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Differentiation of Coastal Sedimentary Environments using GIS and RS Techniques (Case Study: Coasts of Chabahar Gulf)

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Abstract

The coastal region of Chabahar Gulf with 1113.7km^2 area has been located in the southeast of Iran. In this research, satellite images of ETM$^+$ (2004) were used in order to zoning of sedimentary environments in this Gulf. Methodology of this research was baesd on synthesis of supervised and unsupervised classifications in GIS and ENVI softwares. Based on studies and calculation of OIF index, the best selected bands to differentiation of sedimentary environments are 1, 5 and 7 bands of ETM$^+$ that had most information. Zoning maps indicate that in the study area, wide bodies of sedimentary environments consist of profound marine environment (41.13%), Shallow marine environment (7.9%), Sabkha and salt flats (3.07%), Intertidal and lagoon (1.2%), Delta (1.33), Siliciclastic barrier and Aeolian dune (6.45%), Loose Sandy sediments (11.98%), Mud flats (26.93%).

Key words: Chabahar Gulf, Satellite Images of ETM$^+$, Sedimentary Environments, Supervised and Unsupervised Classifications

1. Introduction

Coasts are dynamic areas and affected by mutual function of earth, water and climate and also continuous natural changes and manipulation of human. Coasts are considered of the most important areas that human have been inhabited in it and use of its resources extremely. these regions are changing, by operation of geological phenomena and hydrodynamic processes on the one hand and by human construction on the other hand. Mangroves, coral reefs, falaises, sandy seaside, tidal bodies, estuaries and inlets are only part of the valuable coastal regions that are under pressure of high density of population in these regions [5]. Due to complexity of effective factors, diversity of sedimentary environment [9] in these regions is considerable. Amount of interactions of effective factors in shaping sedimentary facies and units in this region can be represented in the form of classification of coasts based on coastal sedimentary environments [15]. There are diverse patterns and objects for this purpose. Classification of coasts can be done based on field studies, processing of satellite data or combination of both methods [3, 11, 13]. Satellite data with their special features like being multi-bands, availability, and broad land cover, are very suitable for large- scale phenomena. On the other hand, by field studies can distinguish areas that

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there aren't separable in some satellite data because of their low area. Sampling from different facies in field studies, in addition, recording the geographical coordinates can be very helpful in determining the educational points in RS studies to differentiation of environments [10]. Using of GIS and RS data in differentiation of sedimentary environments and evidences of coastal morphology is growing strongly [13, 11, 8, 6, and 4].

2. Materials and methods

2.1 Study area

Chabahar Gulf is the biggest Gulf of Iran in the margin of Oman sea coasts. This Gulf due to having the Ω shape is named type of omega Gulf in the geology. Coastal region of Chabahar Gulf has been located in southeast of Iran country and Sistan and Baluchestan province, between 25 ˚◌15′ - 25 ˚◌30′ latitudes and 25 ˚◌42′ - 61 ˚◌21′ longitudes. Study area with 1113.7km^2 area is part of Chabahar city[1]. This region consists of wide variety of mangroves coasts, coastal plain, raised coasts, sand dunes, estuary and coastal sands [2].

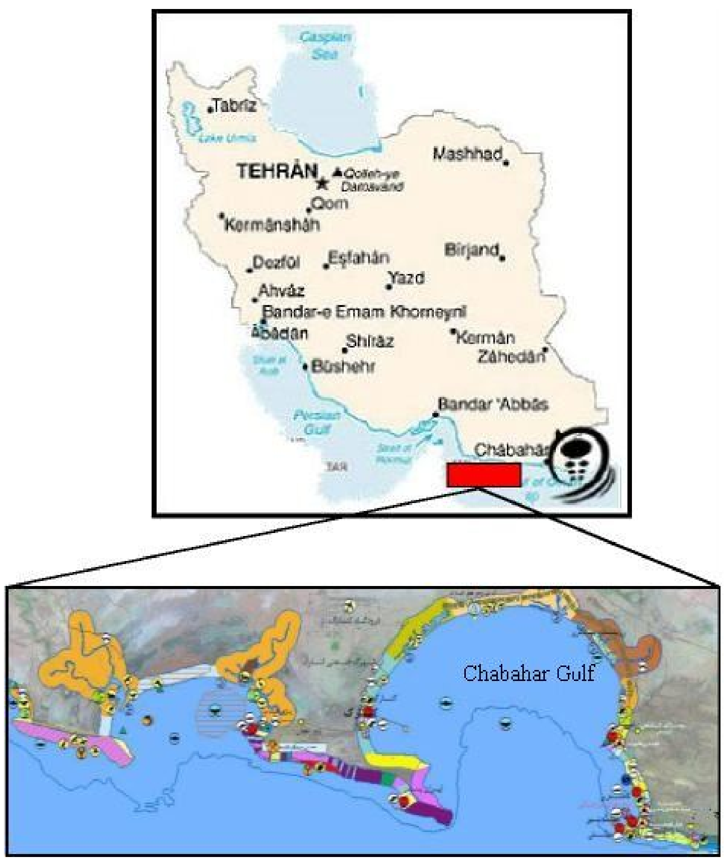

Figure1. Location of study area

In this research, digital data of landsat7 with thematic mapper sensor (ETM$^+$) related to 2004/2/25 have been used for processing. Also, maps such as topography 1:50000, geology 1:25000, and also aerial photos 1:20000 and 1:50000 have been used as helping data. Data like the color images (RGB) 1:100000 have been used to distinguish of sedimentary environments form each other. Differentiation of sedimentary environments on polygon maps has been done based on combination of digital and optical methods. Maps have been created based on color images composed of different bands combination. Digital data of septet bands (ETM^+) classified in the environments of ENVE 4.5 and ILWIS3.2 softwares, based on statistical data of bands. To avoid from participation of bands with low intelligence value (variance) and bands with high replication of data (covariance), selected bands determined based on the statistical data of bands and the difference of reflection properties of data classes and also calculation of OIF. So OIF were used to select the bands. Optimum Index Factor (OIF) calculated based on the following equation.

$$OIF=\frac{Std_i+Std_j+Std_k}{r_{ij}+r_{ik}+r_{jk}} \quad (1)$$

Std: standard deviation of bands (i, j, k)

r: correlation coefficients of i, j and k bands

Combination of different spectral bands to create compound color images is amongst carried out spectral processing in this stage. The desired images have been created using OIF index from combination with nodes that have the lowest correlation in triad combination.

2.2. Geometric and radiometric correction of images

Since the remote sensing images are not map and they will combine with the map information in geographical information system to examination and analyzing, transfer of the remote sensing image to scale and image system of a map is said geometric correction [16]. Digital images usually have distortions so that these images cannot be used as a map. Some of these distortions are changes in elevation and velocity of sensor platform, curvature of the earth, displacement and relief. The object of geometric correction is the recovery of distortions. In this research, to geometric correction of images was used 1:50000 topographic maps. Images corrected geometrically using ground control points with geometric error 0.31 (RMS=0.31) and neighborhood method. Considering that images are related to the different times, different elevation angles, corrections and methods, it is necessary that radiometric and atmospheric corrections be done on images. So, errors of recorded digital nuember (DN) of a specified pixel that is affected by angle and position of the sun and atmospheric conditions should be removed [7]. To atmospheric corrections the Chows method (decreasing the numerical value of dark pixels) was used. decreasing the numerical value of dark pixels technique is based on this assumption that the lowest amount of DN of a pixel in each band must be 0 and radiometric value of DN is result that have been gained from atmospheric error.

3. Results and Discussion

To raise the accuracy of georeferencing, points of Topographic map were selected and were matched with equivalent points in the study area satellite image. Coordinates of the reference points in the metric system (UTM) imported to the respective menu in ILWIS3.2. in this step were tried that prepared maps be georeferenced with minimum RMS (Root Mean Square Error) or standard deviation close to zero for coordinates. Prepared in this research were georeferenced with minimum error (RMS<1). On the other hand, expertise errors decreased with field studies. After the calculation of selected equation and removing the points that lead to more errors, standard deviation was calculated using the method of closest neighbor equal to 0.31. After this stage, geometric deviations of images due to the change the spatial position of pixels and brightness degree of them, removed using resampling with the closest neighbor method. With this operation were modified the geographical aspects of ETM^+ images. Based on OIF index was determined that amount of this index in 1R, 5G and 7B bands is the most amount and thus band combination to classify based on covariance and standard deviation (table1).

Table1: amount of OIF factor of different bands

row	**Combined bands**	**OIF factro**
1	ETM1,ETM2,ETM3	86.68
2	ETM1,ETM2,ETM4	96.77
3	ETM1,ETM2,ETM5	99.81
4	ETM1,ETM2,ETM6	87.69
5	ETM1,ETM2,ETM7	91.59
6	ETM1,ETM2,ETM8	84.92
7	ETM1,ETM2,ETM9	84.45
8	ETM1,ETM3,ETM4	96.96
9	ETM1,ETM3,ETM5	100.62
10	ETM1,ETM3,ETM6	86.74
11	ETM1,ETM3,ETM7	91.93
12	ETM1,ETM3,ETM8	86.24
13	ETM1,ETM3,ETM9	86.79
14	ETM1,ETM4,ETM5	101.66
15	ETM1,ETM4,ETM6	91.96
16	ETM1,ETM4,ETM7	98.57
17	ETM1,ETM4,ETM8	94.52
18	ETM1,ETM4,ETM9	97.17
19	ETM1,ETM5,ETM6	95.48
20	ETM1,ETM5,ETM7	102.11
21	ETM1,ETM5,ETM8	98.06

Calculated OIF factor of different bands showed that 1, 5, and 7 have most information. Geometric corrections of these images were done using earth control points. Providing the needed information to distinguish sedimentary environments was based on processed images and field data. Distinguish and classification of different image parts was done by supervised and unsupervised methods. Supervised classification of study area was done with minimum distance and maximum likelihood methods with distinguish three area (delta, Intertidal and lagoon, Lagoon) (Figure2). To do this, 76 earth points with desired distribution was selected in the area. These points consist of different environments of Chabahar Gulf. Differentiation of other environments was done by user according to field observations and other lateral data with supervised and unsupervised methods. After the differentiation of sedimentary environments and removing the errors in created linear map, sedimentary environments have been added to the map as coded points and polygonal map of region have been prepared after valuation of drawn boundaries (Askari, 2002). With insert the data of each sedimentary environment in ILWIS software, the area of each unit was calculated (table 2).

Table2. Area and coverage percent of sedimentary environments in study area

Coverage percent	Area(km^2)	Type of class	Classes
41.13	457.87	Profound marine environment	1
7.9	87.94	Shallow marine environment	2
1.2	13.37	Intertidal and lagoon	3
1.33	14.84	Delta	4
3.07	34.14	Sabkha and salt flats	5
6.45	71.84	Siliciclastic barrier and Aeolian dune	6
11.98	133.40	Loose Sandy sediments	7
26.93	299.76	Mud flats	8

4. Conclusion

In this study, satellite images of ETM^+ (2004) were used in order to identification, differentiation and zoning of sedimentary environments in Chabahar Gulf. Methodology of this research was baesd on synthesis of supervised and unsupervised classifications in GIS and ENVI softwares. Based on studies and calculation of OIF index, the best selected bands to differentiation of sedimentary environments are 1, 5 and 7 bands of ETM^+ that had most information with the highest accuracy for differentiation of sedimentary environment. Zoning maps indicate that in the study area, wide bodies of sedimentary environments consist of profound marine environment (41.13%), Shallow marine environment (7.9%), Sabkha and salt flats (3.07%), Intertidal and lagoon (1.2%), Delta (1.33), Siliciclastic barrier and aeolian dune (6.45%), loose sandy sediments (11.98%), Mud flats (26.93%). Carried out examinations show that nearly 50% of the coasts of study area, constitute secondary coasts that Mud flats constitute the main part of that. Prepared map of sedimentary environments show that Loose Sandy sediments are one of the most important part of secondary coasts in the region (figure2).

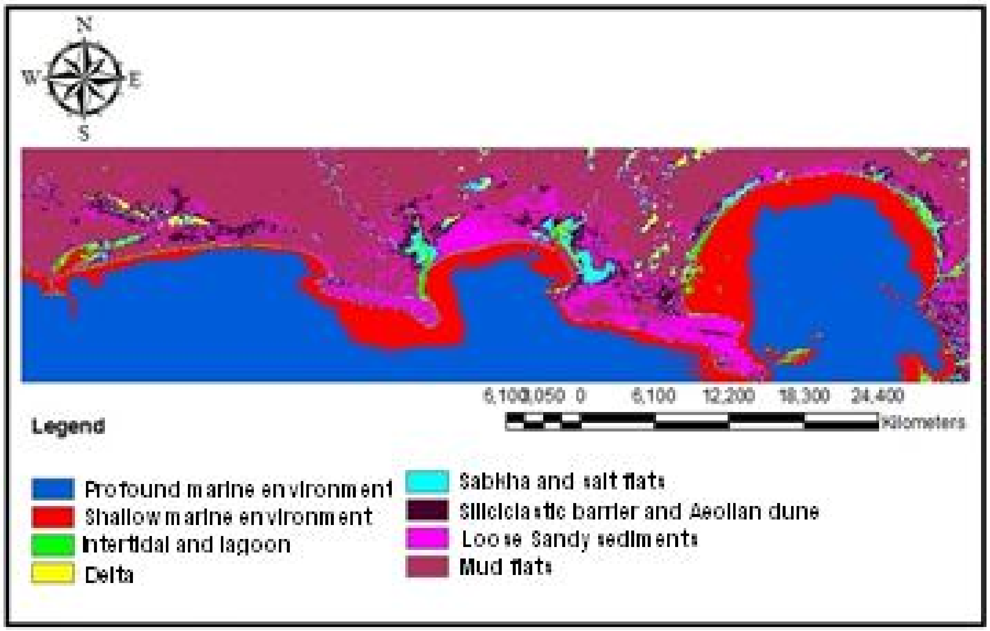

Figure2. Differentiation and classification of sedimentary environments in the study area

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