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Assessment of suspended sediment concentration and sand encroachment change in Atlantic Sahara platform (SW of Morocco) using multi-temporal remote sensing

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ABSTRACT: A study was conducted in Northern part of Atlantic Sahara coast (SW of Morocco) with the aim of assessing change of suspended sediment concentration (SSC) with time in sea surface from Landsat data with 30 m spatial resolution in order to understand the sand encroachment in the continental area. We must be report that is the first study of SSC monitoring in Southwest of Morocco using earth observation satellite (EOS). The methodology adopted in this research is simple and based on using band ratio (Green/Blue) for two images Landsat Thematic Mapper (TM) from the years 1987 and 2005. A step of classification was necessary, so unsupervised classification using K-means algorithm was applied on both band results from band ratio. After that, the statistical data result from classification was compared to determine the SSC and sand change with time. The results show that the sand increase in continental surface was in relationship with SSC decrease in coastal area. The SSC variation in surface sea indicates that sand input be decreased in next year's.

KEYWORDS: Atlantic Sahara coast, SSC, Sand encroachment, Landsat TM, Statistical data change

1 INTRODUCTION

The sand is main movable sediment in depth between 0 and -20m of Atlantic Sahara coast [1] (Figure 1). The simple observation throughout the coastal area between Akhfinir and Cap Jubi using satellite image and field observation show that the sand be accumulated in the beach and be transported to the continent on barchans shape under the maritime trade winds effect (Figure 2). This sediment is responsible of one of the most environmental problem in this basin, is sand encroachment phenomenon which affect the roads and the cities. [2] indicate that the wadis in northern of basin provide enough materials having same mineralogical characters of sand. He estimated that 600.000m^3/year of sand was transported from north to south (Figure 3). Do not prevent that the study of identification of eroded areas using remote sensing confirmed that the coastal erosion caused by wave's action allows feeding the beach by this sediment ([3], [4]). Whatever their source, no study focused on assessment of suspended sediment variation in coastal area of Atlantic Sahara coast to confirm their variation in time and their impact in sand input in continental surface.

During latest years, the study of coastal turbidity does not cease to increase. Because turbidity variations help to understand the distribution of total suspended solids or sediments, and therefore processes like coastal erosion and mobilization of chemicals or pollutants [5]. Since the 1970s, remotely acquired data has been used to quantify surface sediment concentrations in surface waters ([6], [7]). [8] shown that the suspended sediment concentration is often the primary control on turbidity, the two quantities are frequently treated similarly with respect to remote sensing.

Several studies shown that the remote sensing (RS) can provides useful information for sediment transportation mapping in the coastal region [9] and can offers an alternative method for monitoring surface water on a large scale [10]. Mainly, RS has been defined as the technology and science of determining, measuring, analyzing and interpreting the characteristics of an object or phenomena without any direct contact with that object or phenomena.

The Landsat MultiSpectral Scanner (MSS), Thematic Mapper (TM) and the Enhanced Thematic Mapper (ETM+) have been used to assessment, monitoring and mapping of suspended sediment concentration in water surfaces ([11], [12], [13], [14], [15], [16], [17]). Other attempts have utilized the capabilities of SPOT and MODIS images in studying suspended sediment concentration ([18], [19], [20], [21], [22]).

Several studies have been conducted implementing band ratio technique to estimate and mapped suspended sediment concentration in water surfaces ([23], [24]). [23] conducted an investigation on the relationship between water quality and spectral reflectance and concluded band ratios TM2/TM1 and TM3/TM1 had the strongest relationship to total suspended solids.

In the present work, since no field data is available for suspended sediment concentration change in the study area, and for free data available in developing countries we use band ratio of Landsat TM to assessing suspended sediment variation in north part of Atlantic Sahara coast and to understand sand input in continental area.

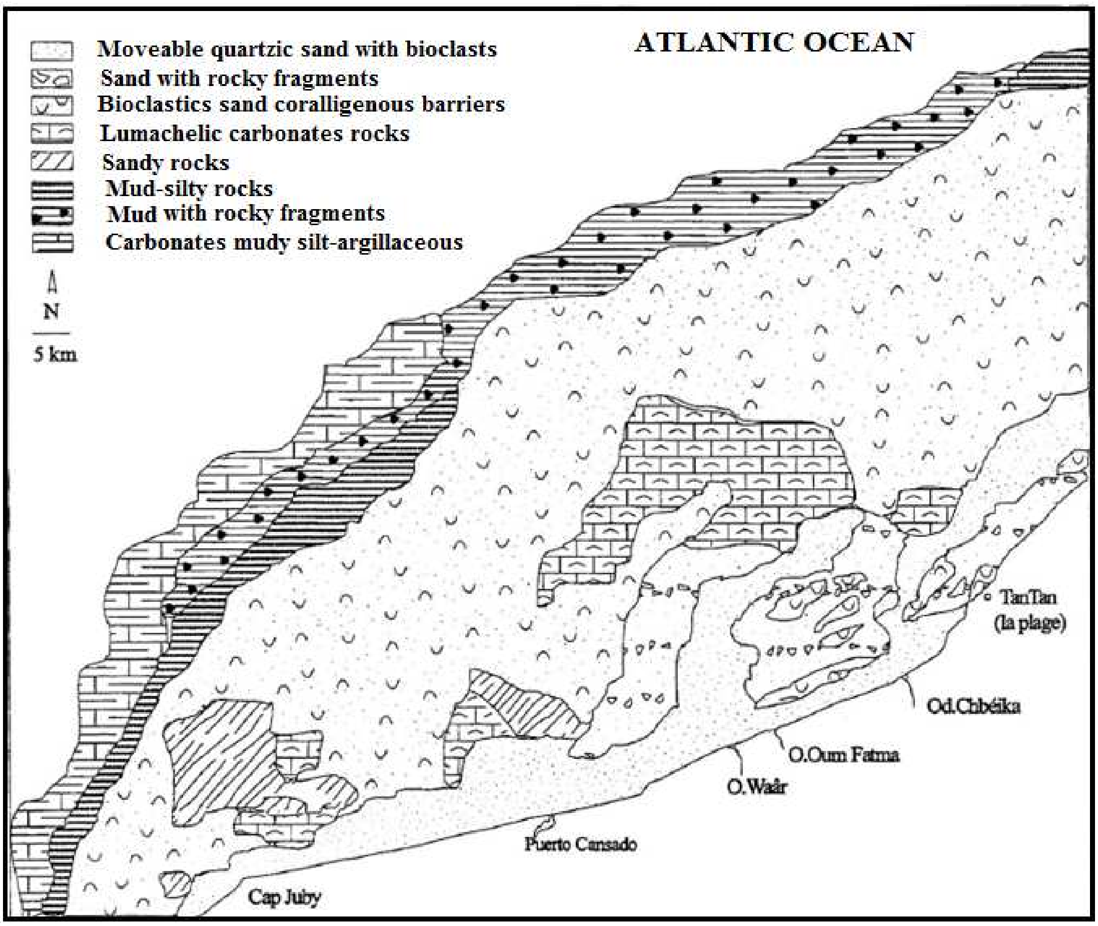

Fig. 1. Sedimentary nature map of the sea floor. Scale 1 / 700 000 [1]

2 Materials and Methods

2.1 Study Area

The study area is located in northern part of Atlantic Sahara (SW of Morocco). It is coastal area, extending from 11°44′41″ to 12°49′ 9″W in longitude and 27°54′ 36″ to 28°13′ 12″N in latitude (Figure 4).

From a climatic point of view, this region is a part of the Boreal domain of maritime trade winds, where precipitation is less than potential evapotranspiration [25]. This wind is one of the most regular winds in the world [26]. According to [27] and [25], the prevailing wind is mostly from the NNE with a yearly speed ranges from 4.5 to 8 m/s. This wind is responsible of swell parameters variation. [28] define all swell parameters of Moroccan Atlantic between Agadir and Tarfaya. He concluded that NNW-SSE is main direction of swell, with period of 8 seconds, an average height of 1.5m, and a spread speed varied from 3-13 m/s.

The surface of the study area is dominated by flat layering of hard rocks at the surface. This flagstone, is overlain by movable sand on dunes form (Figure 5), and broken, in another place, by sabkha depression where marls, silts and sand were deposed.

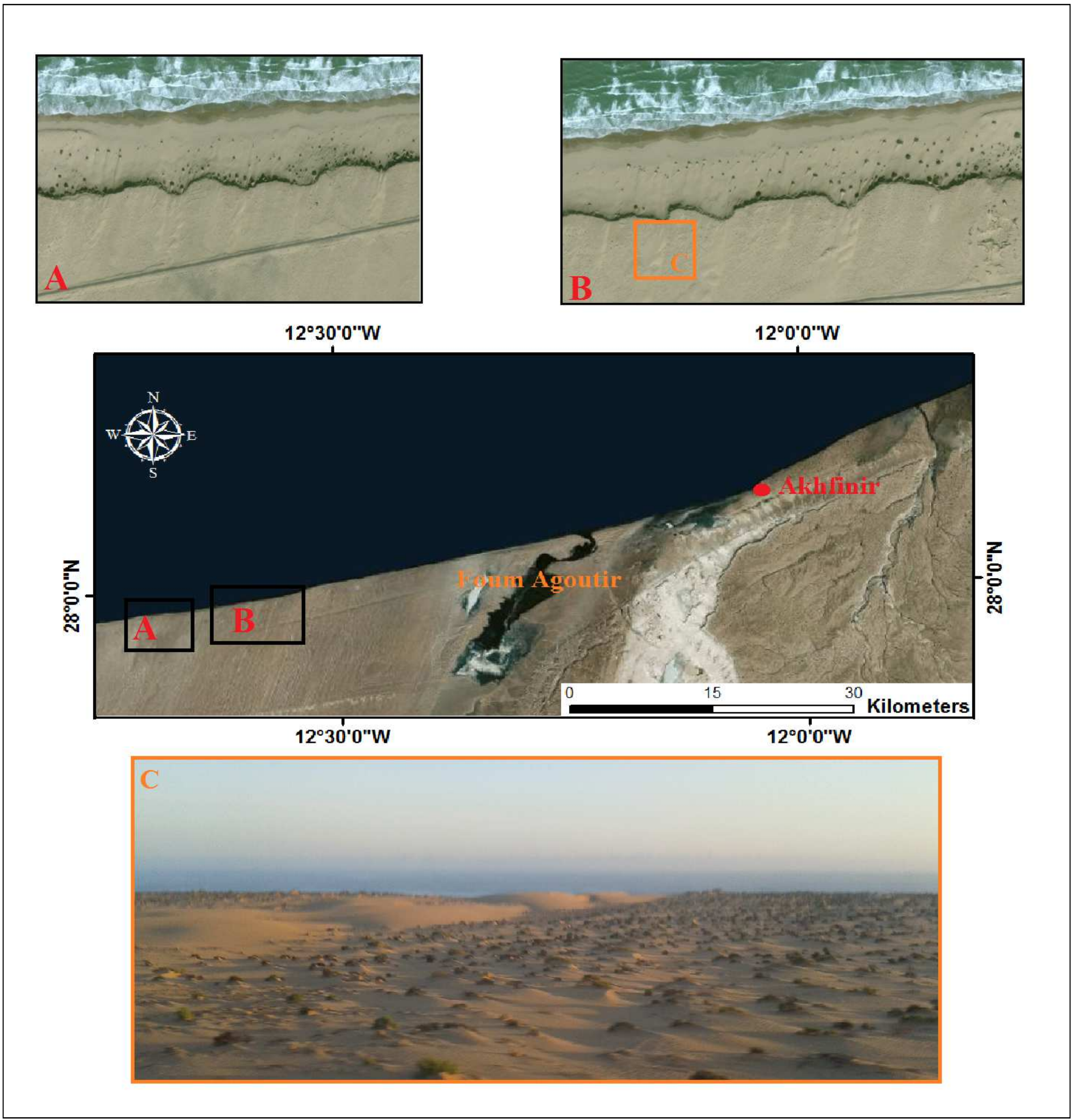

Fig. 2. High resolution satellite image (A and B), and filed picture(C) show sand transport from beach to the continent on dunes form

2.2 DATA SETS

In this study, two free Landsat TM images covering the study area were used to assessing change of suspended sediment concentration and sand encroachment with time. Multi-temporal ortho-rectified Landsat images (1987 and 2005, 30 m) were acquired from the Global Land Cover Facility (GLCF). These data are already corrected in term of atmospheric and radiometric treatment.

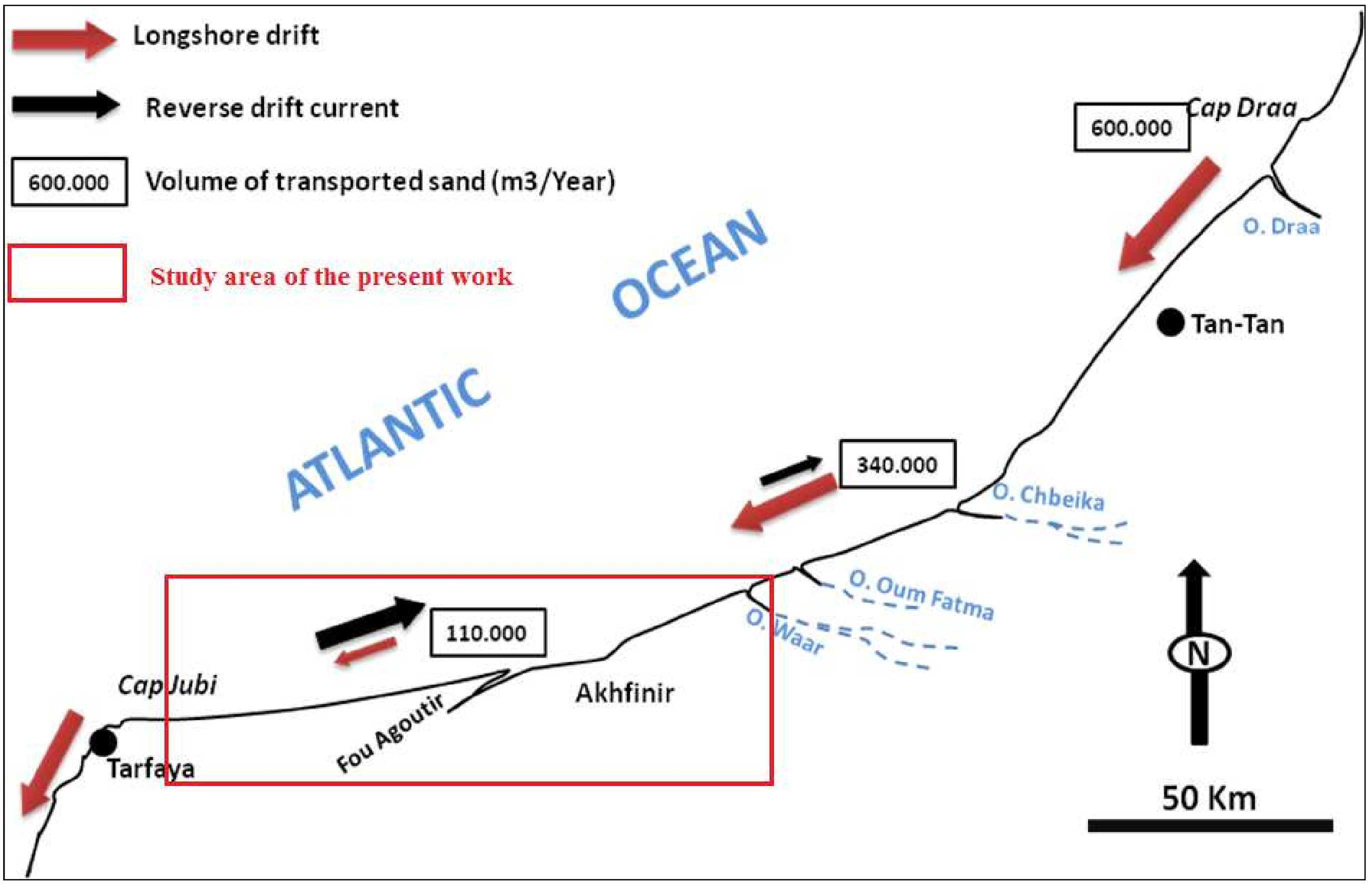

Fig. 3. Volume of sand transported in Atlantic Sahara coast between Wed Draa and Cap Jubi [2]

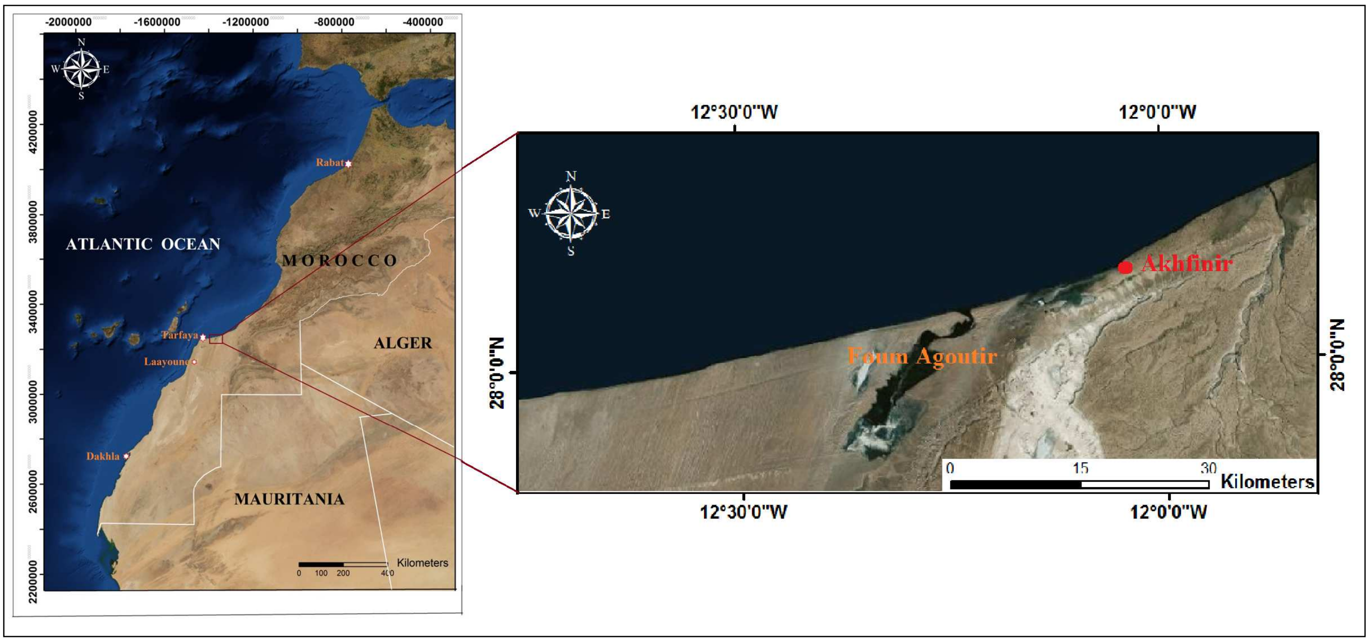

Fig. 4. Location map of the study area

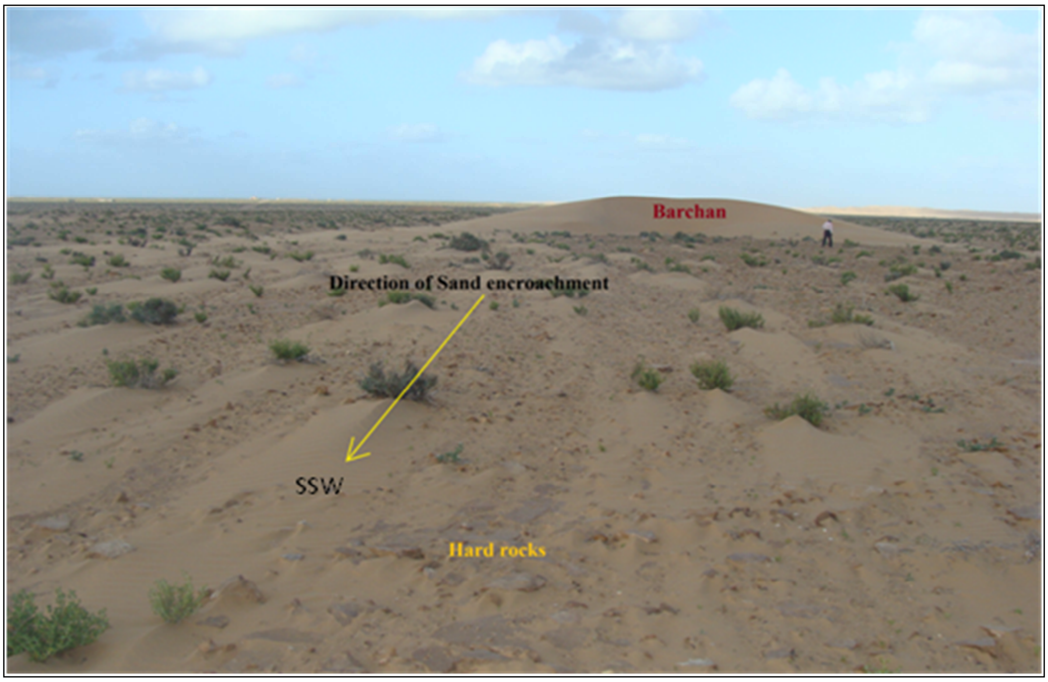

Fig. 5. Sand and hard rock distinguished on surface of study area

2.3 Methodology

The methodology for this study is shown in Figure 6. This methodology was started by extraction of new band result from band ratio TM2/TM1 for two Landsat images from the years 1987 and 2005. A step of classification was necessary to extracting differentiated classes or themes from new data. This classification was obtained from the unsupervised classification algorithm by applying the K-means on two new bands. The statistical data change is final step to estimate the suspended sediment concentration and sand change in time. All steps cited in this research were achieved using ENVI software.

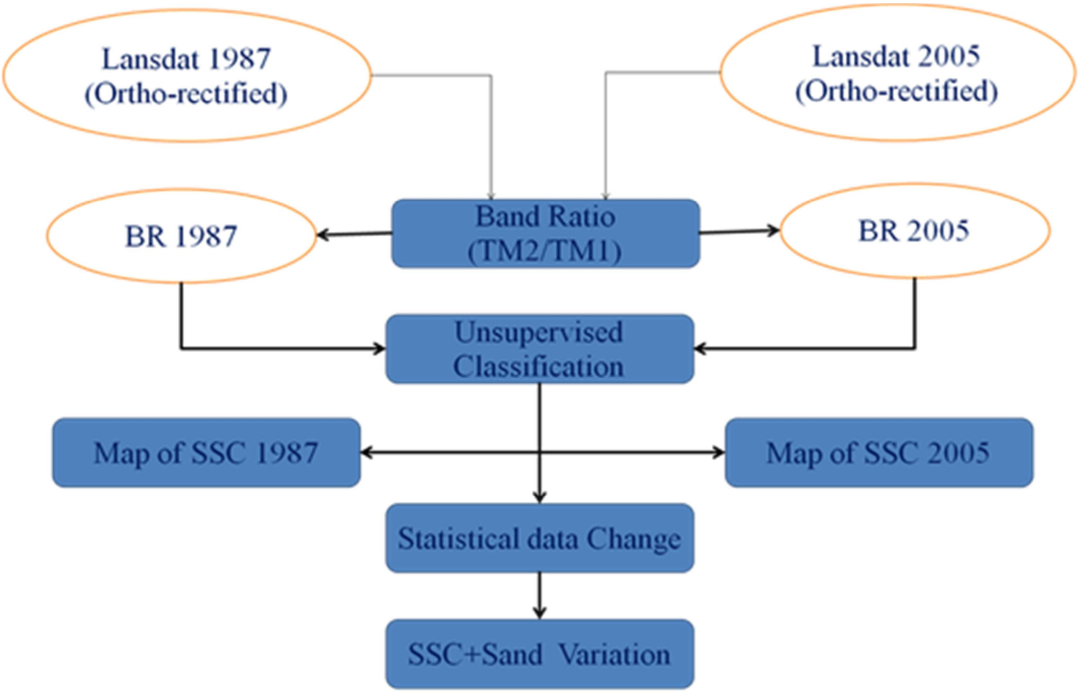

Fig. 6. The methodology of this study

3 Results And Discussion

The results of the classification are shown in Figure 7 and Figure 8. The changes in the classes over the 18 year period are shown in Figure 9.

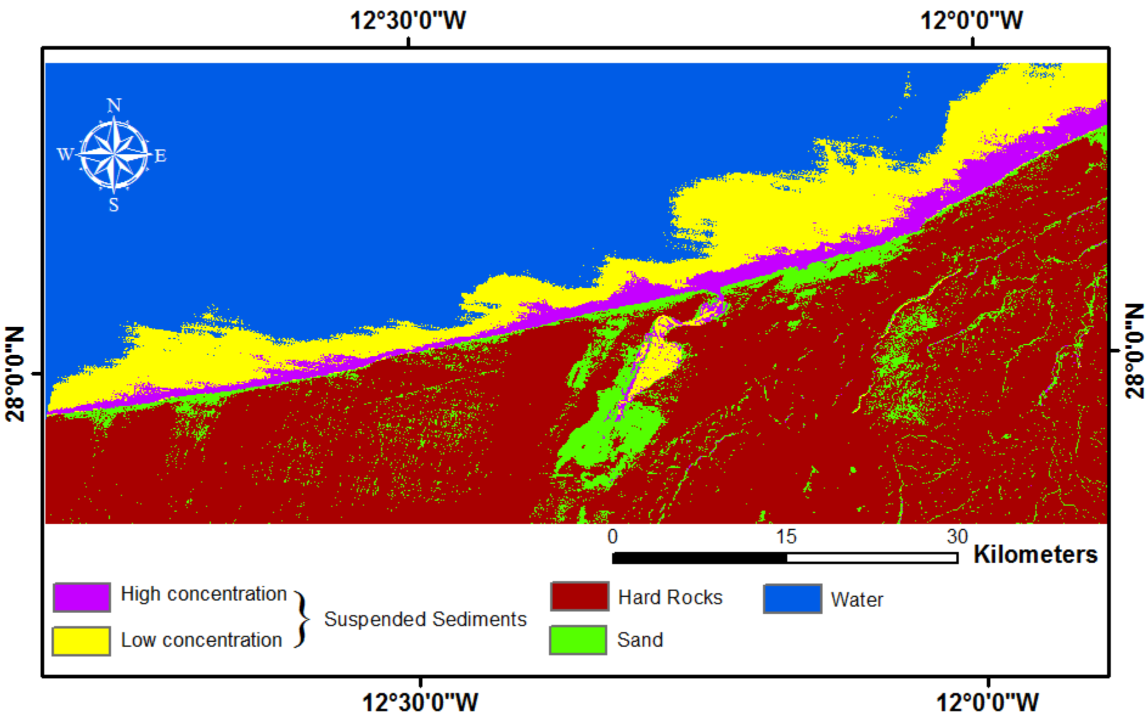

Fig. 7. Classified image for the year 1987

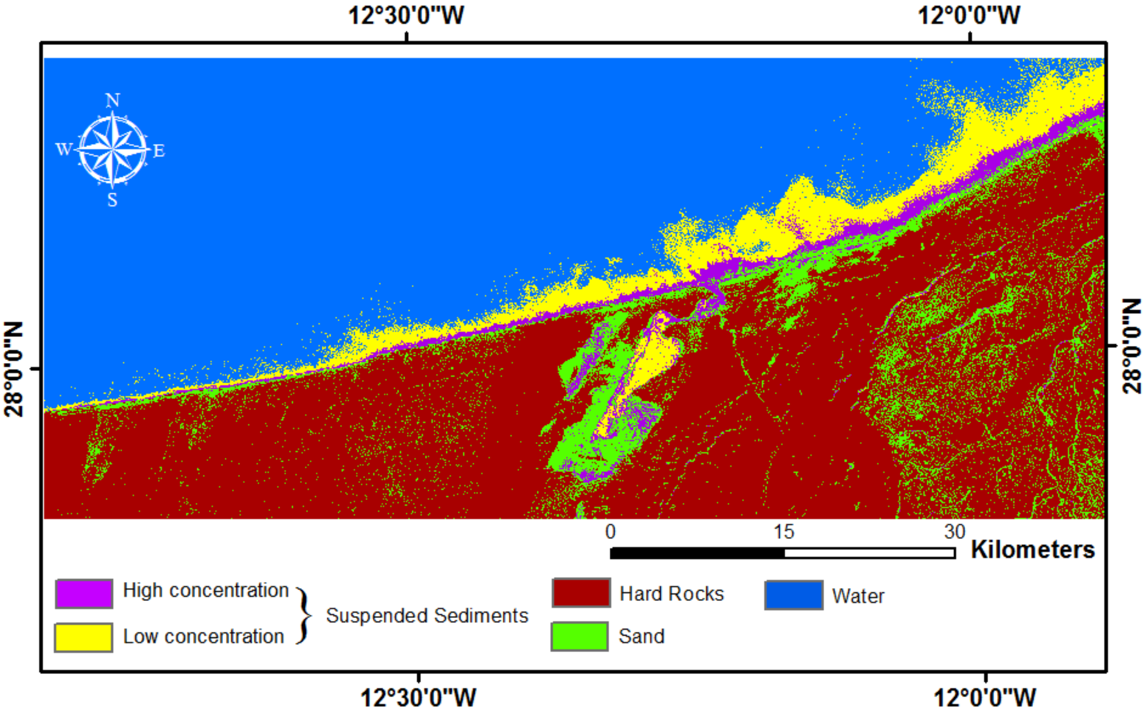

Fig. 8. Classified image for the year 2005

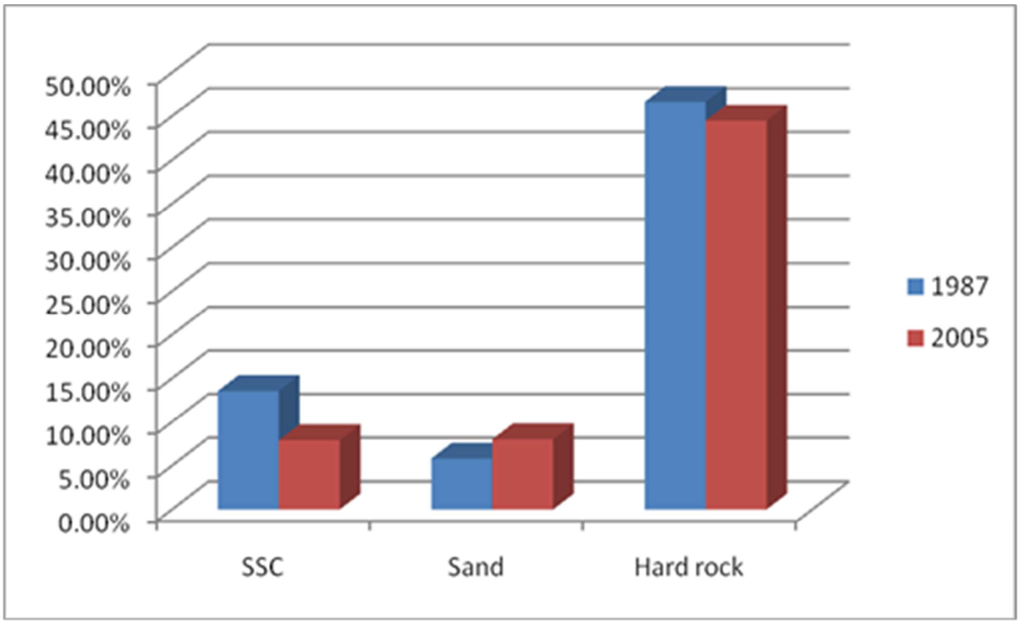

Fig. 9. Statistical changes of classes for the years 1987 and 2005

In 1987, SSC occupied 13.55% of study area. In 2005, this class was 7.89%. This indicates that SSC decreased by 5.66% during the 18 years of study. In addition sand facies in continental area was increased by 2.20%, which was found occupied 5.80% in 1987, while in 2005, it was 7.99%. This increase in sand facies is in relation with SSC decrease when this sand comes up from intertidal area [25]. Similarly, ([3], [4]) were confirmed this increase by using supervised classification. Hence, the sand increase reflects the hard rock decrease. When this latest was decreased by 2.16%, which was covered 46.64% of study area in 1987, whereas in 2005 was occupied 44.49%.

4 CONCLUSION

The aim of this work was to assessing change of suspended sediment concentration (SSC) with time in sea surface in order to understand sand encroachment in continental area. The assessment of SSC was achieved by using band ratio (TM2/TM1) for two images Landsat Thematic Mapper (TM) from the years 1987 and 2005. The statistical data result from unsupervised classification was compared to determine the SSC and sand change in time.

The results show that during the 18 years the SSC was decreased by 5.66%. Decreasing in this class indicates the sand change in continental area, when we found that sand increased by 2.20%. In addition, from these results we interpret that sand input be decreased in next year’s because the SSC storage in intertidal area was decreased.

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