Monitoring of shoreline changes using remote sensing (case study: coastal city of Bandar Abbas)

E Tamassoki¹, H Amiri² and Z Soleymani³
¹ M.S.C graduated of de-desertification, Hormozgan University, Bandar Abbas, Iran
² M.S.C student of remote sensing, Hormozgan University, Bandar Abbas, Iran
³ M.S.C student of de-desertification, Hormozgan University, Bandar Abbas, Iran

Email: ehsantamasoki@yahoo.com

Abstract. Shoreline change is one of the most common natural processes that prevail upon coastal areas. The most important aspect of managing coastal areas is identifying the location and change over time of shoreline. This requires frequent monitoring of the shoreline using satellite imagery over time. We have used imagery from the Landsat TM-5 sensor from 1984,1998 and 2009 in order to monitor shoreline changes using the Max Likelihood Classification method (MLC) in Bandar Abbas city. Monitoring showed that during the period from 1984 to 1998 the area of coastline of Bandar Abbas increased 804.09 hectares. The increase over the next 11-year period was as less, at only 140.81 hectares. In 2009 there was a drastic decrease in shoreline, with the total length of shoreline decreasing from 330 km to 271 km during the period from 1984 to 2009. Results showed that in each period in which the area of coastline advanced, changes in length of shoreline had been less prominent.

1. Introduction
The geographic interface of the shoreline, the boundary between land and sea, along with various land uses, and other effects of geological and hydrodynamic phenomena and their effects have made shoreline change one of the most common processes in coastal areas. These changes can have different manifestations over short and long time periods. The recognition of sediment erosion, transport, and depositions one of the most important and sensitive marine phenomena has a direct impact on the design of ports and marine structures, and in coastal management in general.

Changes in erosion and sedimentation due to increasing precipitation have been observed in coastal areas and estuaries, canals, and coastlines. Therefore, identifying the prevailing procedure to determine volatility and change in position of shoreline is the most important parameter required in managing coastal areas. Therefore it is important to determine measurements of the coastline during...
different times and to be able to compare and evaluate them for inclusion into the prognosis and decisions as to the future status and location. Among the studies that have been conducted in southern Iran are the monitoring of shoreline changes and geomorphology in Assaloye[6]. Results of this study showed that approximately 85% of landforms in these areas have changed due to the construction of industrial plants, and that the estuaries east of the study area remained unchanged because there is habitat of Mangrove forests which is protected by government. In addition to the importance shoreline, another important aspect is the sustainable development and protection of the coastal environment. Monitoring of coastline areas is needed over time, as shoreline are the most important and dynamic of natural phenomenon [8] and changes in one part affects the other parts. Failure of observe this fact so has caused many coastal projects to be unsuccessful, or to have a negative impact on the surrounding areas. Today local studies are an important priority when doing projects of management engineering. The absence of a comprehensive database of coastal areas in Iran created many problems in a number of our building projects, for example in the making of seaports and piers. Remote sensing technology is an effective method for obtaining the required data, and this method doesn't have the usual limitation of time and place [1]. So for optional management of the coast, the location in formation of past present and future coastline and how it changes is essential. And now, the newest and most economical method for this purpose is the use of satellite data. In this case, Landsat images which reflect both visible bands, as well as infrared bands, are widely used to monitor coastlines, for example the use of TM and ETM+ satellites, and Landsat [5]. Hence, in this paper, we used TM-5 images from 1984, 1998 and 2009 to monitor the coastline city of Bandar Abbas. The importance of coastline to Hormozgan Province is demonstrated by some important ports, for example Jask, Kong, Sirik and Shahid Rajaei. The province because of the ports as the biggest commercial port in Iran, Shahid Bahonar, Lenge, and also Ghashm island which can manage their coastal areas by utilizing remote sensing techniques.

2. Study area
The area studied includes the coastal Bandar Abbas city which is located in the territory between 20°45′55″ to 57° east longitude to 40°26′ to 20°27′ north latitude. This area is a widespread area in the Persian Gulf which is adjacent to the Oman sea in the Hormoz canyon. The Persian Gulf is located between the Arabic block and the Zagrouns mountains. Elongation of this basin is due to its geological structures. During the Jurassic and Cretaceous periods the area was situated roughly where the current Zagros mountains are in Iran, but then it gradually moved toward the South West. Considering that the material at times is carried by wind in the Persian Gulf in a mass of dust and sand. As a result this material together with a mixture of marine sediments creates sediment of sea - wind in this area. Limestone Aalyts is created due to wave action on the Persian Gulf coast which sorted out on their diameter. Aalyts are often found in shallow areas in the Strait of Hormuz [2]. These conditions together with and the influence of hydrodynamic processes lead to relatively rapid changes in the coastals rather than geomorphology of other systems (Figure 1).
3. Materials and methods

In this study we quantitatively interpreted the shoreline during three periods being 1984, 1998 and 2009 utilizing satellite imagery TM-5 with a spatial resolution of 30 m. Each of these images were taken in a similar month, so they are comparable in terms of time. Images were analyzed after geometric and radiometric corrections were made to the images utilizing the software ENVI4.8. Since the purpose of this paper is to monitor changes to the shoreline, the best band combination to detect movement in the boundary between land and water, is the color RGB 543. In addition, the spectral bands have a low correlation and hence have more informative [5]. For images analysis we used the method to classify Maximum Likelihood and maps of the shoreline were arranged and presented in ArcGIS. The method of maximum likelihood classification (MLC) is the most common methods of classification of satellite imagery. The method of Parametric maximum likelihood classification acts on basic Basin rule. We found, due to use of the statistical parameters involving basic probability, variance, covariance and average classes that this method in the best method compared to algorithms [3]. This method is based on the probability that a pixel belongs to each classes of m and is checked and t the pixel is then assigned to a class which has the maximum probability.

\[ E \in W_j \text{ if } p(x \mid W_j) > p(x \mid w_i) \text{ for all } j \neq l \]  

(1)

This means that the pixel with vector of spectral of x will belong to the class of spectral w. If the probability of belonging to pixels to class of p(x \mid w_j) be greater than the probability of belonging to the other classes, the first stage of classification is the calculation of probability of p(x \mid w_j). Because
picture data for classification is provided in several bands, it implies therefore that the following equation for each vector of spectral $X$ for each class of data is:

$$p(X|w_i) = \frac{1}{\sqrt{2\pi} |\Sigma_i|^{1/2}} \exp \left[ -\frac{1}{2} (X - M_i)^T \Sigma_i^{-1} (X - M_i) \right]$$

Which in that $w_i = \text{class of } I, \exp f = e$ (the base of logarithms) Exponentiation of desired number, $X$ is the value of a pixel of $M$, and is the mean of all pixels values of training of classes and $|\Sigma_i|$ is the determinant of the matrix of covariance of class, $\Sigma_i^{-1}$ matrix of variance-covariance and $f$ is the number of bands. Therefore it is enough that the mean and variance of each of the classes save to compute the likelihood function [7]. Sometimes due to spectral overlap, the probability calculated for some classes is close together and therefore the greatest probability is very small. In such cases it cannot be confidently attributed to this of pixels and is used as a threshold for control. If we use the threshold as a base we may find or create some pixels that are unclassified which must be tagged in the process of post-processing [3]. For this purpose, the beach and the sea were used as two separate classes of classification. Finally, to determine the accuracy of the classification obtained, we utilized satellite images of the 30 ground control points which were randomly selected. Kappa index was calculated on the changes of shoreline was 0.88 and overall accuracy was 91%.

Images was used of three of images of TM-5 Landsat satellite. These images show the shorelines of city of Bandar Abbas which had taken on the times of following:
- Image 1984
- Image 1998
- Image 2009

4. Discussion
In this study, we interpreted quantitative changes of shoreline in city of Bandar Abbas during a 25-year period. According to previous studies the original formation of these areas is composed predominantly of tertiary geological organizations and made of sandstone and marl. These formations have periodic stratification and are very sensitive to weathering and degradation processes. The climatic conditions commonly associated with seasonal and torrential rains cased these sediments to continuously deposit on the coastline resulting in the therefore coastline being completed. Due to the performance of marine processes especially waves and the gentle slope of the coastline and coastal fine sediment and silt, resulted in the coastline receding [9]. The shoreline was be exposed to erosion and sedimentation because of changes to the shoreline. This resulted follow spatial the dynamic processes of erosion and sedimentation including how erosion of waves or continuity of waves [4]. The first satellite images were taken in 15 May 1984 by the Landsat TM-5 (Figure 2). The shoreline at this time has been cerned by the maximum likelihood classification method and is clear and marked with a green color in Figure 3.
A study of the changes to the shoreline using maximum likelihood classification showed that coastal city of Bandar Abbas has been completed and is 804/09 hectare in extent after 14 years. The Coastline of 1998 is illustrated in blue (Figure 5).
The third satellite image take after 25 years from the first image and 11 years after the second image. This is satellite image Landsat TM-5 of 20 May 2009 (Figure 6). The shoreline classification maximum likelihood method is shown in red (Figure 7). Monitoring of changes of coastline in the period 1998 to 2009 showed the coastline of city of Bandar Abbas has been completed and is 140 /81 hectares in extent which was much lower rather than the last period in 1984 to 1998 (Fig. 8).
Figure 6: The image sensor TM-5 taken on 20 May 2009.

Figure 7: Map of the shorelines of 20 May 2009 constructed on basis the Method of max likelihood classification.
Figure 8: Map of changes of to the shoreline obtained from TM-5 images over a 25-year period based on the basic Method of max likelihood classification.

Shoreline changes in this study show, despite the fact that most progress of the shoreline was during 1984 to 1998, the biggest changes in shoreline occurred in 2009 when the length of shoreline increased by 272 km and in 1984 to 330 km in again in 2009 whilst in 1998 the length of the shoreline was very low (table 1). A comparison of satellite imagery indicated that the greatest changes occurred in the east coast city of Bandar Abbas. The shoreline, due mainly to the presence of numerous estuaries which appeared crinkled, was increased during 2009.

The shoreline length was greater than in 1998. While this changes in 1998 is not very sensible. Despite the instability of shoreline in east of the city of Bandar Abbas, there were no significant changes on the Western shoreline. The changes to the shorelines around the docks of Shahid Haghani and Shahid Rajai were minimal.

Table 1: Length of shoreline have been calculated for the different years.

| Year | Length of shoreline (km) |
|------|--------------------------|
| 1984 | 272                      |
| 1998 | 275                      |
| 2009 | 330                      |

5. Results
One of the most common processes on prevailing coastal area results in shoreline changes. These shoreline changes occur by geological and hydrodynamic phenomena. Understanding changes to shorelines is the most important parameters needed for management of coastal areas. Continual monitoring and studying of satellite images of the coastline is required to study coastline in different times. In this study we have used images from the sensor TM-5 of satellite Landsat for the monitoring
of changes to the shoreline of Bandar Abbas city in periods of 25 years using the Method of max likelihood classification (MLC).

Results showed the during the initial 14-year period from 1984 to 1998 shoreline city of Bandar Abbas 804/09 hectares has been completed. During the next 11-year period from 1998 to 2009, the amount of progress was less and was 140.81 hectares in extent. The most pronounced changes to the shoreline occurred in 2009 resulting in the Length of shoreline increasing from 272 km in 1984 to reach 330 km in 2009 Consider that the length of shoreline in 1998, was 275 km, which is a very small change. The results obtained in this study indicated that during each period in which the shoreline made more progress changes in the Length of shoreline is very low.

6. References

[1] Alesheikh A.A Sadeghi Naeeni F and Talebzadeh A 2003 “Improving classification Accuracy using External Knowledge” GIM International, Aug Vol 17 No 8 pp: 12-15.
[2] Darvish Zadeh A 2010 Geology of Iran. The Institute for Amir Kabir Publications Fourth Edition.
[3] Fatemi S and Rezaei B 2010 Principles of Remote Sensing Publications Azadeh.
[4] Khaledi Sh 2001 Natural Disasters Shahid Beheshti University Publishing.
[5] Moore, L.J.,2000 "Shoreline mapping techniques", Journal of Coastal Research, 16(1), 111-124. Royal Palm Beach (Florida), ISSN 0749-0208.
[6] Naimi Nezamabad A Ghahroudi Tali M 2010 Monitoring of Shoreline Changes and Geomorphologically Persian Guif Using Remote Sensing and Geographic Information System (Case Study: Coastal Zone of Assaloyeh) Scientific- Research Journal Geographical Space Summer Issue 30 pp: 45-61.
[7] Richards J.A. 1998. Remote sensing and Digital Image Analysis. An Introduction 2 nd ed. Springer, Berlin, Heidelberg.
[8] Winarso, G. and S. Budhiman, 2001 “The potential application of remote sensing data for coastal study”, Proc. 22nd Asian Conference on Remote Sensing.
[9] Yamani M and Nohegar A 2006 Coastal Geomorphological in the East Strait of Hormoz, Hormozgan University Publishing.