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RESEARCH ARTICLE

SPECTRAL INDEXES TO DETECT LAND COVER CHANGES DUE TO THE FLOODS (MOROCCO).

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Abstract

The objective of this study is to detect land cover changes in fact of flood risks, with using a new method, fast and efficient. This technique needs only a diachronic satellite images in input data.
The variability of reflectance spectral indexes is a characteristic of land cover changes. For applying this theory, we were including four spectral indexes those look on the principal indicator for land cover changes which are (Brightness index, Color index, Salinity index and clay index).
To applying this method, we choose the Souss Massa basin as a study area. In 2014, this basin especially rounded of Guelmim city was affected by floods which caused a lot of damages in different ecosystems.
Another step is used in the laboratory to validate our procedure; we talk about the physic-chemical analysis of land cover taken in two different dates, before and after floods.
Finally, the comparison of the spatial results with those of the physic-chemical analysis, show there is a good correlation between of all parameters.

Introduction:-

Availability increased free download data of remote sensing has allowed to make environmental studies much more temporal multi easy. A huge advantage has summer for the study of the degradation of soils under the effect dare floods and erosion of the soil. This decline in the quality of the soil leads to a reduction of productivity land that is more uniform, the same landscape lies in a deteriorated condition. The space images provide an effective way for the management costs of this degradation direct on the ground then the methods are expensive and tedious (Mumby et al, 1999). Thus, this information extracted on the land cover, using remote sensing and geographic information systems tools, provide data on a large scale and to better identify the areas exposed to the risk of change with their geographical distribution (Yuan et al.., 2005).

Previous studies on the detection of land cover changes, using remote sensing and geographic information systems tools showed that there are several approaches to detect them.

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These methods include those which are based on the study of the dynamics land cover change (Halmy et al., 2015) , as well as on the principal components analysis (PCA) (Li and Yeh, 2004) , others are based on the algorithms of classification by the texture of the image (Schumann et al., 2007; Vinu Chandran et al., 2006; Emran et al, 1996a, 1996b) and algorithms of automatic classification (Hoque et al, 2011; Hakdaoui and Rahimi, 2008; Bonn and Dixon, 2005; Sohn and al., 2005; Emran and al., 1996a and 1996b). Adding to this, others methods as to focus on direct comparison between two images, or to use an index for comparison and identification changes (Hansen and Loveland, 2012).

So, the procedures of mapping land cover changes have been proposed typically fall into two major categories: those who apply change detection techniques using diachronic images of the same area. And those, who apply different algorithms and image filters for differentiation and division to produce binary maps of "change" vs. "no change" (Disperati and Virdis, 2015; Yuan et al., 2005).

The main objective of this work is to detect land cover changes that accrued areas as a result of the floods. The technique used is to merge between two major methods: the first is to detect land cover changes using the spatial technics of remote sensing and GIS, the second, is to identify the changes in the quality of soils with applying the physic-chemical analysis.

In particular, chosen the Guelmim basin as a study area is focused on a lot of principal reasons such as: Its arid climate, is located on the South of morocco and exposed to erosion and desertification risks. Also, this basin was affected by floods that caused more damages.

Material and Methods:-

Study Area:-

The study area is a part of the Souss Massa basin, is located in the South of Morocco, according to the following geographical coordinates: 28 ° 97' N and 10 ° 06' W (Fig1), limited to the North by the Tensift basin, to the South and East by the Daraa basin.

It includes the Sub basin of Assaka which extends over an area of 6500 km² and which crosses the coastal landscape by a throat and collects residual flooding of the complex basin and a complementary pool of 410 square kilometers after their spreading in the plain.

Soils that predominate in the study, according to the soil map (Fig2) area, are usually made up of:

- Raw minerals soils composed of stony sand desert on a bedrock limestone and eruptive who thrive on Paleozoic formations of the Western Anti-Atlas and dominating almost all of the eastern region of the Guelmim province;
- Mineral soils raw unorganized corresponding to the ergs and dunes of the Quaternary, they can be found at the level of the coastal dunes;
- little advanced soil Xeric, salt sub-deserter sandstone that dominate the Western region of the province and who thrive on trainings Paleozoic and inherent in the coverage of Neocene and Quaternary formations;
- little advanced joint contribution of the sandy dunes of the Quaternary soils.

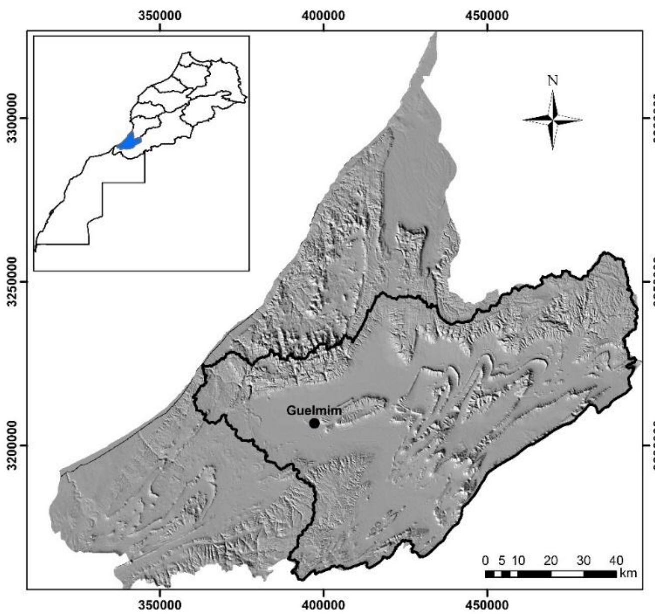

Fig 1:- Geographic Situation of the study area

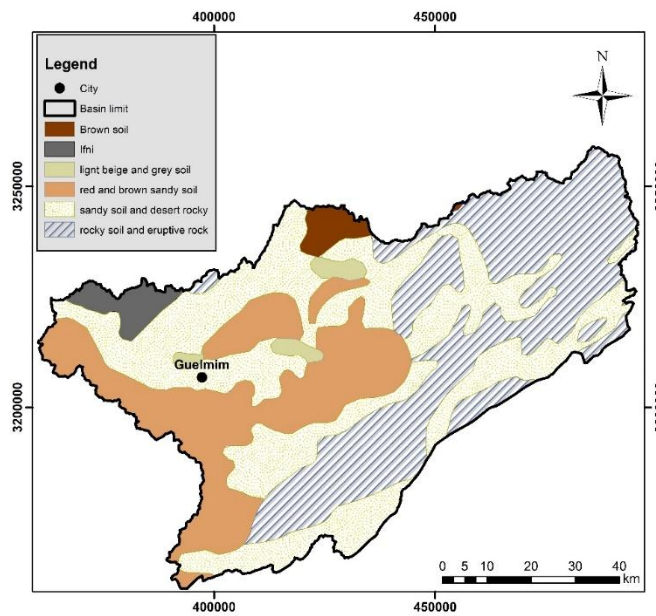

Fig 2:- Digital soil map of the study area.

According to the ABH (2016), study site is characterized by a semi-arid climate with extreme heat and insufficient precipitation; this is due to changes in temperature, rainfall and the degree of aridity. The rainfall is very low, it is marked by an irregularity of the rainy season interrupted by dry seasons between 5 to 6 months, sometimes 7 months (table1). On the last raw, the average rainfall during the month November was able to reach 60,8 mm in 24 hours, however the month December average was in the order of 11,1 mm in 24 hours.

Table 1:- Rainfall in the study area

2014/2015													
Month Station		**SEP**	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MAR**	**APR**	**MAI**	**JUN**	**JUL**	**AGU**
TAGHJIJT	**TOTAL**	24,5	4,00	189,9	0,00	1,0	0,00	6,3	0,00	0,00	0,00	5,00	14,9
	DAILY MAX	21,5	4,00	58,5	-	1;0	-	3,5	-	-	-	4,00	7,7
	DATE	21/9/ 2014	11/10/ 2014	28/11/ 2014	-	19/1/ 2015	-	22/3/ 2015	-	-	-	20/7/ 2015	12/8/ 2015
ASSAKA	**TOTAL**	11,1	0,00	262,9	16,0	11,7	0,00	19,0	0,00	0,00	0,00	0,00	9,8
	DAILY MAX	9,6	-	60,8	11,1	9,8	-	6,1	-	-	-	-	6,1
	DATE	20/9/ 2014	-	28/11/ 2014	1/12/ 2014	18/1/ 2015	-	22/3/ 2015	-	-	-	-	12/8 2015

Data Used:-

Despite the large number of satellite programs operated in the detection of changes of Landsat is unique because it provides operational and absolutely essential images to monitoring and mapping of the land (Abd El-Kawy et al., 2011; Wulder et al., 2008). The images used are those of the sensor Landsat 8 OLI (Operational Land Imager) acquired the first in 10-22nd-2014 in two dates before the floods and the second in 12-09th-2014 just a month after the floods. Table2 shows the different spectral bands available for LANDSAT-8 with the resolution of each

Table 2:- Characteristics of the bands of OLI and shots Landsat - 8 (NASA) sensors

Landsat 8	Bandes spectrales	Longueur d'onde (micromètres)	Résolution (mètres)
Mis en orbite 11 février 2013	Bande 1 - aérosoll	0.43 - 0.45	30
	Bande 2 - bleu	0.45 - 0.51	30
Operational Land Imager (OLI)	Bande 3 - vert	0.53 - 0.59	30
	Bande 4 - rouge	0.64 - 0.67	30
	Bande 5 – proche infrarouge (NIR)	0.85 - 0.88	30
	Bande 6 - SWIR 1	1.57 - 1.65	30
	Bande 7 - SWIR 2	2.11 - 2.29	30
	Bande 8 - panchromatique	0.50 - 0.68	15
	Bande 9 - cirrus	1.36 - 1.38	30
Thermal Infrared Sensor (TIRS)	Bande 10 - infrarouge thermique	10.60 - 11.19	100 * (30)
	Bande 11 - infrarouge thermique	11.50 - 12.51	100 * (30)

Methodology:-

The method used consists of several steps, which are shown in (Fig3). It started by the extraction of spectral indexes, then the detection of difference land cover changes from diachronic images. The comparison and validation of results are obligatory, for that two procedures are applying:

- Comparing the spatial result with soil map of the study area
- Applying physic-chemical analysis, showing the changes and comparing all of results.

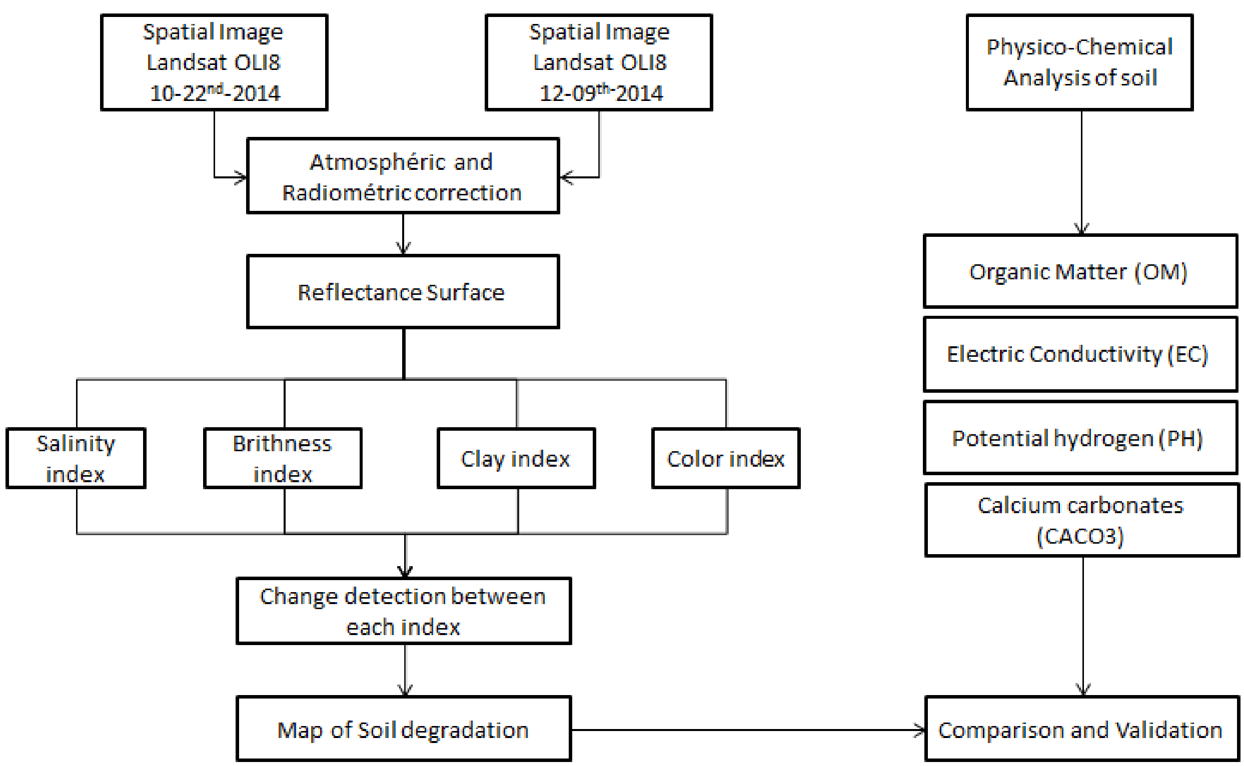

Fig 3:- Land cover change detection model

Spectral indexes:-

Several works have shown interest to use spectral indexes based on the curve of reflectance of land to characterize the surface condition of soils, particularly in arid and semi-arid, regions such as the color index (CI) and the brightness index (IB) (Maimouni and al., 2011).

For the detection of land cover changes by the effect of the floods, spectral indexes chosen for the distinction of areas that have undergone changes are (table3):

Table 3:- Spectral indexes Characteristics.

Spectral index	Definitions	Relations	Authors
Brightness index (IB)	To estimate the presence of water in the soil.	$IB = (\sqrt{(PIR^2) + R^2})$	***(Escadafal et al., 1994)***
Color index (CI)	To Characterize the color of soil, which is acquired from their chemical compositions and their levels of organic matter.	$IC = (R - V) / (R+V)$	***(Escadafal et al., 1994)***
Clay index (Clay mineral)	To identify the elements of clay.	***Index of clay ratio = MIR1/MIR2***	***(Drury, 1987).***
Salinity index	To identify the soils which contain elements of salt.	***Index of salinity =*** $(V^2 + R^2)^{1/2}$	***(Mike and al,.2004).***

Detection of land cover Changes:-

The detection of land cover changes by diachronic images in input is based on the comparison pixel of pixel of the same images area, to produce as a final result the modified information based in the pixel (Rawat & Kumar, 2015).

This technique is an image that highlights the changes over time. It represents an efficient technic to compare and detect land cover changes in two different dates.

Analyses physico-chimiques du sol :-

In this work, we proceed with the determination of the main physic-chemical parameters known: the organic matter, the calcium carbonates, the pH and the electric conductivity (Sumner, 2000; Sparks, 2003; Shtangeeva, 2005). For that, a random sampling has been adopted. The samples have been made according to the horizon (0 - 5cm) in four stations then put in plastic bags. Once arrived in the laboratory, they were dried in the open air for at least 5 days, crushed using a mortar in agate and after that sifted in a 2mm sieve.

The analyses that have been Carried out Are:-

Table 4:- Physico-chemical Analyses:

Physico-chemical Analyses	Method
pH	***Mc. Lead (1982)***
OM	***Walkley and Black (1934)***
$CaCO_3$	***Bernard : Chamley (1966)***
EC	***Rhoades (1984)***

Results and Discussion:-

Results Analysis:-

The results obtained from the calculation of spectral index used to characterize situation of the environment in order to discriminate and identify areas that have changed as a result of floods

The brightness index reflects the illumination of constructive elements of soil, it estimates their clarity. Figures 4a and 4b show the BI maps derived from diachronic satellite images dated at October 22nd 2014 and December 9th 2014. Before floods the BI test, Figure 4a shows the reflectance of the dry soil with strong values. While after the floods (Fig4b) soils become dark, and this is represented by the low values of brightness index reflectance, we can explain these changes by the presence of water in soils are caused by flooding.

Regarding the color index, it reflects the soil color which can differentiate between many types of soils. The results obtained in the two maps (Fig5) present significant variations, the difference is marked in the soil color level. Probably this is due to the changes of the chemical and mineralogical composition of the construction materials of these soils, before floods (Fig5a), soils in the area were clear and bright with the reflectance color clearer, after the floods, the soils become increasingly dark and mat (Fig5b).

The clay index allows the identification of clay items, as the area is known by sandy soils, the absence of clay is reflected in Figure 6a, whereas after the floods (Fig6b) we could see a new cover formed by clay soils, this layer of mud is the result of the submission of fine particles that was transported at the flood. In contrast, salinity index indicates the presence of the salt components in the construction materials of the soil. The reflectance of this index is low in Figure 7a, by after the floods (Fig7b) we see the reflectance of the salinity index with a whitish color, this is maybe related to the filing of new material.

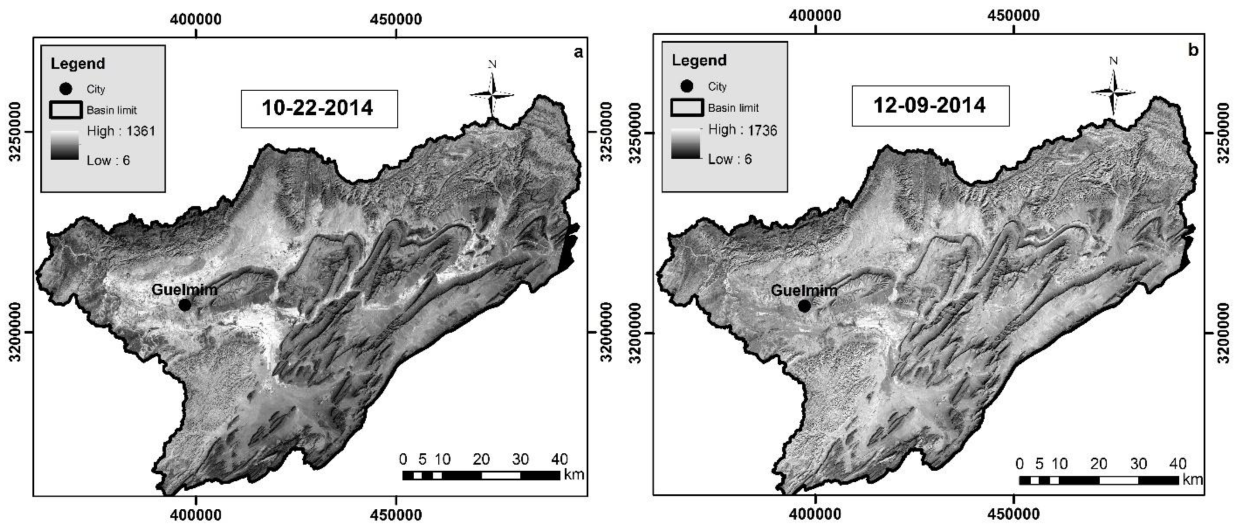

Fig 4:- Brightness index map.

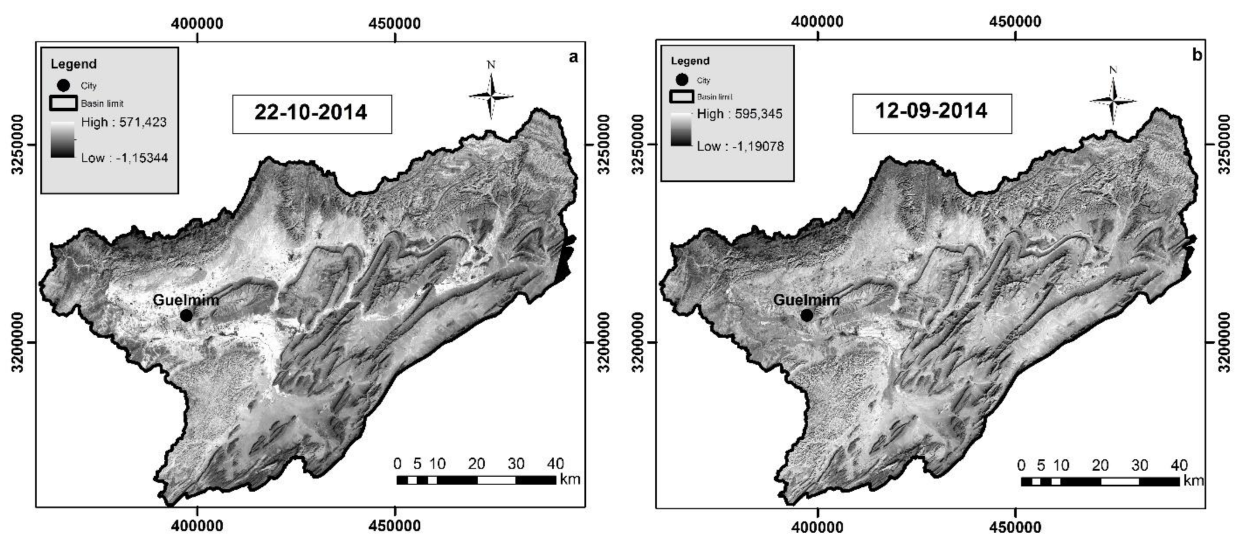

Fig 5:- Color index maps.

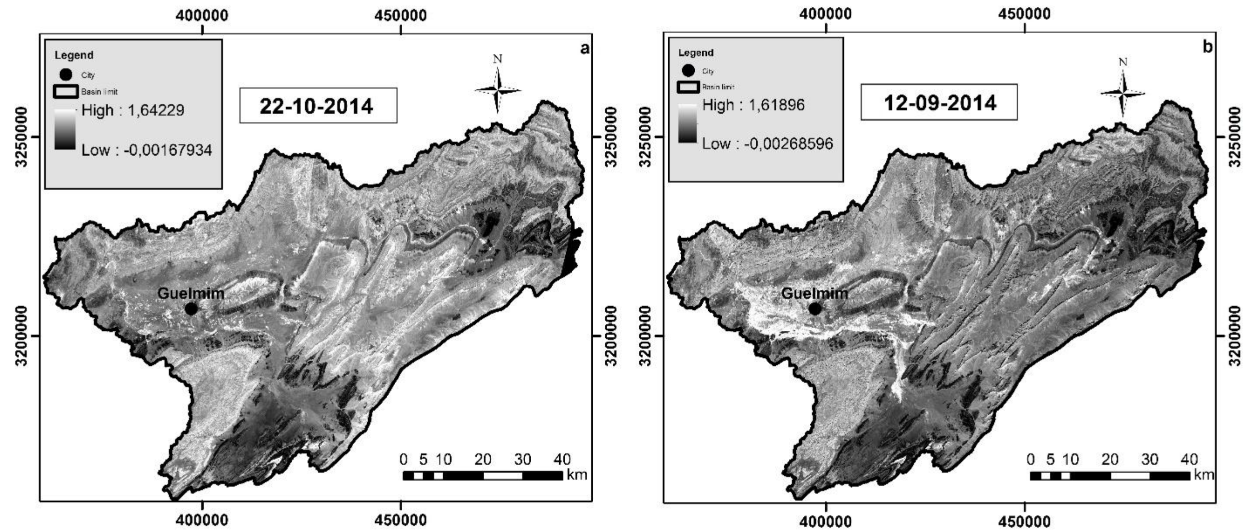

Fig 6:- Clay index maps Fig7: Salinity index maps

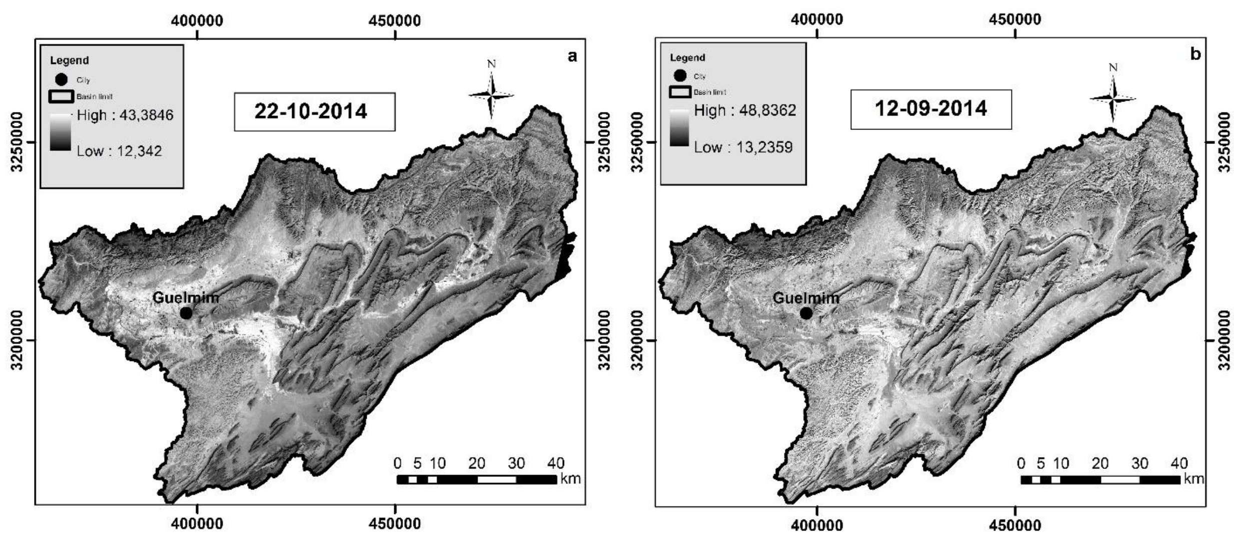

Fig 7:- Salinity index maps.

The changes observed in all spectral indexes maps vary according to the characteristics marking of soils already existing and deposited soils.

We note that for all of the indices, the Detected Changes have affected almost the same areas (Fig 8).

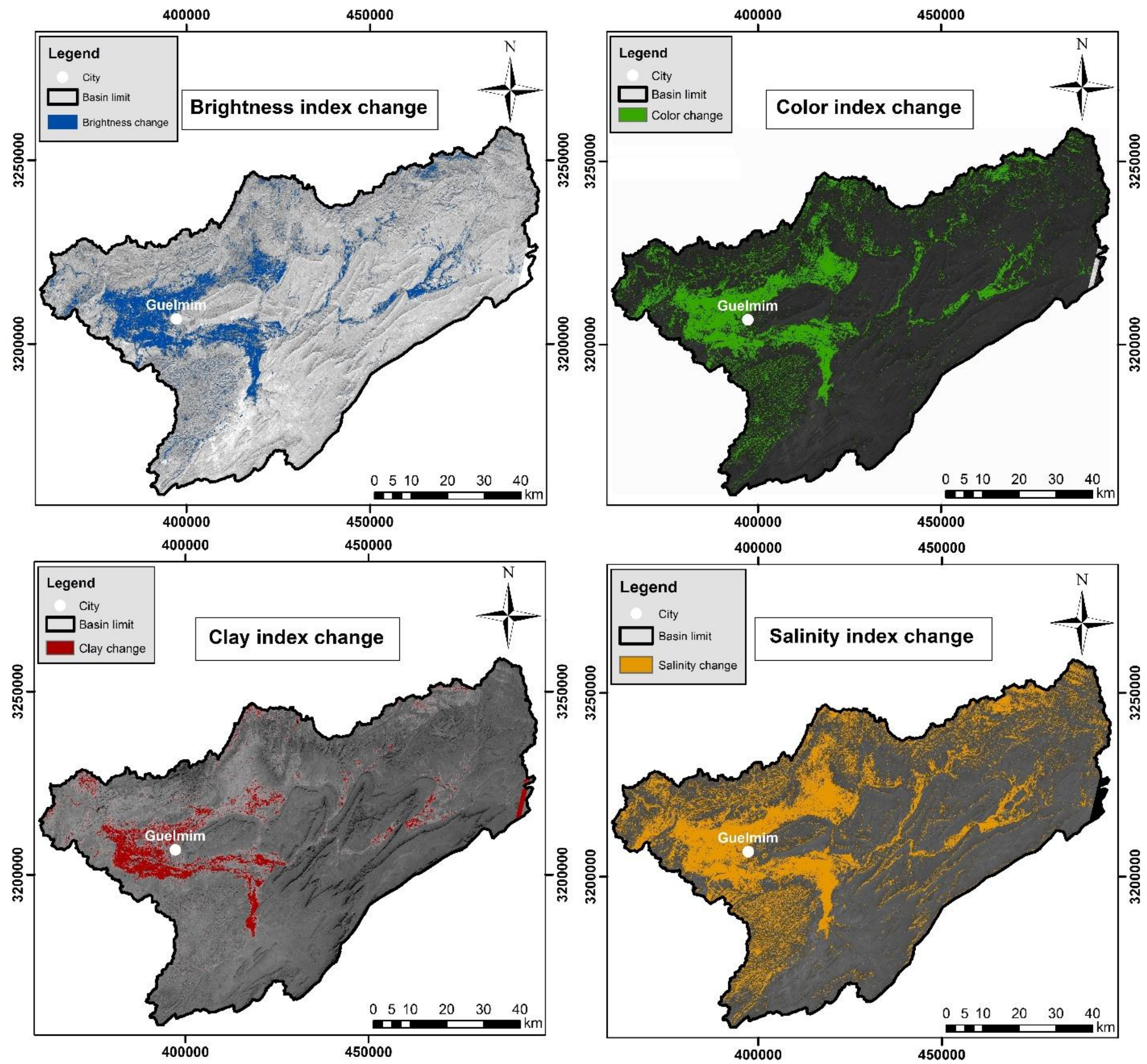

Fig 8:- Difference changes maps into before and after floods for each spectral index

As a result, space detection of land cover changes showed good results, all maps illustrating precisely the vulnerable areas at flood risk. To validate these results, we had procedure to the physic-chemical analyses of samples taken from the same area in four stations.

The descriptive statistics of the physic-chemical parameters of soils studied (table5) highlighted that:
According to the standard in DRHA/DIAEA/SEEN (2008), changes in pH show that the majority of the studied soils are neutral in the three stations (6.60 to 7.20), except the first station 'Abaynou' that contains weakly acidic soils with values ranging from 6.3 to 6.5. Almost 75% of the analyzed soils are poor in organic matter with values averaged 1.24% to 1.31%. The concentration of $CaCO_3$ soils sampled in the three stations 'Abaynou, Guelmim and Laqsabi' are excessively calcareous, however the station "Asrir" presents highly calcareous soils. The results of electrical conductivity show that 50% of the studied soils are greater than 4 mS/cm, which allows to classify these soils in the range of saline soils.

Table 5:- Descriptive statistics after the floods.

Stations	Variables	pH	CaCO3 %	OM %	EC mS/cm
Abaynou	Max	6,50	57,50	1,55	6,06
	Min	6,30	42,00	0,77	5,12
	Median	6,5	43,25	1,39	5,53
	Mean	6,43	47,58	1,24	5,57
	Standard deviation	0,12	8,61	0,41	0,47
Guelmim	Max	7,20	54,00	1,85	6,59
	Min	6,60	13,75	0,77	3,01
	Median	7,06	38,38	1,31	5,61
	Mean	6,98	36,13	1,31	5,20
	Standard deviation	0,26	16,64	0,54	1,54
Asrir	Max	7,20	33,50	1,86	3,09
	Min	6,60	21,75	0,77	2,56
	Median	7,20	29,00	1,24	2,76
	Mean	7,00	28,08	1,29	2,80
	Standard deviation	0,35	5,93	0,54	0,27
Laqsabi	Max	7,10	60,25	2,47	3,85
	Min	6,70	24,00	1,39	2,21
	Median	7,00	43,50	1,55	2,88
	Mean	6,95	42,81	1,74	2,96
	Standard deviation	0,19	18,97	0,51	0,69

To achieve our objective, which is the detection of land cover changes, a comparison of the State of the soils after the floods with those before the floods was made (fig9).

Changes in physic-chemical parameters clearly show the difference between the land taken and analyzed before the floods and those taken after the floods. Soils before the floods, have high values at the level of pH and low values at the level of the content of carbonates, organic materials and electrical conductivity, however, after the floods the analyses show some remarkable changes which is illustrated by the decrease in pH with an increase in the level of the other parameters.

This is probably due to deposit a new layer which brings together the debris and new materials degraded, transported and deposited at the level of the accumulation zone of the sediments under the effect of the floods.

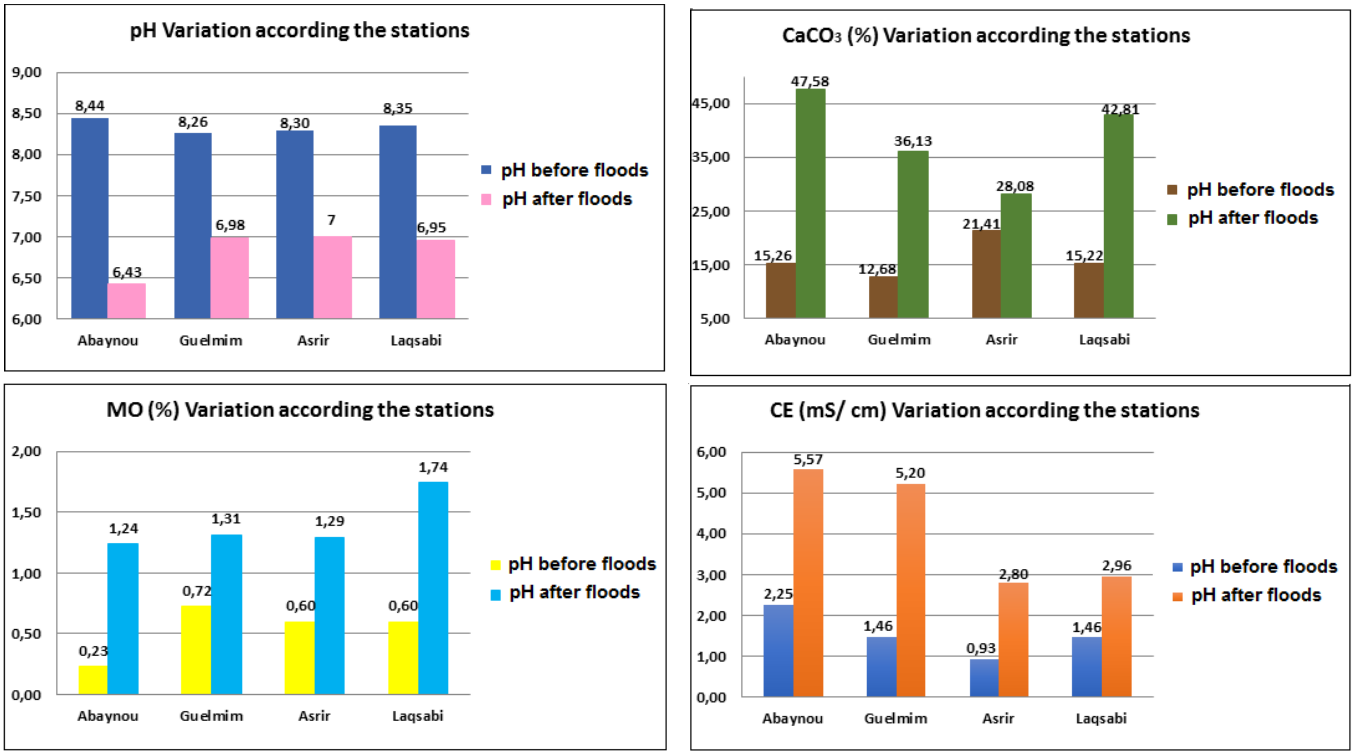

Fig 9:- variation of physico-chemical parameters analysed before and after floods.

Comparison and validation of Results:-

Moreover, by joining the results obtained from the physic-chemical analyses and results from using the tools of remote sensing and geographic information systems, there is a strong correlation between the two results, resulting in the detection of the dramatic changes at the level of the ground cover.

The comparison between the results obtained enabled us to identify areas of change, to detect and characterize soils. Also, she has uncovered that the changes which have affected the quality of the soils in the study area are figured in the difference images of each spectral index after the floods.

However, these changes are possibly due to the land degradation by water erosion due to the heavy rains and floods.

Conclusion:-

Using remote sensing tools and geographic information systems (GIS) based on spectral indexes, allowed to make a simple model dedicated for the detection of land cover changes by the effect of floods in the basin.

The results show clearly that method allowed to generate specific information on areas at degradation risk due to the floods. According to our study, in the study area, the changes affected the nearly grounds of wadis due to land degradation and deposits of fine particles carried by the floods.

It is a new cover formed the clay elements reflected in the clay index, Color index map and brightness index map with a dark color and a low reflectance.

To confirm the reliability of the model proposed in this work, we have been procedure to the physicochemical analyses of samples, then we can be concluded that this technique allows:

- to get land cover change maps with mapping areas at risk of floods and land degradation, using only a diachronic satellite imagery as data sources.

-to map land cover changes in arid and Saharan environments where the sands are the dominant soils, just the clay index is a strong indicator of changes. Therefore, the application of this model with the clay index alone will illustrate the areas at risk of floods.

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