Journal of ENVIRONMENTAL Treatment Techniques

Enviro. Treat. Tech.
ISSN: 2309-1185
Journal web link: http://www.jett.dormaj.com

Monitoring the Area and Distribution of Mangrove Forests in the Southern Coasts of Iran

Alireza Salehipour Milani[1*], Razyeh Lak[2], Mansour Jafar Beiglu[3]

1- Marine Geology Management, Geological Survey of Iran, Meraj St. Azadi Sq. Tehran, Iran
2- Research Institute for Earth Science, Geological Survey of Iran, Meraj St. Azadi Sq. Tehran, Iran
3- University of Tehran, Faculty of Geography, Vesale Shirazi St. Enghelab St. Tehran, Iran

Received: 21/10/2013 Accepted: 13/12/2013 Published: 15/12/2013

Abstract

Mangrove forests in Iran begin from the easternmost part of the border in the Oman Sea (Gwatre Bay) and continue to the western parts of the Persian Gulf ending in Dayer (Bushehr Province). Mangrove ecosystems areas have sensitive habitats that are not only important in terms of purpose and protection but also because of the function of their irreplaceable values which have also been the focus of Biodiversity Convention. Mangrove ecosystems are susceptible to environmental stresses. Globally mangrove forests are decreasing by 1 to 2 percent annually. Mangroves in Iran which are preserved by Environmental Protection Organization include 4 International Wetlands, 1 Coast National Park, 8 protected areas, and one Biosphere Reserve. This study attempts to assess the area, distribution and changes in mangrove forests in the southern coasts of Iran During 37 year period (1973-2010) using an integrative method of Normalized Difference Vegetation Index (NDVI) and Landsat (MSS, TM, and ETM+). This Research could be used as a model for future Mangrove planning in landscape management in Iran. The results of this study determined the changes in extent of mangrove forests in Iran and showing 66.1% increase from 1973 to 2010.

Keyword: Mangrove, Monitoring, Remote Sensing, Estuary, NDVI, Iranian Coasts

1- Introduction

Mangroves are found in tropical and subtropical tidal areas. Areas where mangroves occur include estuaries and marine shorelines (Mildred, 1997). Mangroves protect coastal areas from erosion, storm surge (especially during hurricanes and tsunamis) (Mazda, 2005). The mangroves' massive root systems are efficient at dissipating wave energy (Massel ,1999) Likewise, mangroves slow down tidal water to levels that are enough for sediments to be deposited as the tide comes in, leaving all except fine particles when the tide ebbs (Mazda, *et al.* ,1997). In this way, mangroves build their own environment. Wave energy is typically low in areas where mangroves grow (Baird, 2006) so their effect on erosion can only be measured over long periods of time (Massel, 1999). Their capacity to limit high-energy wave erosion is limited to events such as storm surges and tsunamis (Dahdouh-Guebas, *et al.*, 2005).

Worldwide, the total area of mangrove ecosystems is estimated as 15 million ha (Lacerda & Diop, 1993). Mangrove cover in the Indo-Pacific region is about 6.9 million ha. African mangroves cover about 3.5 million hectares and Latin American and Caribbean mangroves represent approximately 18% (4.1 million hectares) of the total area. As these represent, the largest mangroves cover is located in the Indo-Pacific region as such an ecosystem is formed in large river deltas such as Ganges-Brahmaputra, Irrawaddy, Mekong, and also protected coastal areas with wide-ranging lands such as Madagascar, Kalimantan, Indonesia, Papua New Guinea. The largest portion of mangrove ecosystem lies in Bangladesh which is associated with the Sundarbans ecosystem. According to the 1985 estimate, the total area of the Bangladesh Sundarbans is said to cover about 401600 ha (Chaffey, Miller and Sandom, 1985). High population pressure in coastal areas, however, has led to the conversion of many mangrove areas to other uses, including infrastructure, aquaculture, rice growing and salt production (FAO, 2003). Approximately 35% of the total mangrove area has been lost during the last several decades of the twentieth century (in countries for which sufficient data exist, encompassing about half of the area of mangroves) (Millennium Ecosystem Assessment, 2005). Likewise, the 2010 update of the World Mangrove Atlas (WMA) indicated that a fifth of the world's mangrove ecosystems have been lost since 1980 (The Nature Conservancy, 2010a).

An important part of the Iranian mangrove forests (of Paleotropical origin), known as Harra forest in between the mainland and Qeshm Island were designated as Biosphere Reserve by UNESCO's Man and the Biosphere (MAB) Program in 1972. As an important and critical habitat for aquatic organisms, this wetland was also internationally recognized as Ramsar Site in early 1970s.

Coresponding author: Alireza Salehipour Milani, Marine Geology Management, Geological Survey of Iran, Meraj St. Azadi Sq. Tehran, Iran .
email: Ar.salehipour@gmail.com

In a study of *Iran's Forests* (Safari, 2005) which included mangrove forests, satellite data and aerial photography were used (Mirshojaei *et al*., 1985). In addition, aerial photography (scale of 1:20000) was used in surveying mangrove forests in Siri Island (Danehkar, 2003), Khamir and Qeshm Island (Jafarbeglu *et al*., 2010; Hajjarian, 2004), Tiab and Kolahi (Isini, 2006), Bushehr province (Rashvand, 2011), Naybandan (Ranjbar, 2007), and Gwatre Bay in Sistan and Baluchestan Province (Danehkar, 2008). These studies were mainly local and examined the changes of mangrove forest cover over short periods of time.

Over the past decades, major steps have been taken toward estimating the amount of vegetation cover using Landsat sensor imagery (e.g. ETM+) (Hansen *et al*., 2002). As one of the main resources in collecting spatial information for management and planning of land and natural ecosystems, digital satellite data have been greatly developed in Iran over the past decade (Darvishsefat, 1997). Several studies have been carried out worldwide to develop forest cover maps using various satellite images (Jensen, *et al*., 1997;, Kairo, 2002; Mohamed *et al*., 1992; Pala ganas, 1992; Long and Skewes, 1994; Asc hbacher *et al*., 1995; Asch- bacher *et al*., 1995; Vits and Tack, 1995; Rasolofoharinoro *et al*., 1998; Ramsey, 1996; Rasolofoharinoro *et al.*, 1998; Blasco *et al*., 1998; Green *et al*., 1998; Dahdouh-Guebas *et al*., 2000; Kairo *et al*., 2002; Tong et *al*., 2004; Ko vacs *et al*., 2005; and Jafar beglu, *et al*., 2010). The Normalized Difference Vegetation Index (NDVI) is an index that can be used to map and identify vegetated canopies. The NDVI, which is a combination of red and NIR reflectance measurements, is one of the most widely.

Used vegetation indices in the world (. Huete, 1994) and has been used extensively as an indicator of the state of vegetation over many spatial and temporal resolutions(Leprieur , 2000).This method however has never been used to investigate mangrove distribution in Iran, while a couple of studies have been used it in Bangladesh (Michael Emch, 2006; Chandra Giri *et al*., 2007), Taiwan (Tsai-Ming *et al*., 2009), Mexico (Arturo *et al*., 2010), and Alabama (John C. Rodgers *et al*., 2009). This study attempted to assess the distribution and changes in the area of forests in the southern coasts of Iran using an integrative method combining NDVI. The results could be used as a model for future planning in landscape management and planning in Iran.

2- Study Area

Mangrove ecosystems in Iran are exclusively home to two mangrove species, *Avicennia marina* and *Rhizophora mucronta*. Not being able to compete, the other species are removed from the environment. Mangrove forests in Iran are located in the coastal areas along intertidal zone as discrete or connected small and large communities. These forests are conceived as the western most mangrove forests in Southwest Asia. Mangrove forests in Iran begin from the easternmost part of the border in the Oman Sea (Gwatre Bay) and continues to the western parts of the Persian Gulf ending in Dayer (Bushehr Province) by law under the jurisdiction of the Department of Environment including four Internationally Important Wetlands (Ramsar Sites), One marine National Park, eight Protected Areas, and one Biosphere Reserve (Danehkar, 1998). Mangrove forest distribution in the southern coast of Iran is shown in figures 1 to 3.

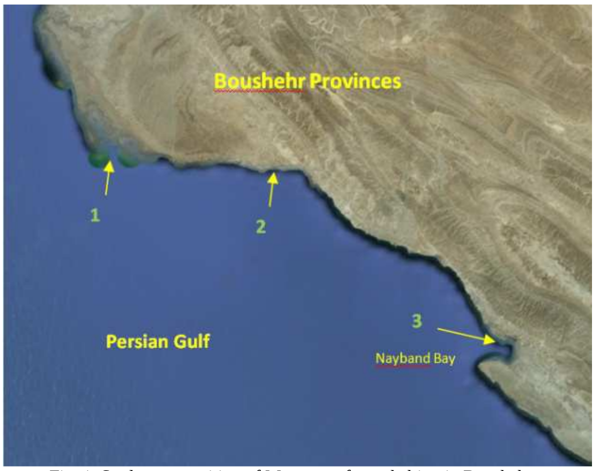

Fig. 1. Study area position of Mangrove forest habitat in Boushehr province

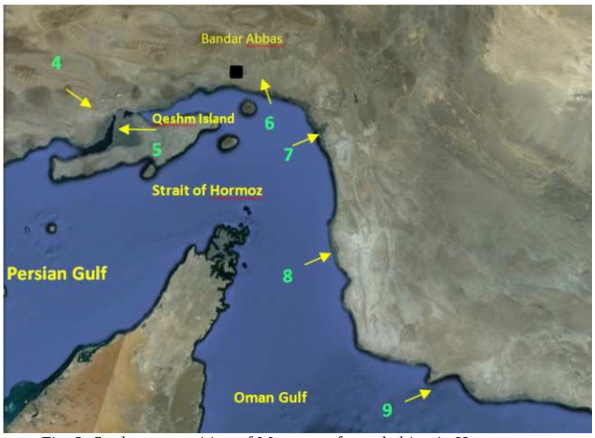

Fig. 2. Study area position of Mangrove forest habitat in Hormozgan province

Fig. 3. Study area position of Study area Mangrove forest habitat in Sistan and baluchestan provinces

3- Methodology

Most of the studies investigate the relationship between the reflected energy in red and near infra-red bands and the extent of vegetation. In healthy plants the amount of reflected energy in red band decreases by plant growth since the chlorophyll inside the leaves absorbs electromagnetic spectrum in the photosynthesis process. On the other hand the amount of reflected energy in near infra-red band, due to the mesophyll structure of the leaves, increases (Alavipanah, 2006). Therefore, using an appropriate vegetation index which is capable to identify the changes in plant canopies quantitatively seems to be necessary. Vegetation index are mathematical functions on the basis of different bands are defined as sensors which are designed to assess the plants in satellite observations. NDVI is one of the most widely used vegetation indices and its utility in satellite assessment and monitoring global vegetation cover has been well demonstrated over the past two decades (Huete and Liu, 1994; Lep *et al*., 2000).

$$\left[\text{NDVI} = \frac{\rho_{857} - \rho_{645}}{\rho_{857} + \rho_{645}} \right]$$

The symbols (ρ) which represent reflectance in red band and that in infra-red band. This index ranges from 1 to -1. The higher the value of this index shows an increase in identification of Plant Cover (Allen, R., Bastiaanssen *et al.*, 2002). In this study, various kinds of multi-temporal satellite images, obtained from ETM, TM, and MSS Landsat were used for the period 1975-2010 in order to monitoring mangrove forests in the southern coasts of Iran. Among the earliest observations were the images taken by Landsat MSS sensor with 80 meters spatial resolution which were taken in 1973 and 1975. TM (1989) and ETM (2000, 2010) satellite data were also used in this study whose results are presented in Table1.

Table 1: Satellite data used in this research

Date of Acquire	Satellite Sensor	Resolution (m)	Number of Images
1975	MSS	80	9
1989	TM	30	13
2000 and 2012	ETM	30	26

Geometric and radiometric corrections for all images were performed by ERDAS software. Digital topographic maps 1:25000 at 1:250000 blocks of Chabahar, Pibeshk, Jask, Sirik, Minab, Bandar Abbas, Qeshm, Bandar Lengeh, Lar kangan, Khormoj, and Biram were used in order to carry out geometric corrections in satellite images. Image processing was carried out using ERDAS software for calculating the NDVI index.

4 Discussions

After the satellite images were processed in different time periods, distribution and changes in the area of mangrove forests were assessed (Table 2). As it is shown in Table 2, the biggest density of mangrove forests in the studied time period was observed around Qeshm Island (Regions 4 and 5)(Fig. 12-15) .totally , growing trend in the area of mangrove forests showed in period of 1975-2010.

In 1975, only 8 regions, out of 12 Study areas, had mangrove cover and areas of Regions 6 and 8 were less than 1 km^2. In this year, Iran's mangrove forests area was 66.58 km^2. Region 5 (northwestern part of Qeshm Island) had the largest communities of forests in this year and Tiab and Kolahi estuaries had the smallest communities of mangrove forests.

During 1975-1989 mangrove forests grew in an increasing trend along the southern coasts of Iran, while only in Region 9 (Jask region) whose mangrove cover decreased from 4.71 km^2 in 1975 to 3.28 km^2 in 1989 (fig. 8,9). In these periods of time, the area of mangrove forests increased from 66.58 km^2 to 92 km^2 showing a 28.75% increase (25.41 km^2). Mangrove forests can be found in Region 2 and 3 (Dayer and Asalouyeh) which showed maximum expansion of mangrove forest area during the period 1975-1989(Fig. 16,17). In these years, the maximum increasing mangrove cover was in the northwestern part of Qeshm Island (fig. 12, 13) a 10.75 km^2 increase, and the highest percentage was in Region 7 (Tiab, Kolahi, and Minbab), with a 93.13 percent increase.

In the year 2000 compared to 1989, the increasing trend in mangrove growth continued, this trend was slow and forest area extended only 3.3 km^2 (3.5%) and forest area expanded to 94.73 km^2 in 2000. This is due to a decline in the area of mangrove forests in major habitats such as Qeshm Island, Khamir, and Gwatre. The increasing trend in mangrove growth continued in Regions 2, 3, 6, 7, 8, and 9 and the greatest increase (5.1 km^2) in the area of mangrove cover was observed in Region 6, east of Bandar Abbas, in the vicinity of Kouleghan (Jalabi and Hassan-Langi region) at the mouth of the Shoor River). However, in most of the major habitats such as Qeshm Isalnd, Khamir, and Gwatre Bay, the area of the forests had decreased by 2.57, 0.7, and 2.18 km^2 respectively. The highest decrease in mangrove forest area had occurred in Qeshm Island and the lowest decrease (fig. 14) (33.3%) had occurred in Gwatre Bay (fig. 6).

Compared to year 2000, in 2010, mangrove forests in Nayband Bay (fig. 19) and Bandar Abbas showed falling trend and the mangrove forest had decreased by 0.04 $km^2$and 2.28 km^2 respectively. Other regions shows an increasing trend in mangrove forest growth, reaching 107.1km^2, showing a 12.29 km^2/ (11.26%) increase, compared to 2000. In Regions 11 and 12 (Chabahar and Pozm Bay) where there was no mangrove forests (before 2010), mangroves had started to grow. Results in south coast of Iran Compared to the early period (1975), the area of mangrove forests in 2010 showed a 37.8% (40.43km^2) increase.

Some of Study area Mangroves distribution changes in the southern coast of Iran are illustrated with red in Figures 5 to 20.

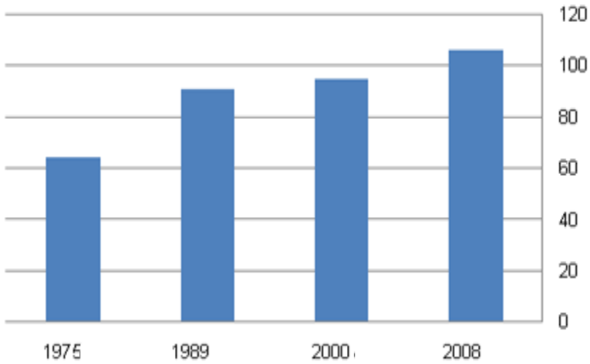

Fig. 4. Changes in Kilometre mangroves area in South Coast of Iran (1975-2010)

Fig. 5. Distribution of Mangrove forest in Gwatre bay (1975)

Table 2: Mangrove area Changes in Studies area during (1975-2010)

Study Area	Mangrove forest area in 1975 Km^2	Mangrove forest area in 1989 Km^2	Mangrove forest area in 2000 Km^2	Mangrove forest area in 2010 Km^2
1	0.12	0.78	0.22	0.33
2	0	0.07	0.1	0.3
3	0	1.01	1.17	1.13
4	13.14	18.12	17.42	20.2
5	44.28	55.03	52.46	58.95
6	0.14	4.3	9.81	7.73
7	0.07	1.1	1.9	1.99
8	3.49	5.03	5.51	7.19
9	4.71	3.28	3.78	5.16
10	0.63	3.27	2.18	4.09
11	0	0	0	0.03
12	0	0	0	0.06
Total	66.58	92	94.73	107.1

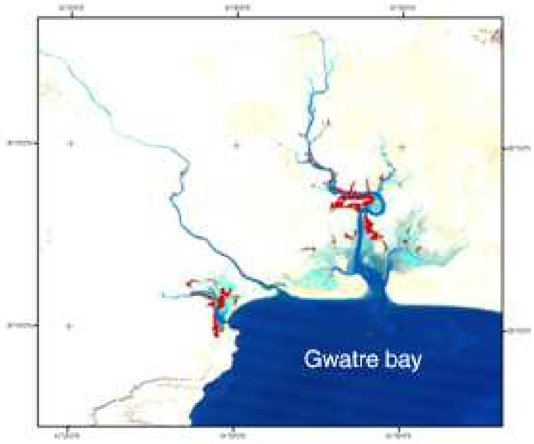

Fig. 6. Distribution of Mangrove forest in Gwatre Bay (1989)

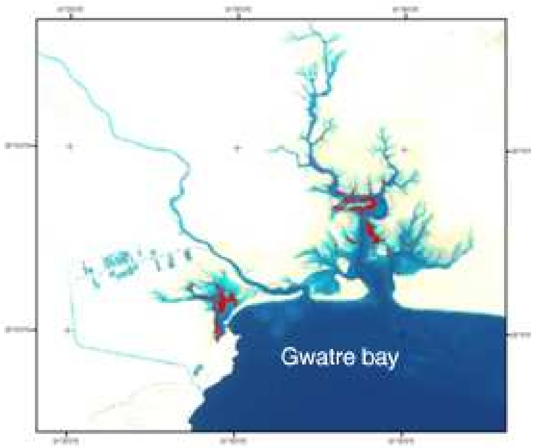

Fig. 7. Distribution of Mangrove forest in Gwatre Bay (2000)

Fig. 9. Distribution of Mangrove forest in Jask Estuary (1989)

Km

Fig. 11. Distribution of Mangrove forest in Jask Estuary (2010)

Fig. 12. Distribution of Mangrove forest in Jask Estuary (2000)

Fig. 8. Distribution of Mangrove forest in Gwatre Bay (2010)

Fig. 13. Distribution of Mangrove forest in Study area 4 and 5, Qeshm and Laft Estuary (1989)

Fig. 10. Distribution of Mangrove forest in Jask Estuary (1975)

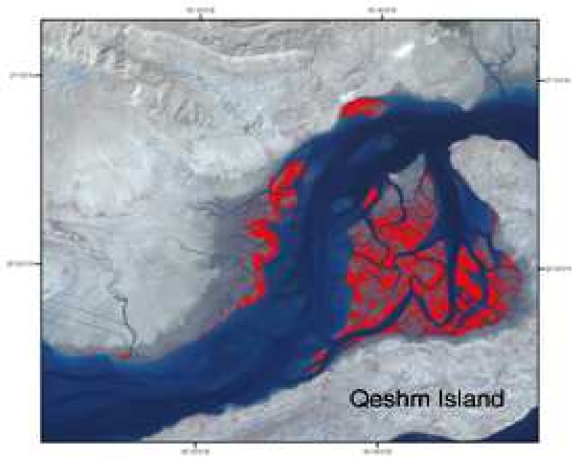

Fig. 15. Distribution of Mangrove forest in Study area 4 and 5, Qeshm and Laft Estuary (2010)

Fig. 17. Distribution of Mangrove forest in Study area 3, Nayband Bay (1975)

Fig. 18. Distribution of Mangrove forest in Study area 3, Nayband Bay (1989)

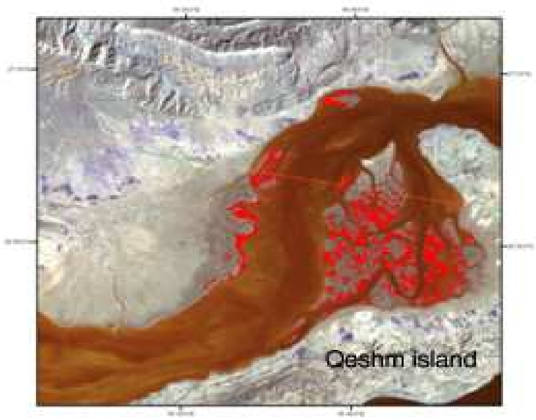

Fig. 14. Distribution of Mangrove forest in Study area 4 and 5, Qeshm and Laft Estuary (1975)

Fig. 16. Distribution of Mangrove forest in Study area 4 and 5, Qeshm and Laft Estuary (2000)

Fig. 19. Distribution of Mangrove forest in Study area 3, Nayband Bay (2010)

5 Conclusions

The results of this study show the area of mangroves in the southern coast of Iran has been growing from 1973 to 2010, except for some time periods. The trend analysis indicates that the mangrove area worldwide has in 2005 fallen to about 15.2 million hectares, down from 18.8 million hectares in 1980. The world has thus lost some 3.6 million hectares of mangroves over the last 25 years, or 20 percent of the extent found in 1980(FAO, 2007) Therefore, the necessity of an integrated monitoring of mangrove forests area and changes is recognized. This study investigated the changes in the distribution and area of mangrove forests in the southern coasts of Iran during a 37 year period using satellite images and NDVI model. The results revealed that most of the countries confronting the decline in mangrove forest areas, mangrove areas in Iran increased from 66.76 km^2 in 1975 to 107.1 km^2 in 2010. Mangrove growth has increased by 36.7%. The highest decrease in mangrove forests occurred in the period 1989-2000. In this periods we saw downward trend in mangrove areas in some regions such as Qeshm Island, Khuran Strait, and Gwatre Bay, which having the largest mangrove communities on the Iranian coast. Using Landsat satellite images and NDVI model proved efficient in determining mangrove forest changes. Such satellite data are quite appropriate for dense vegetation canopy but fairly inefficient once used with newly-planted mangroves or with low density canopies such as those found in the mouth of Mond River in Bushehr province, which, due to the low-resolution images, it was hard to identify the mangrove forest extent.

Fig. 20. Distribution of Mangrove forest in Study area 3, Nayband Bay (2000)

Therefore, in order to obtain more accurate estimates to achieve the areas of these forests, need for high-resolution satellite data such as Ikonos and Quickbird. Various climatic, environmental and human factors may be involved in explaining the changes in mangrove growth. The climatic factors which contribute to mangrove growth include temperature and precipitation. Since most of the changes in mangrove areas have occurred in the Hormozgan province, the statistics in Synoptic Meteorological station of Bandar Abbas' was used as a criterion for studying the changes in mangroves in this area.

5.1 Changes in temperature

Since 1880, the Earth has warmed 0.6-0.8° C and it is projected to warm 2-6° C by 2100 mostly due to human activity (Houghton et al., 2001). Mangroves are not expected to be adversely impacted by the projected increases in sea temperature (Field, 1995). Most mangroves produce maximal shoot density when mean air temperature rises to 25°C and stop producing leaves when the mean air temperature drops below 15°C (Hutchings and Saenger, 1987). At temperatures above 25°C, some species show a declining leaf formation rate (Saenger and Moverly, 1985). Temperatures above 35°C have led to thermal stress affecting mangrove root structures and establishment of mangrove seedlings (UNESCO 1992). At leaf temperatures of 38-40°C, almost no photosynthesis occurs (Clough *et al.*, 1982; Andrews *et al*., 1984). By studying Bandar Abbas' annual mean temperature (**Fig. 21**) in the period of 1975-1989 (the highest rate of mangrove growth) and the period 1989-2000 (the highest decrease in mangrove growth), it is found that the annual means of temperature in 1975-1989 was 26.6°C and 26.8°C, respectively, in year 1989/2000 which was yield a minor difference and probably had no major effect on mangrove growth.

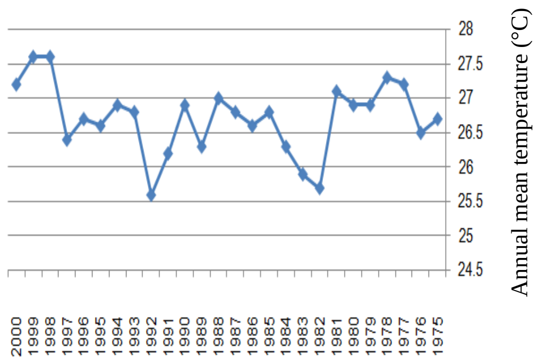

Fig. 21. Average annual temperature in Bandar Abbass Station

Obviously, temperatures above 35°C which lead to thermal stress should not be overlooked. The statistics concerning the temperatures above 35°C is unavailable; hence, by investigating the mean number of the days with temperatures above 30°C in Bandar Abbas' station, it was concluded that differences between the period 1975-1989 (234 days) and the period 1989-2000 (227 days) was not significant and even the mean number of days with temperatures above 30°C was more in 1975-1989 (**Fig. 22)**

5.2 Precipitation

Precipitation rates are predicted to increase by about 25% by 2050 in response to global warming. However, at regional scales, this increase will be unevenly distributed with either increases or Decreases projected in different areas (Knutson and Tuleya 1999; Walsh and Ryan 2000; Houghton *et al*., 2001).

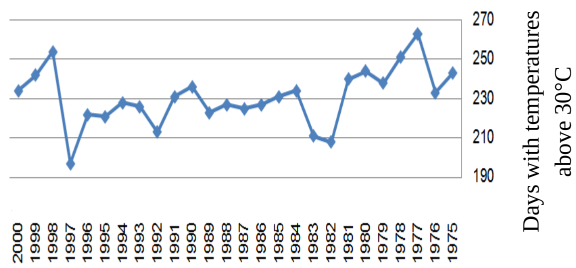

Fig. 22. Mean number of days with temperatures above 30°C

Changes in precipitation patterns caused by climate change may have a profound effect on both the growth of mangroves and their areal extent (Field 1995; Snedaker 1995).

Decreased precipitation results in a decrease in mangrove productivity, growth, and seedling survival, and may change species composition favoring more salt tolerant species (Ellison 2000, 2004). Decreased precipitation is also likely to result in a decrease in mangrove area, decrease in diversity, and projected loss of the landward zone to unvegetated hypersaline flats (Snedaker 1995). Increased precipitation may also allow mangroves to migrate and outcompete saltmarsh vegetation (Harty, 2004).

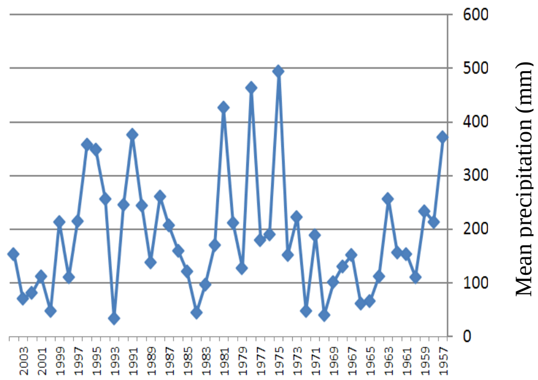

Fig. 23. Mean annual precipitation in Bandar Abaas Station

Mean precipitation in a 25-year period (1975-2000) in Bandar Abbas' station was 225 mm and during 1989-2000 it was 233.5mm (Fig. 23). The mean annual precipitation in the first period was less than the second period and the percentage of the years in which precipitation was lower than the mean annual in the period 1975-1989 (57%) was more than the period 1989-2000 (41%). These data reflected the fact that the changes in mangrove area extent in this time period were not a function of mean annual precipitation. However, according to Fig. 23, the amount of precipitation in the years 1976 (494.7mm), 1979 (464.4mm), and 1982 (496.8mm) was twice more than the mean annual precipitations, whereas the amount of precipitation did not exceed 400mm in the period 1989-2000. This level of precipitation had probably major effects on mangrove growth. Furthermore, the 1994 drought (with only 33.7mm rainfall) was also likely to have contributed to a decrease in mangrove area.

5.3 Changes in sea level

In the last century, sea level has risen 10-20 cm, primarily due to thermal expansion of the oceans and melting of glacial ice caused by global warming (Church *et al*., 2001). Sea-level rise is the greatest climate change challenge that mangrove ecosystems will face (Field 1995). Mangroves can adapt to sea-level rise if it occurs slowly enough (Ellison and Stoddart 1991), if adequate expansion space exists, and if other environmental conditions are met. Sea level change during 1975-2010 in the study region within the study period was very low, therefore this factor was not considered to be very important in mangrove changes.

5.4 Human factors

Besides climatic and environmental factors, human's factors can have a major role in changes of mangrove ecosystems. Over the past four years, by implementing a "Mangrove Forests Development Plan" in the southern provinces of the country (Forests and Rangelands Organization) and addition of 7000 ha of man-planted forests an increase in mangrove forest areas was expected over the past decades in Iran. However, anthropogenic threats to mangroves such as development and overexploitation of mangrove forests as food for livestock, drought in Qeshm Island in 1993, conversion of forests into agriculture farmlands, salt extraction, diversion of freshwater for irrigation and tourism, establishment of shrimp aquaculture ponds accounted for the main factors in contributing to the loss of mangrove forests in Iran.

6- Acknowledgement

This project was funded in the Geological Survey of Iran and Marine Geology Management. We would like to express our appreciation to all colleagues who provided us with their valuable support and comments.

7- References

1- Alavi Panah. S.K , Application of Remote Sensing in Earth Science , University of Tehran Publication, 2006, p.125

2- Allen. R, W.Bastiaanssen, M.,Tasumi, and R.Trezza, "*SEBAL, Surface Energy Balance Algorithms for Land Idaho Implementation*" Advanced Training and Users Manual,2002.

3- Zahed. A, M.Rouhani, S. Mohajeri and F. Bateni, An overview of Iranian mangrove ecosystems, northern part of the Persian Gulf and Oman Sea, Acta Ecologica Sinica, Vol. 30, 2010, 240–244.

4- Arturo. R.L, Aimeé Cervantes. E and César. B , Assessing Distribution Patterns, Extent, and Current Condition of Northwest Mexico Mangroves, Wetlands, Vol. 12, 2010,717-723

5- Aschbacher. J, Ofren. R, Delsol. J.P, Suselo. T.B, Vibulsrest, An integrated comparative approach to mangrove vegetation mapping using advanced remote sensing and GIS technologies: preliminary results, Hydrobiologia, Vol. 295, 1995, 285-294.

6- Baird. A,False Hopes and Natural Disasters, *New York Times* editorial, 2006

7- Behroozi Rad. V, Gando Protected Area, Journal of Environmental Research, No 8, 1998, 28-35

8- Botkin. D and Keller. E, *Environmental Science: Earth as a living planet*, John Wiley & Sons. ,2003 p.2

9- Caroline. J. N , Uwe. R, Shizue. M and Barr O. y, Assessing photosynthetic efficiency in an experimental mangrove canopy using remote sensing and chlorophyll fluorescence, Trees - Structure and Function, Vol. 20, N. 1, , 2006, 9-1

10- Miller. C and Sandom. K, A forest inventory of the Sundarbans, Bangladesh, Land Resources Development Centre, 1985,196

11- Church. J, Gregory. J, Huybrechts. P, Kuhn. M, Lambeck. K, Nhuan. M, Qin, D and Woodworth. P, Changes in Sea Level in Houghton, Chapter 11. 2001, Pp. 639-693.

12- Ding, J. Y, Griggs. D, Nogue, M. r, van der Linden. P, Dai. X, Maskell and K, Johnson. C, The Scientific Basis, Published for the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom, and New York, NY, USA, 2001,881

13- Clough, B.F, Mangroves. In Control of Crop Productivity, Academic Press, Sydney, 1984,253-268

14- Cloug. B.F, Andrews.H and Cowan, I.R, Primary productivity of mangroves In Mangrove Ecosystems in Australia- structure function and management. AIMS with ANU press, Canberra, Australia, 1982

15- Danehkar. A, Mangrove Forest Zoning in international Wetland of Gaz and Harra", Journal of Environmental Research, No 34,1998,43-49
16- Danehka.r A, marine Sensitive Zone of Iran, Journal of Environmental Research, No 24,1998,28-38
17- Dahdouh-Guebas. Fm, How effective were mangroves as a defense against the recent tsunami?, *Current Biology*, Vol. 15(12), 2005, 443–447
18- Dahdouh. G, Verheyden. F.A, De Genst. W, Hettiarachchi. S and Koedam. N, Four decade vegetation dynamics in Sri Lankan man- groves as detected from sequential aerial photography: a case study in Galle Bulletin of Marine Science 67, 2000, 741 -759.
19- Danielsen. F, The Asian tsunami: a protective role for coastal vegetation, *Science*, 310,2005, 643
20- Ellison, J.C, Vulnerability of Fiji's mangroves and associated coral reefs to climate change. Review for the World Wildlife Fund. Launceston, Australia, University of Tasmania,2004
21- Ellison. J.C, How South Pacific mangroves may respond to predicted climate change and sea-level rise, Chapter 15, pages 289-301 In A. Gillespie and W. Burns, (eds.) Climate Change in the South Pacific: Impacts and Responses in Australia, New Zealand, and Small Islands States, Kluwer Academic Publishers, Dordrecht, 2000,pp. 289-301
22- Ellison. J.C, Stoddart. D.R, Mangrove ecosystem collapse during predicted sea-level rise: Holocene analogues and implications, Journal of Coastal Research Vol. 7, 1991, 151-165.
23- FAO, State of the World Forest (SOFO) 2003. Part 1, the situation and development in forest Sector,2003
24- FAO, The World's Mangroves 1980-2005", 2007, Pp 56
25- Field C.D, Impacts of expected climate change on mangroves", Hydrobiologia Vol. 295(1-3),1995,75-81
26- Salehipour Milani A, Coastal Geomorphology Atlas of Chabahr Quadrate 1:100000, Geological Survey of Iran, Marine Geology Management, 2007.
27- Nejad Afzali. K, Coastal Geomorphology Atlas of Chabahr Quadrate 1:100000, Geological Survey of Iran, Marine Geology Management, 2007
28- Green. E.R, Mumb. P.J, Edwards. A.J, C.D. Clark, A.C.Ellis, The assessment of mangrove areas using high-resolution multispeciral airborne imagery, Journal of Coastal Research 14, 19984,33 -443
29- Harty. C, planning strategies for mangrove and saltmarsh changes in Southeast Australia, Coastal Management, Vol. 32, 2004,405-415
30- Hajjarian M, Investigation of Quantities Change of Mangroves using aerial photo and Satellite Images in 40 year period, Msc Thesis, Tehran University, Faculty of Natural resource, Tehran University,2005.
1- 31- Haudhury. M.U, Digital analysis of remote sensing data for monitoring the ecological status of the mangrove forest of Sunderbans in Bangladesh, Proceedings o f the 23rd International Symposium on Remote Sensing of the Environment, vol. 1, 1990, pp. 493 -497.
32- Houghton. J, Ding. D. Y, Griggs. M, Noguer. P, van der Linden. X, Dai K., Maskell. C, Climate Change, the Scientific Basis. Published for the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom, and New York, NY, USA, 2001,881 pp.
33- Huete. A. R and Liu. H, An error and sensitivity analysis of the atmospheric- and soil-correcting variants of the NDVI for the MODIS-EOS, IEEE Transactions on Geoscience and Remote Sensing, Vol. 32, 1994, 897− 905.
34- Huete. A. R, Jackson. R. D and Post. D. F, Spectral response of a plant canopy with different soil backgrounds, Remote Sensing of Environment, Vol. 17, 1985, 37− 53.
35- Salehipour Milani. A and Jafar Beiglu.M , Satellite-based assessment of the extent and changes in the mangrove ecosystem of the Qeshm Island (Iran), J. Environ. Res. Develop, 2012,Vol. 7 No. 2A, 1052-1060
36- Jensen. R. J, Hongyue. L, Xinghe. Y, The measurement of mangrove characteristics in Southwest Florida using Spot multispectral data, *Geocarto International*, Vol. 2,1991,13-21.
37- Rodgers, J. C, Adam Murrah. W and William. H , Chandra Giri. Cooke, Bruce. P, Zhiliang. Zhu, Singh. Ashbindu and Larry. L. Tieszen , Monitoring mangrove forest dynamics of the Sundarbans in Bangladesh and India using multi-temporal satellite data from 1973 to 2000, Estuarine, Coastal and Shelf Science, Vol. 73, 1-2, 2009, 91-100.
38- Khosravi. J, Program of Ecological Research in Mangrove Forest, Environmental Group, 1992
39- Lacerda.D, ITTo/ISME Project on conservationand sustainable utilization of mangrove foret in Latin America and Africa, International Society of Mangrove Ecosystem, No.PD114/90F,1993.
40- Kair, J. G, Kivyatu. B and Koedam. N, Application of remote sensing and GIS in the management of mangroves forests within and adjacent to Kiunga Marine Protected Area, Lamu, Kebya, *Environment, Development and Sustainability*, Vol. 4, 2002, 153-166.
41- Kay. R.J, Hick. P. T and Houghton. H.J, Remote sensing of Kimberley rain- forests. Rainforests, Surrey Beatty & Sons, Chipping Norton, 1991, pp. 41-51.
42- Khan. MA and Al-Homaid. NA, Remote Sensing Study On Mangrove Depletion Tarut Bay, Saudi Arabia
43- Ko vacs. J.M, Wang. J and F. Flores-Verdugo, Mapping mangrove leaf area index a t the species level using IKONOS and LAI-2000 sensors for the Agua Brava Lagoon, Mexican PacificEstuarine, Coastal and Shelf Science, Vol. 62, 2005, 377-384.
44- Leprieur. C, Kerr. Y. H, Mastorchio. S and Meunier. J. C, monitoring vegetation cover across semi-arid regions: Comparison of remote observations from various scales, International Journal of Remote Sensing, 21, 2000, 281−300.
45- Lorenzo. R and de Jesus. R.B, Assessment of mangrove forest deterioration in Zamboanga Peninsula, Philippines, using Landsat MSS data, Proceedings o f the 13th International Symposium on Remote Sensing of the Environment,1979.
46- Massel. S. R, Furukawa. K and R. M. Brinkman, Surface wave propagation in mangrove forests, *Fluid Dynamics* Roy, P.S., 1989. Mangrove vegetation *Research*, Vol. 24(4) 1999, pp. 219–249.
47- Mazda. Y, Kobashi. D and Okada. S, Tidal-Scale Hydrodynamics within Mangrove Swamps, *Wetlands Ecology and Management,Vol* 13(6): 2005, pp. 647-655.

48- Mazda. Y, , Drag force due to vegetation in mangrove swamps, *Mangroves and Salt Marshes,Vol.* 1, 1997, pp. 193–199
49- Emch. M and Peterson. M, Mangrove Forest Cover Change in the Bangladesh Sundarbans from (1989-2000): A Remote Sensing Approach, *Geocarto International*, Vol. 21, No. 1, 2006.
50- Mildred E, Mathias Botanical Garden, Mangal (Mangrove). *World Vegetation*. University of California at Los Angeles.
51- Millennium Ecosystem Assessment, Ecosystems *and Human Well-being: Synthesis*, Island Press, Washington, DC. World Resources Institute, 2005, p.2
52- Ramsey. E. W and Jensen. J. R, Remote sensing of mangrove wetland- Relating canopy spectra to site-specific data*, Photogrammetric Engineering & Remote Sensing*, Vol. 62 (8) 1996, 939-948.
53- Ramsey. R.D, Wright. J.r and Ginty. Mc, *Geocarto Int.* 2004. 19: 39-47.
54- Ranjbar. S, nvestigation of Ecological Potential in Nayband Coastal and Marine Park to Tourism Development, Msc thesis in GIS, Science and Research Azad University,2005
55- Rashvand. S, Comparasion of mangrove Structure in Coastal Province of Boushehsr, Msc Thesis in Forestry, Agriculture and Natural Resource university of Gorgan,1998
56- Rasolofoharinoro. R, Blaso. F, Bellan. M.F, Aizpuru. M, Gauquelin. T and Denis. J, A Remote Sensing based methodology for mangrove in Madagascar, International Journal of Remote Sensing 19, 1998, 1873-1886.
57- Safa Eisini. Hengameh, Ecological Management of Mangrove Forest in Tiab and Kolahi with Reference to Changes and Structure, Msc thesis in Environment, Bandar Abas Azad University2006
58- Safiyari. S, Iranian Mangrove Forest, Research Institute in Forest Publication, 2005
59- Sistan and Baluchestan Environmental Administrator, Application of Mangrove Forest Management in Gwatre Bay with Reference to Monitoring Changes using Satellite Images, 1992
60- Danehkar. A, Erfani, and Snedaker. M, Mangroves and climate change in the Florida and Caribbean region: scenarios and hypotheses, Hydrobiologia, 295, 1995, 43-49.
61- The Nature Conservancy (TNC), World Atlas of Mangroves, Highlights the Importance of and Threats to Mangroves: Mangroves among World's Most Valuable Ecosystems", Press release. Arlington, Virginia, 2010
62- Tong. P.H.S, Auda. Y, Populus. J, Aizpura. M, Habshi. A.A.L, Blasco. F, Assessment from space of mangrove s evolution in the Mekong Delta, in relation to extensive shrimp farming, International Journal of Re- mote Sensing, Vol. 25, 2004, 4795-4812.
63- Tsai-Ming. L and Chung. Y. Hui, Applying remote sensing techniques to monitor shifting wetland vegetation: A case study of Danshui River estuary mangrove communities, Taiwan, Ecological Engineering, Vol. 35, 4, 2009, 487-496.
64- UNESCO, Coastal systems studies and sustainable development, Proceedings of the COMAR Interregional Scientific Conference, UNESCO, Paris, Vol. 276 ,1992pp. 21-25
65- Vibulsresth. , Downreang. D, Rata nasermpong. S and Silapathong. C, Mangrove forest zonation by using high resolution satellite data, In: Proceedings of the 11th Asian Conference on Remote Sensing, D – 1990.
66- Vits. C and Tack. J, The use of remote sensing as information source for environmental accounting of coastal areas in Kenja, Feasibility Study Ref- erence. University of Ghent, No. T3/02/603, 1e45. 1995
67- Huete, A and Liu. H, An error and sensitivity analysis of the atmospheric- and soil- correcting variants of the NDVI for the MODIS-EOS. IEEE Transactions on Geoscience and Remote Sensing, , 32, 1994, 897–905.
68- Leprieur. C, Kerr. Y.H and Mastorchio. S. ,Monitoring Vegetation Cover Across Semi-arid regions, Comparison of Remote Observations from Various Scales, International Journal of Remote Sensing, 21 (2) (2000), pp. 281–300