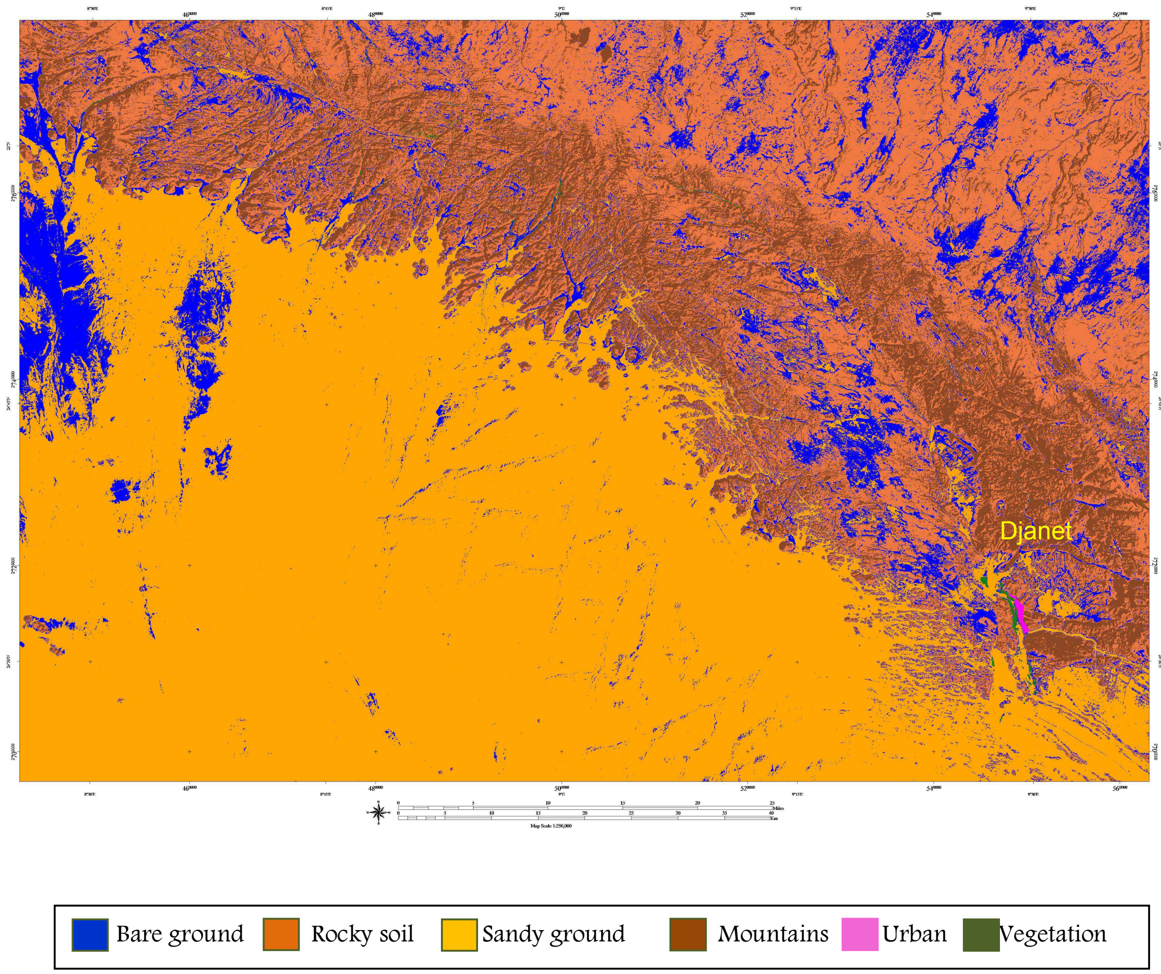


Fig. 13 Land cover in 2010 (Djanet)

4.3 Site of Illizi

Mapping vegetation

In this case, we have used Landsat TM satellite image of January 17th, 2010 corresponds to the coordinates (path, row) = (190, 44). The aims of adopted approach are to study the possibility to quantify vegetation (in terms of area) and similarly to determine the characteristic of the vegetation cover (dense, average or weak). For this purpose, we used the five vegetation indices (NDVI, TNDVI, SAVI and the MSAVI2) in order to allow the comparison of results. The study of the statistics associated with the calculated indices showed clearly that the margins (min, max) are strongly different from one index to another; NDVI [- 0.4; 0.65], TNDVI [0.5; 1.30], SAVI [- 0.58; 0.97], MSAVI2 [- 1.13; 0.78]. So several coloured compositions and a principal component analysis were involved in order to discriminate the margin of values for each index. Table 7 shows the margins of the three vegetation classes.

Table 7 Classes associated to the different indices

Vegetation cover	NDVI	TNDVI	SAVI	MSAVI2
Dense	0.2311 – 0.6535	0.9974 – 1.3084	0.3468 – 0.9764	0.4086 – 0.7896
average	0.1418 – 0.2311	0.8550 – 0.9974	0.2146 – 0.3468	0.2378 – 0.4086
weak	0.0526 – 0.1418	0.7125 – 0.8550	0.0823 – 0.2146	0.0670 – 0.2378

Therefore, the Table 8 illustrates the three classes of vegetation with their percentages compared to the site of study and eventually the occupied surface in square kilometers. The class “dense vegetation” is almost identical for the four indices, it is approximately 2 km² (either 0.02%), while for the class of “average vegetation”, both the NDVI and SAVI indices gave the same percentage (0.08%) which represente 9 km², a slightly higher percentage of 0.12% for the two other indices. Both NDVI and SAVI gave an average surface of 60 km² for the class of “weak vegetation”. A surface of 72 km² was registered in the case of the TNDVI, however almost the double of surface (approximately 100 km ²) for the MSAVI2, the index that we have recommended to be used in case of area which characterized by weak vegetable cover (elimination of the ground effect).

Table 8 Characteristic of the vegetal cover (2010)

	NDVI			TNDVI		
	%	**nb pixel**	**Surface (km²)**	**%**	**nb pixel**	**Surface (km²)**
Dense vegetation	0.0245	3002	2.7018	0.0188	2307	2.0763
Average vegetation	0.0871	10675	9.6075	0.1243	15234	13.7106
Weak vegetation	0.5638	69133	62.2197	0.6574	80600	72.54
	SAVI			**MSAVI2**		
Dense vegetation	0.0247	3030	2.727	0.0172	2103	1.8927
Average vegetation	0.08	9804	8.8236	0.1129	13847	12.4623
Weak vegetation	0.4935	60513	54.4617	0.9365	114828	103.3452

A representation of surfaces for the three classes is illustrated through Fig. 15:

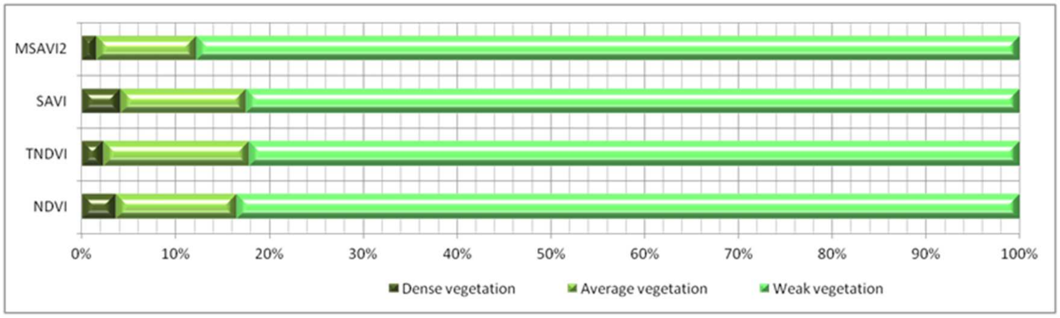


Fig. 14 Calculated surfaces for the three classes

Classification

For the case of the Illizi site, a supervised classification for the year 2010 based on the method of the maximum likelihood, was retained. The existence of several important wadis such as: wadi of Tekhammat, wadi of Allaïtala, wadi of Isakra, wadi of Tan Hankat, constitute a key factor to the formation of an important vegetation cover along the wadi beds. Thus, the themes chosen for the supervised classification are presented in Fig. 16 such as: bare ground, rocky terrain, sandy ground, the mountains in the region, the urban (town of Illizi and the Thakhamalt airport) and vegetation cover.

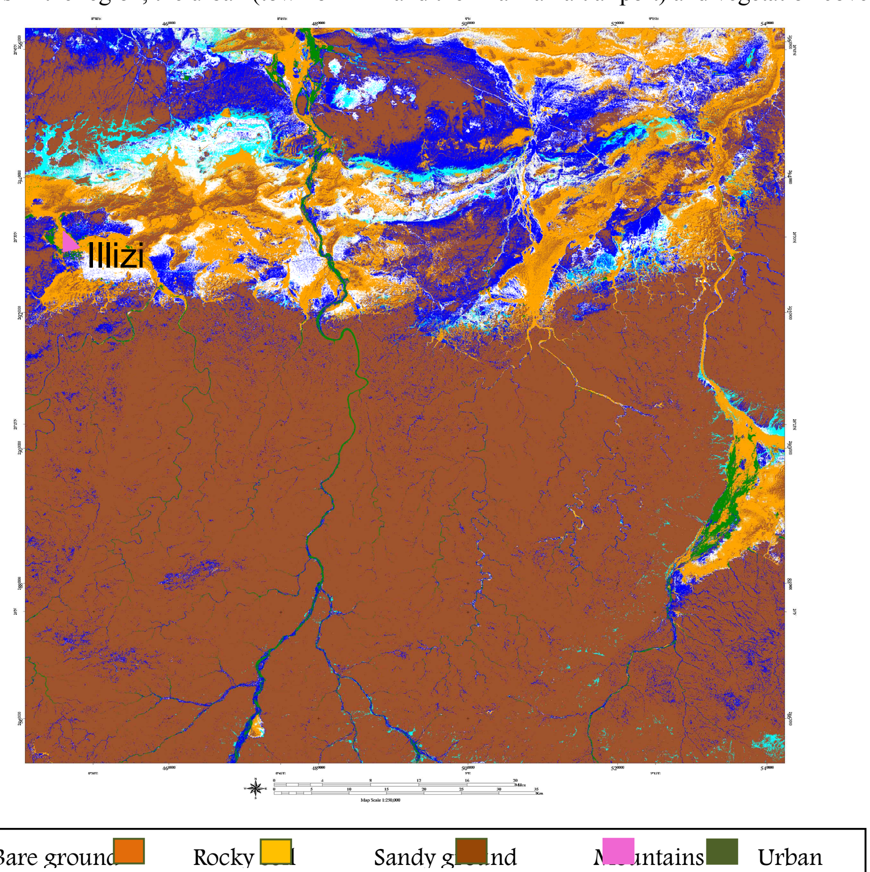


Fig. 15 Land cover in région of Illizi on 2010

4 DISCUSSION

The main purpose of this research is creation of land cover maps and detection of changes in vegetation cover over the period of 20 years (1990, 2010). The study area is mainly characterized by a week vegetation cover (southeast of Algeria), which is distributed along the wadis. In this case, data from Landsat TM5, TM7 were used. Geometric and radiometric corrections are one of the most important steps of image processing before classification of images.
A series of false color composites were made to make easy the identification of the different land cover units. Also, new images were created from georeferenced, orthorectified and improved radiometric images such as: brightness index, normalized difference vegetation index, transformed normalized difference vegetation index, soil-adjusted vegetation index, modified soil-adjusted vegetation index and principal component analysis.
The methodological approach, based on the comparisons of several vegetation indices, has affirmed that the NDVI index is globally, disturbed by the ground effect because of the sparse vegetation in this area.
Contrary to NDVI index, important surfaces were registered as degrading areas in terms of vegetation cover. For all study area, they are approximately 600 km² of surfaces that suffer an important loss of vegetation over 20 years.
During our field work, we found that most of the threatened sites (from the results obtained) suffer considerable degradation of flora, fauna, and ecosystem. Through several discussions with experts of the Ahaggar and Tassili Parks Offices and people we met, the causes of this situation can be summarized as follows:
(1) Deforestation depleting forest trees because the wood is often utilized by humans for heating and handicraft. (2) Overgrazing, when a very large number of goats, sheep are placed in a small area. (3) The uncontrolled use of animals or plants for food, economic, handicraft or other pharmaceutical needs. (4) Overhunting and poorly controlled hunting that do not obey the periods studied respecting the physiological status of the species. (5) Various types of pollution are contributing to the disappearance of both flora and fauna.

5 CONCLUSION

The integration of RS data in geographic information systems is an effective, essential approach for monitoring and preserving the biodiversity on an expanded important region where access is often difficult. According to the obtained results, we can affirm that over a period of twenty years there is a degradation of vegetation cover for the three selected sites. However, there has been a good improvement of vegetation cover for certain (some) locations, which brings us to confirm the presence of a strong indication for the activity of the saharan ecosystems in spite of the various threats. The vegetation cover in this region (southeast of Algeria) is characterized by a weak vegetation cover, which is distributed along the wadis. Consequently, the comparative approach, based on the combination between several indices (vegetation, brightness, redness of ground, PCA, etc) on the one hand, and the photo interpretation of the various colored compositions on the other hand, contributed effectively for the localization of the vegetation and at the same time its spatiotemporel monitoring over extended periods.

The methodology based on the integration of several indices of vegetation has makes it possible to quantify the vegetation in terms of occupied surface and to determine with precision the areas where vegetation is dense, average and low.

The results obtained constitute a reference frame and a base of work, which started to be created. That is, without any doubt, subordinated to the convictions, the implication of all for a sustainable conservation of biodiversity in these regions.

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