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Analysis of bitemporelles images to follow-up the flooding phenomenon in the western high plains of Algeria

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ABSTRACT

In these last decades, the High Plains Steppe of Algeria have been marked by an intense degradation affecting the land, due to several factors such as the floods. The proposed solutions that allow to combat these phenomena and retain the nature of these areas remain inadequate due to the absence of identification model, tracking and flood forecasting.

This article shows the results of the spatiotemporal study of parameters that define the natural phenomena geography, in other words, it is the first time where, the follow-up spatiotemporal aggravating factors the flood, then see their effects on the map of the risk hazard.

The algorithmic diagram of our study focuses on the development and the application of techniques for the purpose of the characterization and monitoring of the spatio-temporal dynamics of environmental systems at the watershed scale “wadielbiodh”, in order to integrate the spatial data and maps in Geographic Information System (GIS) that will allow to establish or implement a forecasting model which helps in the protection of the urban space and to anticipate the intervention of local authorities.

1. Introduction

The multi-time satellite imagery used to develop dynamic flood risk maps and track geographically risks, that contribute in damages attenuation according to these disasters.

The availability of satellite data, the repetitiveness of their acquisition, and the analysis of the images multi-temporal have helped to expand the applications of remote sensing to include the surface earth change detection and the follow-up of the dynamic phenomena [4].

Detection of change in remote sensing is a process that identifies differences states of an object or phenomenon by carrying out observations with several dates. It essentially involves the ability to quantify the temporal effects by using multi-date data [2].

The aim of this study is to develop a process application of characterization techniques and monitoring of the spatio-temporal dynamics of environmental systems at the watershed scale of “wadielbiodh”, the combination of Geographic

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Table 1
Typology and sources of collected data.

Organization/Direction	Data type	Properties
The National Agency for Hydraulic Resources (**ANRH**)	Geological Map	e = 1/200 000
The National Institute of Cartography and Remote Sensing (**INCT**)	Topographic Map	e = 1/50 000
Direction of Météorology	Data Raifall	Series of ten stations (10 years interval)
Earth Science Data Interface (**ESDI**)	Satellite Image(LANDSAT)	Spatial résolution: 30 (m)
		Acquisition date: 2001,2014 (spring)

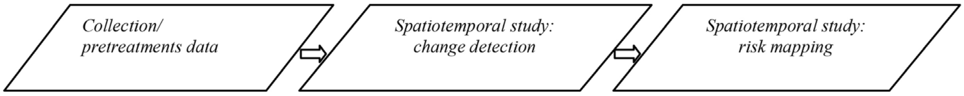


Fig. 1. Analysis and processing phases.

Information System GIS and the Multi-criteria analysis (MCA), allows the decision-making by delimitation and definition risk's area in the order of the weighting of the factors studied.

Regardless of the use of GIS and the MCA, the space images classification is essential, techniques of analysis, position classification of images resulting thematic allow to see the change in each parameter defining the risk.

Finally, in order to have a correct and accurate decision, the dynamic maps were developed by combining a multisource data, allow to make a comparative study taking into account all obtained results.

2. Methodology

In order to achieve our objectives, a three-phase approach was defined. During the first one, we have collected the necessary data from different institutions and services "Table 1". For each type of data, we applied a preliminary treatment as required GIS/MCA integration formats (Space Technics Center, ANRH, INCT, Meteorology Department).

The extraction of the information about the change of the factors studied by the time is the subject of the second phase by the application of the methods of detection of changes qualitative/quantitative and the interpretation of the results of a temporal space of 13 years.

The final phase use the spatial analysis techniques and MCA to develop the geography maps of the hazard flood risk during the two dates 2001 and 2014, the interpretation and reading of the maps must be done by a comparison with the previous phase results (Fig. 1).

2.1. *Choice of study area*

In our situation, the choice of the study area is stipulated by the availability of necessary data for the practical realization of the project on the one hand, on the other hand the area that we have selected is an area affected by the flood in October 2011 and in 1953 according to the history.

El Bayadh is a municipality in the wilaya of El Bayadh, which it is the chief-town, located 370 km south-east of Oran, 520 km south-west of Algiers and 500 km north-east of Bechar. It covers an area of 463.50 km^2. The population is estimated at 120,948 inhabitants according to the General Census of Population and Habitat 2015 (Fig. 2).

2.2. *Pretreatments and combination of image data*

They are classified in the Table 1, the set of data collected based of their typology and the provider agency.

2.2.1. *Realization of the land use map*

For Landsat TM images, radiometry correction has been applied to improve the contrast that is necessary for the choice of training sites in the supervised classification. The type of radiometric correction is linear stretch.

The image was re-projected from WGS 84 system to the North Sahara 1959 UTM system.

After the geometric and radiometric correction, the image was classified, by applying the maximum likelihood algorithm to identify four main classes: soil, vegetation, urban, career (Fig. 3).

2.2.2. *Analysis of vegetation cover*

The Normalized Difference Vegetation indicator is "NDVI" an indicator that identifies the vegetation object, based on the red and near infrared channel image TM. In the process of realization of flood risk maps, it is used as an information layer on plants and non-plant areas (Fig. 4).

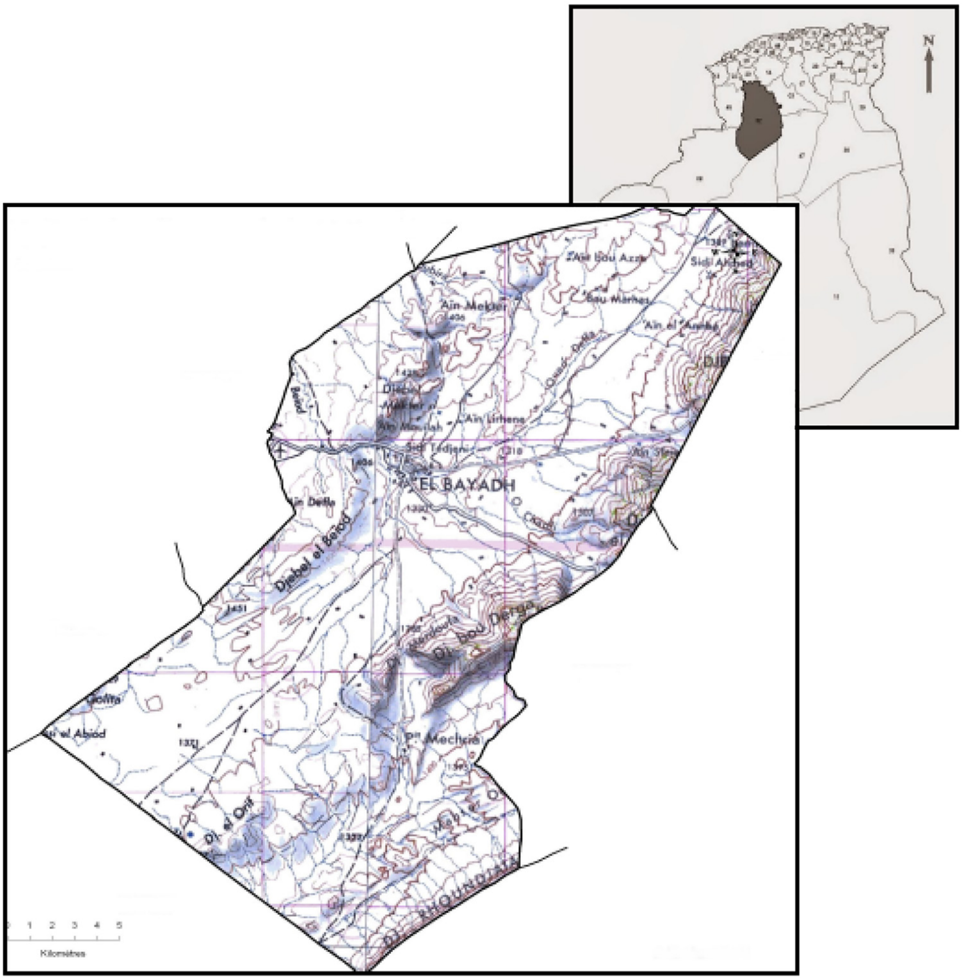


Fig. 2. Location of the Study area.

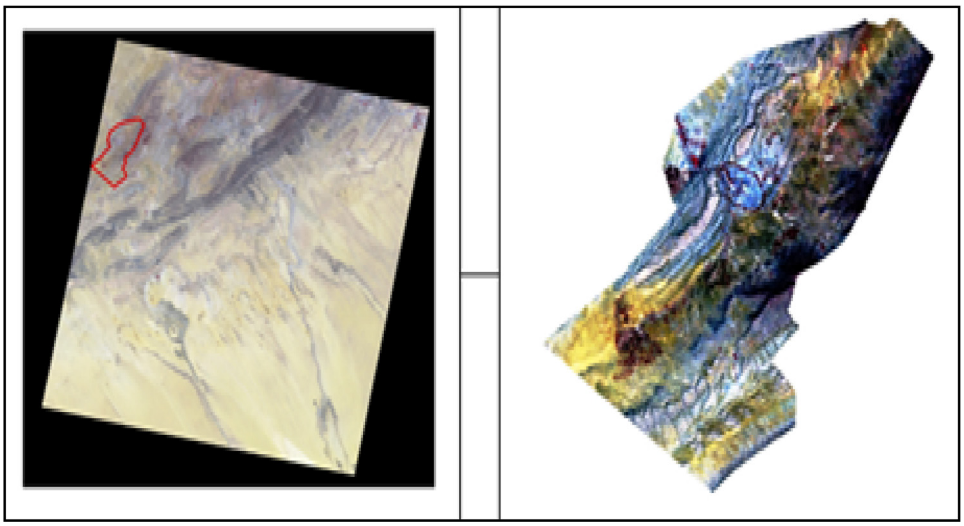


Fig. 3. Colored composition, extraction and improvement of radiometry.

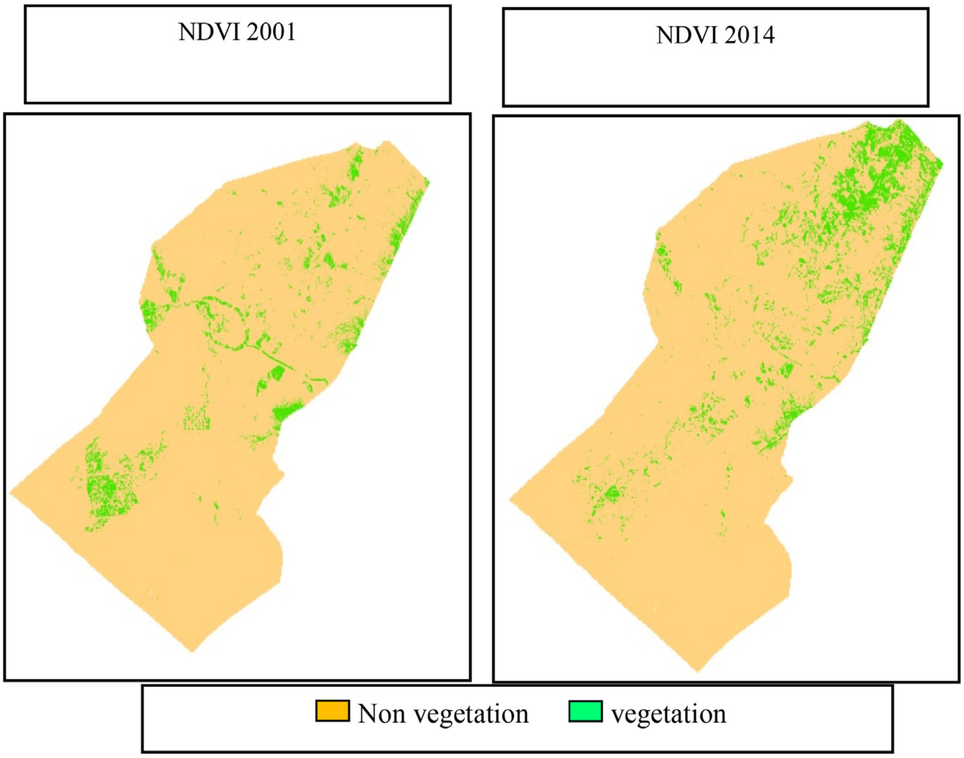


Fig. 4. Object vegetation masks by calculation of NDVI 2001 and NDVI 2014 indices.

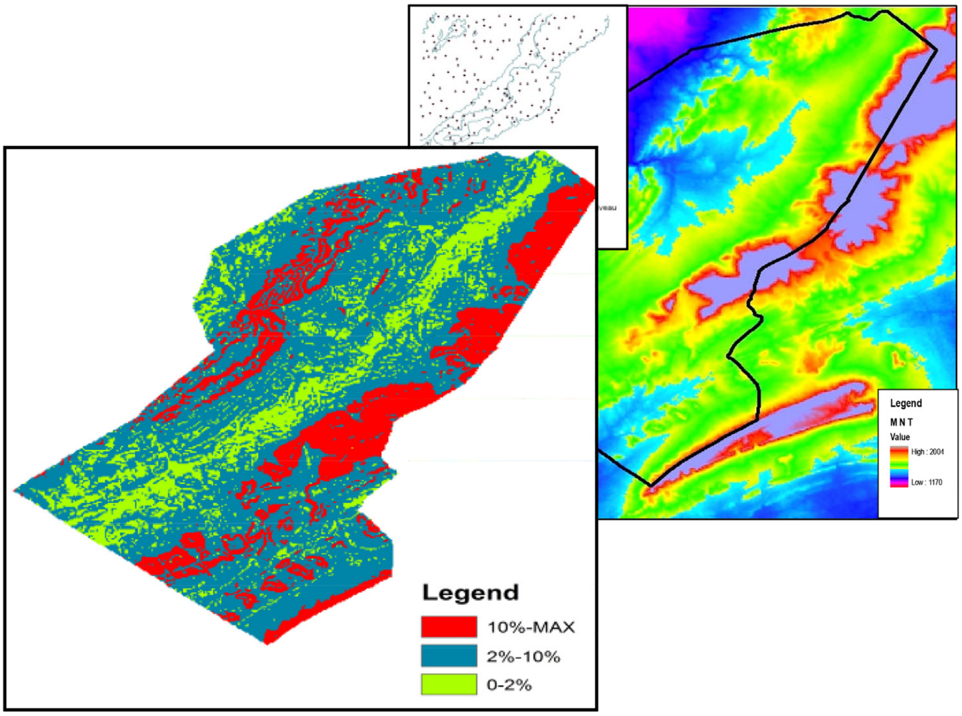


Fig. 5. improved DTM and slopes map derived.

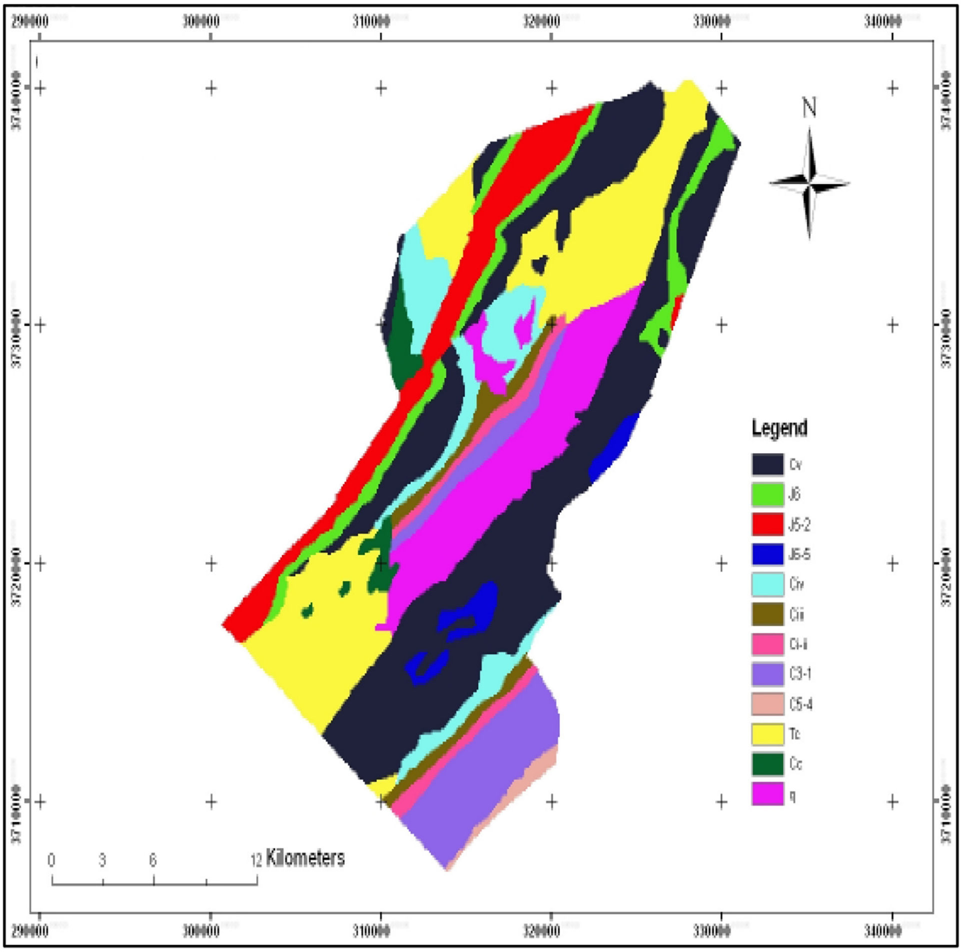


Fig. 6. Geological map of El-Bayadh municipality.

2.2.3. *Study of the topography*

The slopes of the map is an essential layer in natural hazards studies, the fact that it defined the field topography in the form of classes. In our case the map was created based on a DTM after improvement.

The numerical model of land acquired is the Gtopo90 not characterized by its 30 m sampling and precision variable altitude measurements. For this, we followed a process of improving its information quality through the integration of contour lines and spot the topographic map. Similarly, improved product has been re-projected from WGS84 system to the North Sahara 1959 system to generate the slope map (Fig. 5).

2.2.4. *Extraction of geological information*

We extracted the geological map which corresponds to the extent of the municipality of El-Bayadh, this extraction has allowed us to identify rocks geological units components.

After extraction, we have taken information from geologists scientists about the properties or the sensitivity of these rocks to the flood.

these information was used as criteria to classify the geological map according to the subject study (Fig. 6).

2.2.5. *Realization rainfall map*

After analyzing the series of meteorological observations, we made statistical calculations to apply later an interpolation algorithm of rainfall measurements from ten stations: El-Bayadh, Naama, Ain Sefra, Laghouat, HassiR'Mel, Ghardaia, Saida, Tiaret, Bechar and Adrar (Fig. 7).

2.3. *Change detection by satellite imagery*

After analyzing data on the Oued-El-Bayadh pool, we chose to work first on the land cover change, evolution or degradation and how will influence the risk mapping?

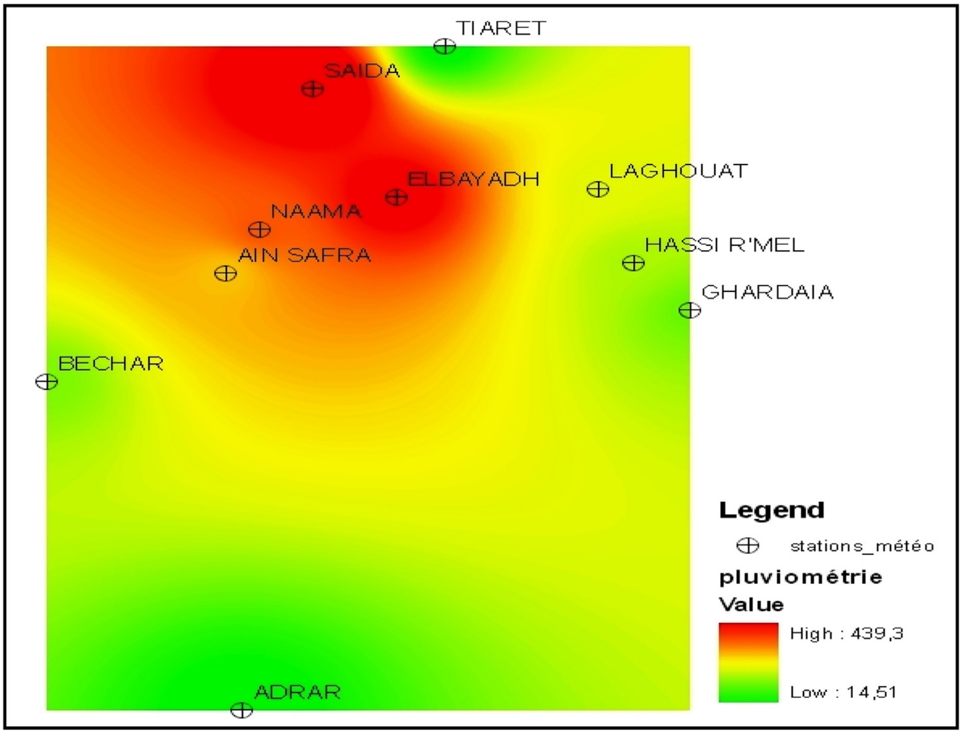
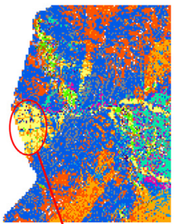
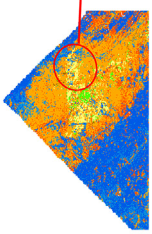


Fig. 7. Generation of rainfall map.

Table 2
Comparative analysis of the both samples.

	Extract of Fusing index map	Post_classification Extract map
Sample 1	 Degradation of vegetation	 Vegetation_ground Combination
Sample 2		

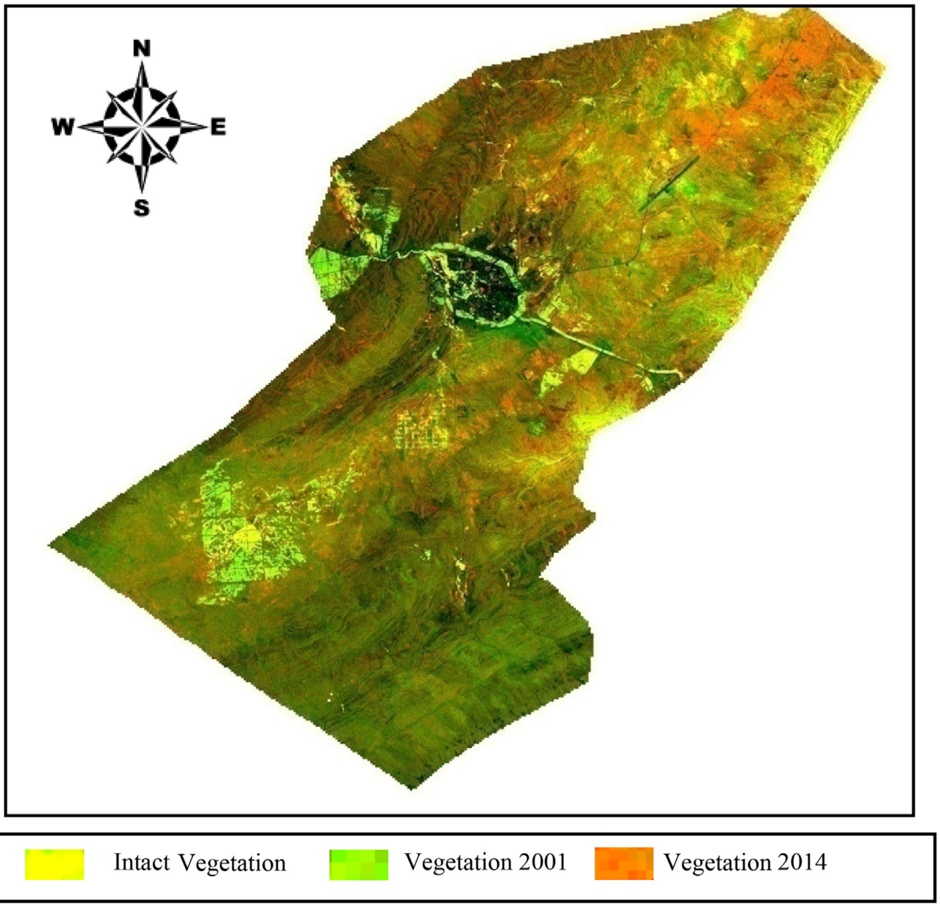


Fig. 8. Merging of NDVI 2001 and NDVI 2014 indices.

This phase is not a comparative study in the sense of algorithmic study but rather an application of qualitative or quantitative detection algorithms to ensure the information.

There are several changes of detection methods in the literature [1–3], for our case, we used two methods: Method melt indices, and Comparison method post-classification.

2.3.1. Fusing index method

The vegetation index uses the vegetation spectral signature (very high infrared reflectance and very low close in red), this index is a relatively reliable indicator of chlorophyll activity of vegetation [5].

We applied treatment on vegetation indices calculated from our bi-temporal images.

The interpretation of the results obtained "Fig. 8" has allowed us to identify vegetation (new and old) in a comprehensive manner.

This method of fusion has the advantage of quantifying change, although the accuracy is not better because the quantification is done on the basis of a manual thresholding of the two indices.

The applied solution has limitations as regards the change detection for objects of small dimensions.

2.3.2. Post-classification analyses method

Post-classification comparison methods provide information about the nature of the changes, and have the advantage of comparing object classes in pairs, which makes it easier to extract changes accurately [3].

The statistical analysis of the results of the classifications of the both dates makes it possible to estimate relatively (classification accuracy – thematic confusion) the rate of change between the two dates.

For the pair comparison, the result obtained "Fig. 9" for classifications of four classes: soil, vegetation, quarry, and urban, comprises 16 combinations of classes.

The comparison approach of classifications requires having good results of field trips. The problem of omission and shadow may distort the interpretation of certain objects (Fig. 10).

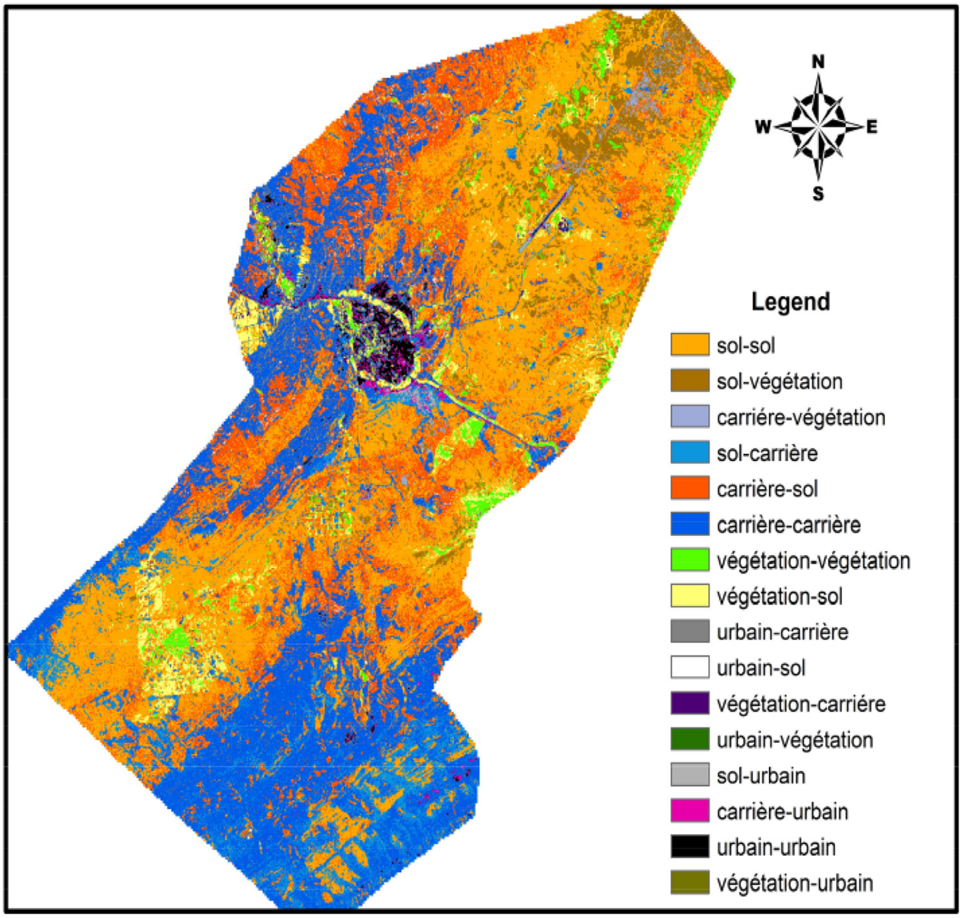


Fig. 9. Results of compared post classification.

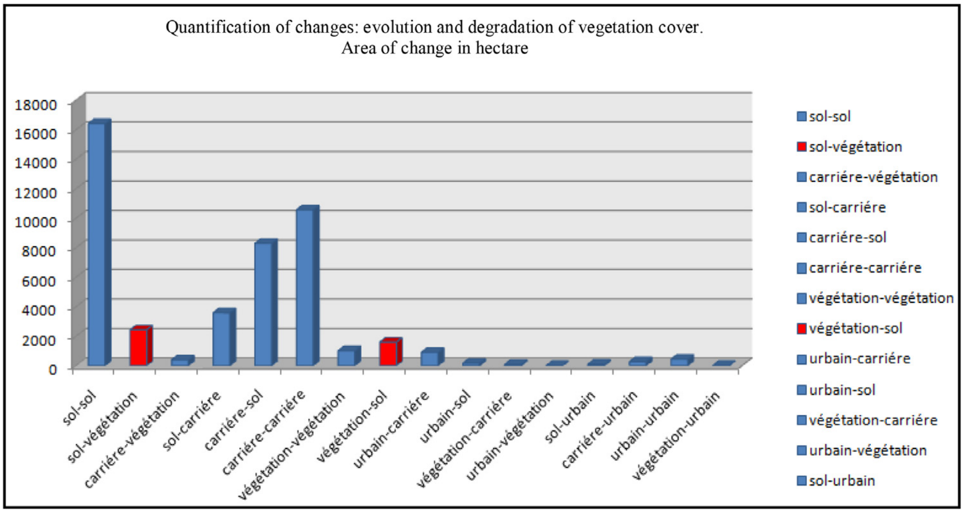


Fig. 10. Quantification of the analysis results of the post classification comparison.

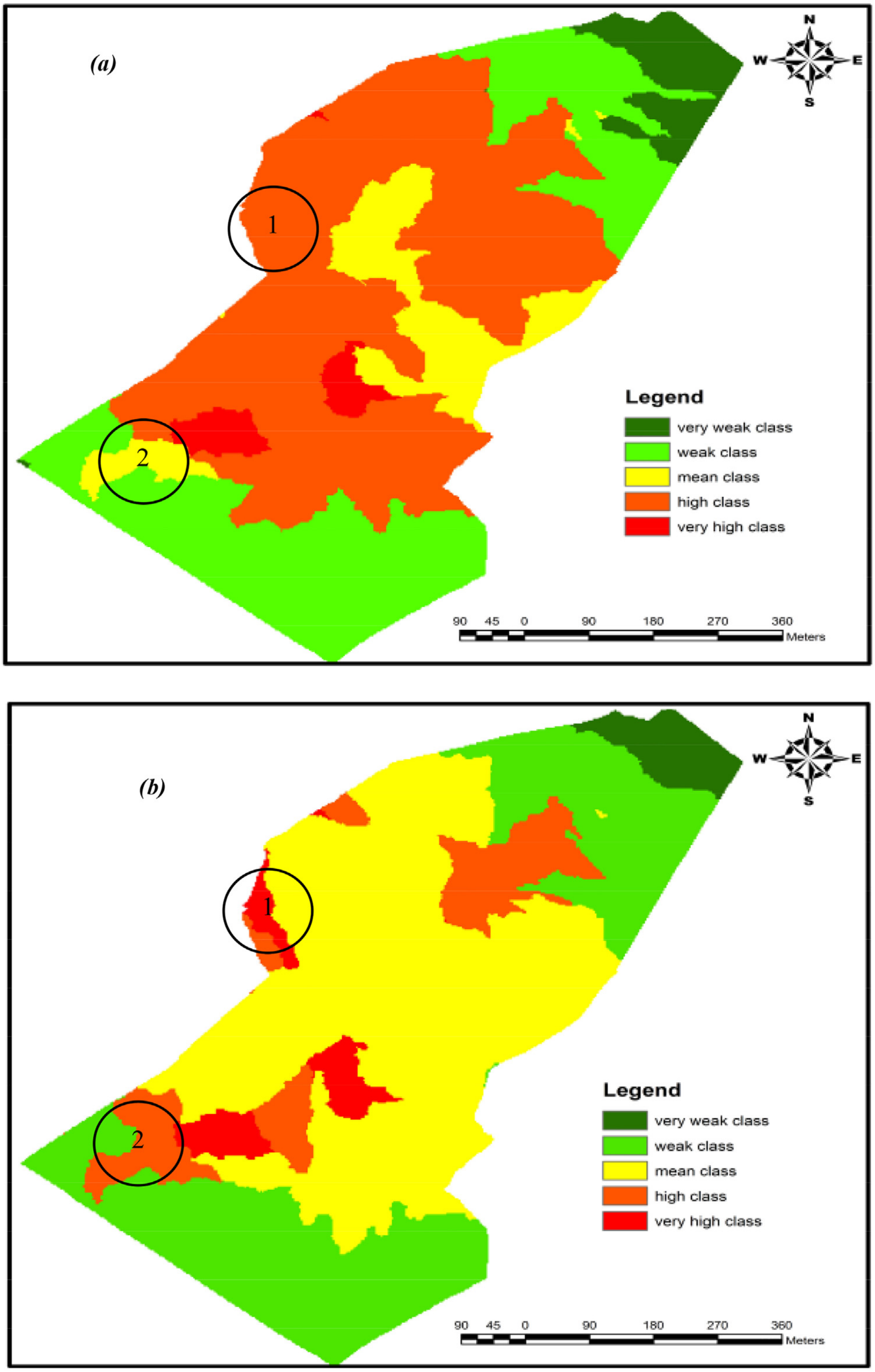


Fig. 11. Flood risk maps by watersheds for both dates (a): 2001, (b): 2014.

The change detection methods applied in this phase show a significant change especially on the turf of the municipality of El Bayadh in an interval of 13 years, our goal is not to investigate the causes of this change, but view is that this change affects the flood hazard map and how to interpret this change?

2.4. Mapping flood hazard: approach and analysis results

The knowledge of the factors aggravating the flooding hazard and the periodic monitoring of their variations, increase our understanding of the phenomenon, also allows us to identify areas likely to be hit by flooding and determine their degree of risk.

2.4.1. Maps elabortation

We have selected the MCA algorithm AHP (Analytical Hierarchy Process) to merge data with advanced weighting for the development of flood risk map. Two types of pretreatments are applied before integrate them into the GIS process on two levels:

- First level on the analysis of data acquired according to their geometrical properties, scales, resolutions.
- The second level is an advanced level, is to create thematic maps and mapping of flood risks.

The flood risk map obtained by fusion is a representation by classes that show the degree of risk, but also a representation of heterogeneous merged pixels which makes interpretation difficult for non-experts. To solve this problem, we have chosen spatial units of geographical integration which are the watershed boundaries.

"Fig. 11" shows the result of the spatial multi-criteria combination by integrating of risk information by watershed. by the lecture of the Maps of two dates show 5 classes lands that differ in terms of risk, in other words, it represents a decision-making map at the municipal level where the lands are classified and identified.

2.4.2. Comparative study and analysis of results

The changes are detected and risk maps are established, we now looking for the relationship between the change in the risk map between the two dates and the change of the land map and the NDVI.

two samples were selected to find the links and check the influence of the recorded changes, the comparative analysis of the two samples is shown in Table 2.

In the first sample and from the index melting result, degradation of vegetation is very noticeable, which is the same result obtained by analysis poste_classification, change of the vegetation in ground.

This change has increased the risk of flooding by passing from high class to very high risk class.

On the other hand in the second sample, from the result of the index melting, degradation of vegetation, this result is confirmed by the analysis post_classification change detection method, that has been applied in where a change of the vegetation in ground has been detected.

The effect of this change represented in the flood risk map by converting the mean class to the high class.

3. Conclusion

The main objective of this research was in first time to analyze the risk geographically (is to say) i.e, identify the parameters that increases the risk of flooding in a steppe zone Elbayadh (North West Algeria) which is an area affected by the flooding in October 2011.

The use of multi-criteria analysis and GIS, combines these parameters to achieve the flood hazard maps without taking into consideration the return period, the implementation of such a map, despite its difficulty, does not make a real problem, but it is to study the parameters that can change over the time.

In order to change detection, we used the given multi dates-TM (2001 and 2014) whose purpose was monitoring the evolution of the factors increasing or attenuating the phenomenon studied.

The study of change also allowed us to identify areas likely to be affected by flooding and determine their degree of risk. A comparison of the hazard maps was made subsequently to the link: risk factor & decision making.

We estimate that the results of this work could form a support of aid decision in terms of prevention, forecasting, and protection of areas against the threat of flooding.

The results of this mapping (of flood hazard map) are represented schematically by a simple way and allow to different actors (users) in the flood risk management frame, using them to know how to manage the territory before and after the crisis.

Applied change detection methods show a significant change especially in the sward. This change correspond in the hazard map to a conversion of risk classes. A change that must be taken into account by decision makers in the development projects and urban planning to create of new urban areas.

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