

Distribution of Mangroves along the Red Sea Coast of the Arabian Peninsula: Part-3: Coast of Yemen

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Abstract

This is third and final paper of our ongoing study on distribution of mangrove cover that provides base line data along the Red Sea coast of the Arabian Peninsula. Historical Landsat Enhanced Thematic Mapper (ETM) data of the years 2000 and 2001 were used to numerically illustrate the distribution of mangroves along the Saudi Arabia -Yemen border (Latitude 16° 41' 16", and Longitude 42° 46' 27.18") in the north to the southern most point of the Red Sea coast, Bab al Mandab strait between Yemen and Djibouti. As reported in the earlier two papers, distribution of mangroves off the coast of Yemen is also patchy and they do not occur as a continuous cover and are generally restricted to the low energy quieter environments like estuaries, bays, lagoons and intertidal environments of mainland and offshore islands. In this region mangroves are under less environmental stress in comparison to the mangroves of the Red Sea coast of Saudi Arabia because of minimal human interference along the Red Sea coastal regions of Yemen. Information on mangrove cover of the Yemeni offshore islands in the Red Sea, and the Arabian Sea coast of Yemen and Oman are calculated from the ETM data for 1999 and 2001. The numerical data about mangrove cover on Socotra Archipelago offshore Yemen in the Arabian Sea is from the available published literature.

Key Words: Mangrove, Red Sea, Yemen, Oman, Socotra Archipelago, Arabian Peninsula.

Introduction

The initial two papers of this on going study (Kumar *et al.*, 2010; Khan *et al.*, 2010) have discussed our earlier work on mangroves of the Red Sea coast of the Arabian Peninsula. The geographic and oceanographic data about the Red Sea, its coastal environments, climate and vegetation types have already been published. The present paper provides numerical data on distribution of mangroves along various Red Sea coastal environments of the Arabian Peninsula from the Saudi Arabia -Yemen border (Latitude 16° 41' 16" and Longitude 42° 46' 27.18") in the north to the southern most point of the Red Sea coast, Bab al Mandab strait between Yemen and Djibouti (Fig.1) covering a length of ~450 Kilometers. This paper is third and concluding part that covers eleven more sites along the coast (Table-1; Fig. 2 sites 38 through 48).

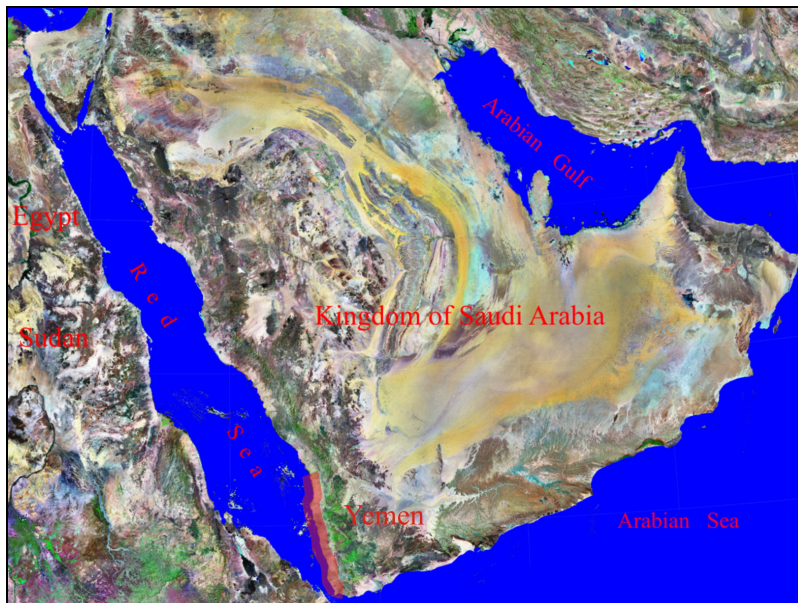


Fig. 1: Study area along the Red Sea coast of Yemen.

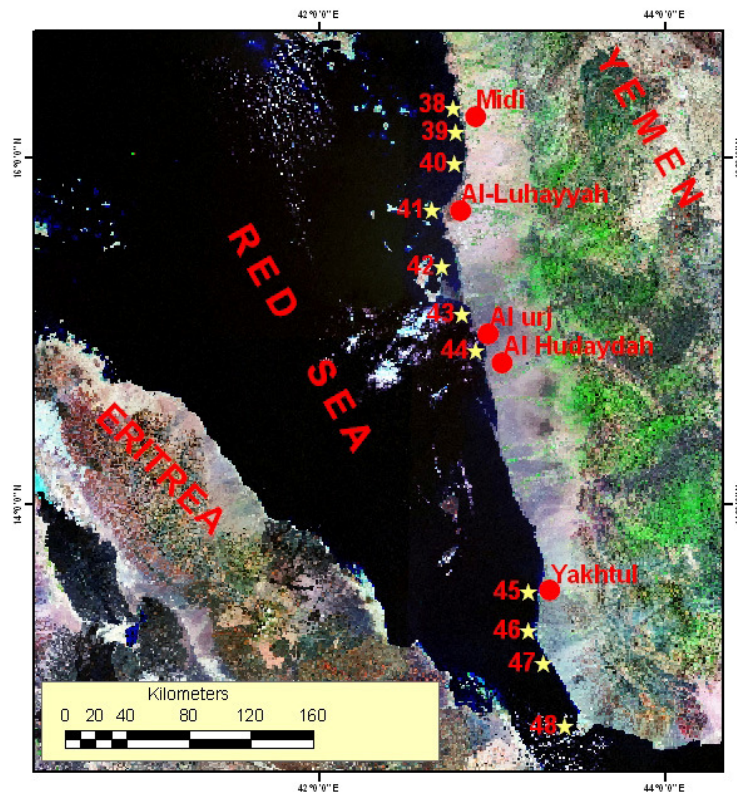


Fig. 2: Locations of 11 study sites along the Red coast of Yemen.

The United Nations Environment Programme (UNEP) report number 64 provides some rudimentary information about the distribution of mangroves in the Red Sea and the Gulf of Aden and discusses reasons for their patchy distribution. As shown in our earlier

papers (Kumar *et al.*, 2010; Khan *et al.*, 2010) mangrove cover along the Arabian coast of the Red Sea is patchy, and they are almost absent in the Gulf of Aqaba (Por *et al.*, 1977; Guilcher, 1982) and the Gulf of Suez (Kassas and Zahran, 1977) where their growth may be limited by lower temperature and lack of suitable substrate (Ormond *et al.*, 1984a). Soft bottom habitats suitable for mangrove growth are rare in the northern part of the Red Sea where coastline is mainly built by coral reefs. Growth of mangroves require good supply of fresh water (Saenger *et al.*, 1983; Kathiresan and Bingham, 2001) which is almost non-existent in the northern part of the Red Sea coast, thus restricting the growth of mangroves. Since tidal range in north is less thus mangrove growth is less too, and in south tidal range is high, freshwater availability is also high thus higher mangrove cover (Ormond *et al.*, 1985b, c). Mangroves occur in sheltered waters with soft bottom habitat and also occur in shallow bays protected by fringing reefs (Hemming, 1961; El Karemy and Al Zahrani, 2000). Due to these reasons mangrove cover off Yemeni coast of the Red Sea are relatively higher and denser than the northern Saudi Arabian coast. The Tawila Archipelago (Latitudes 20°09' and 20°15'N, Longitudes 40°00' and 40°15'E) of the Red Sea consists of four islands and lies west of Al Leith (see site 21 in Khan *et al.*, 2010). Here *Avicennia marina* occupies the eastern sides of the islands (El Karemi and Al Zahrani, 2000).

Although this study primarily deals with the Red Sea coast but we decided to include published information about mangrove cover on the Socotra Archipelago and the Arabian sea coast of the Arabian Peninsula that includes Yemen and Oman because there are small and isolated mangrove stands in these areas. The Socotra Island (area 3,796 km²) is a Yemeni territory in the Arabian Sea and is part of the Socotra Archipelago (12°30'36"N 53°55'12"E / 12.51°N) that constitutes four islands and lies around 350 km south of the coast of Yemen in the Arabian Sea (Fig. 3&4). These islands are often referred as the “Galapagos of the Indian Ocean” due to their high biodiversity, exotic and endemic flora and fauna. Socotra Island is this region’s first protected area to join UNESCO’s world list of “Man and the Biosphere” reserves (UNEP, 2008). Mangroves occur on five different locations of this Island mainly on the landward side of the beach consisting of almost 4 m high *Avicennia marina* and other halophytic plants that cover an area of merely 2.94 km² (Klaus and Turner, 2004). The most extensive and dense cover of mangrove is found at Ghubbah di-Nit on the southwest coast of the island where *Avicennia marina* is growing at sea level and over the coastal sand dune (see plates 13-16 in Klaus and Turner, 2004). Here too, like other parts of the Arabia, mangroves are being destroyed and cut for firewood, timber and fodder for goats.

Although Oman has a long coastline along the Arabian Sea and the Gulf of Oman but has narrow and few patchy cover of mangroves. Only *Avicennia marina* stands occur mainly in tidal creeks locally known as ‘khors’ (Fouda and Ali-Muharrami, 1995). Few such patches also occur along the northeast coast along the Gulf of Oman, near Muscat. The largest mangrove forest (162 ha) occurs on the Mahout Island (Fig. 5) in the Gulf of Masirah along the Arabian Sea coast (Fouda and Ali-Muharrami, 1996; Spalding *et al.*, 2010). This island is the only locality with mangrove cover to be found on the Arabian Sea coast of the Arabian Peninsula. Otherwise this long coastline lacks any mangrove cover due mainly to its rocky coast line that lacks soft sediment substrate. It also lacks sources of fresh water and has higher energy coastal environments.



Fig. 3: Location of Socotra Archipelago (<http://www.investmentoptions.asia/wp-content/uploads/2010/10/socotra.jpg>).



Fig. 4: The Socotra Archipelago (<http://en.wikipedia.org/wiki/Socotra>)

Materials and methods

Mapping mangrove areas using remote sensing techniques is easy because of their low elevation, proximity to coast which can be readily distinguished and they also have characteristic reflectance giving them recognizable spectral signatures (Spalding *et al.*, 1977, 2010). However, their mapping in narrow and patchy formations can be difficult. The study area is located along the southern Red Sea coast of the Arabian Peninsula extending from Saudi Arabia– Yemen border (Latitude $16^{\circ} 41' 16''$ and Longitude $42^{\circ} 46' 27.18''$) in the north to the southern most point of the Red Sea coast at Bab al Mandab strait between Yemen and Djibouti. Historical Landsat Enhanced Thematic Mapper (ETM) data of the years 1999 and 2001 were used for eleven sites 38 to 48 (Table-1&2). Research methodology and details about image processing techniques used in this paper is given in Kumar *et al.* (2010). Howari *et al.* (2009) used remote sensing data along with field observation to mangrove forest cover in the United Arab Emirates (UAE).

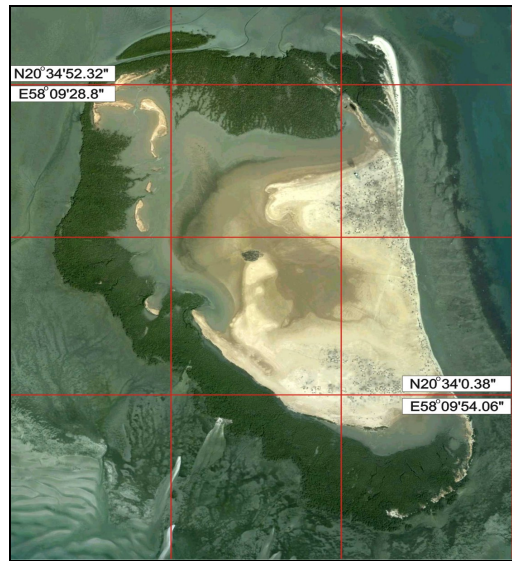


Fig. 5: Mahout Island (area 1.1 km²) in the Gulf of Masirah, southern coast of Oman showing mangrove cover north, south and west side of the island (Google Image).

Table- 1: Satellite image data used in this study.

Location	Sensor	Image Acquisition Date
site-38	ETM	09-09-2000
site-39	ETM	09-09-2000
site-40	ETM	09-09-2000
site-41	ETM	09-09-2000
site-42	ETM	09-09-2000
site-43	ETM	23-12-2000
site-44	ETM	23-12-2000
Site45	ETM	13-05-2000
site-46	ETM	13-05-2000
site-47	ETM	13-05-2000
site-48	ETM	13-05-2000

Results and discussion

This paper concludes our three part study on the extent and environment of mangrove cover along the Red Sea coast of the Arabian Peninsula. The earlier two papers covered the Saudi Arabian Red Sea coast. This paper covers the Red Sea coast of Yemen including offshore islands in the Red Sea, Socotra Archipelago in the Arabian Sea and the southern coast of the Arabian Peninsula including Yemen and Oman.

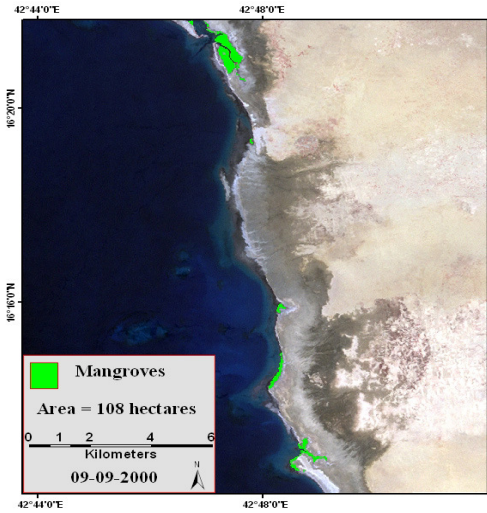


Fig. 6: Satellite image of mangroves shown in green color at site 38.

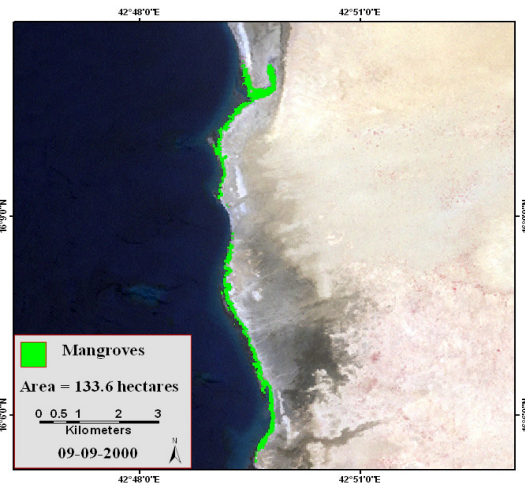


Fig. 7: Satellite image of mangroves shown in green color at site 39.

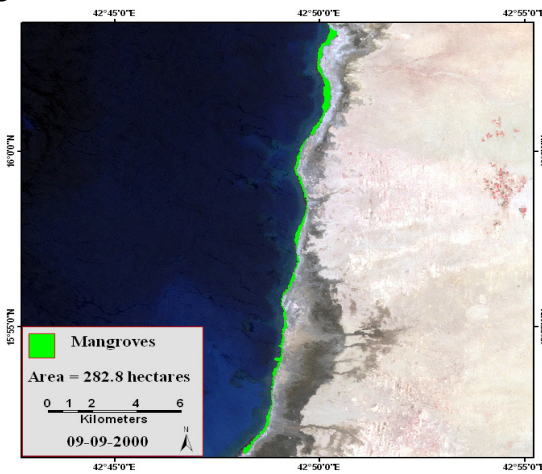


Fig. 8: Satellite image of mangroves shown in green color at site 40.

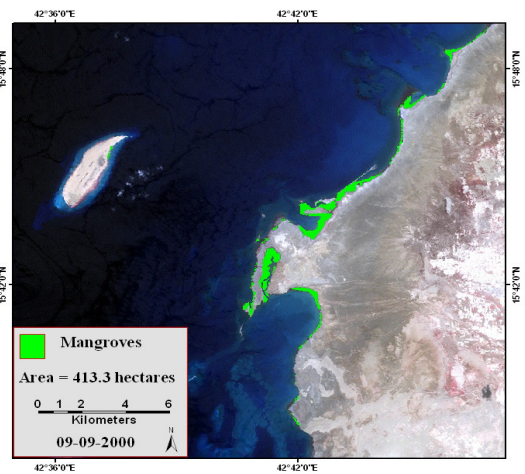


Fig. 9: Satellite image of mangroves shown in green color at site 41.

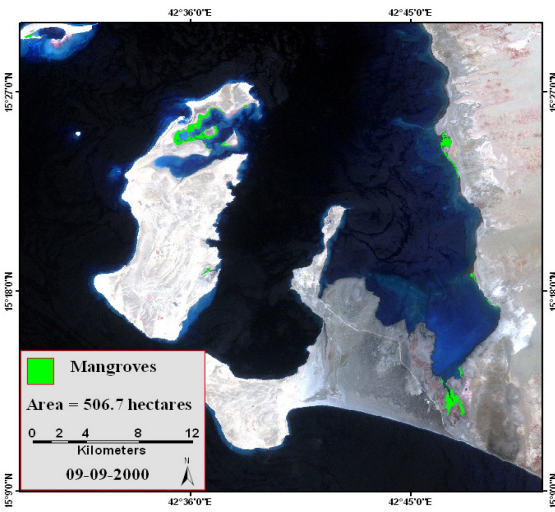


Fig. 10: Satellite image of mangroves shown in green color at site 42.

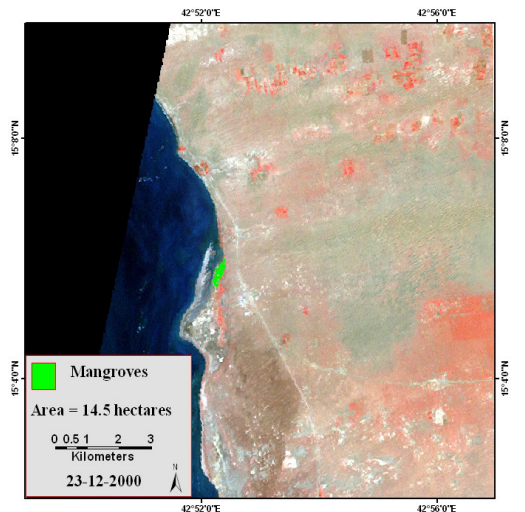


Fig. 11: Satellite image of mangroves shown in green color at site 43.

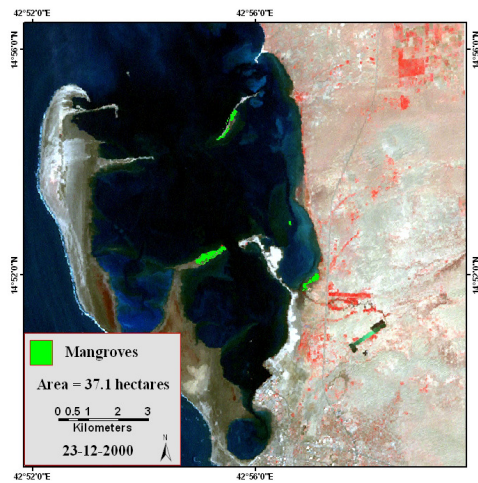


Fig. 12: Satellite image of mangroves shown in green color at site 44.

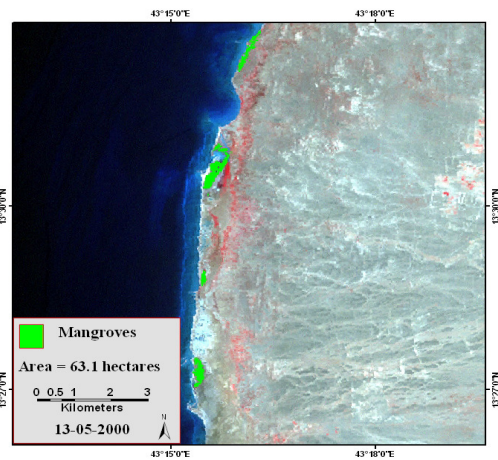


Fig. 13: Satellite image of mangroves shown in green color at site 45.

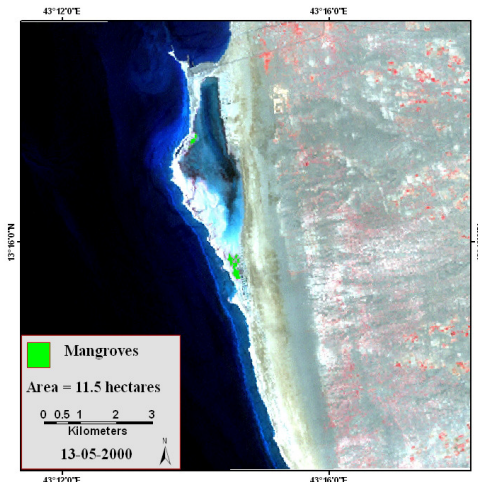


Fig. 14: Satellite image of mangroves shown in green color at site 46.

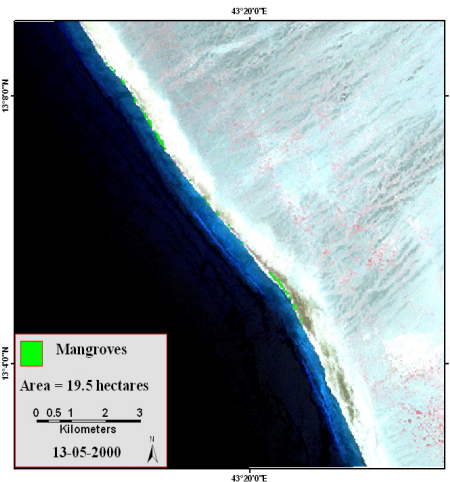


Fig. 15: Satellite image of mangroves shown in green color at site 47.

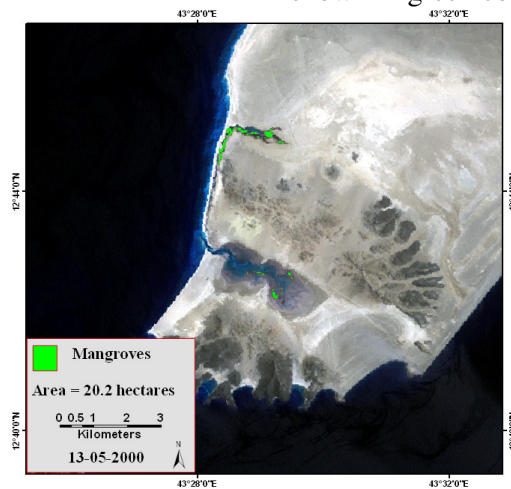


Fig. 16: Satellite image of mangroves shown in green color at site 48.

Table-2: Area of mangrove forests (hectares) at eleven locations along with their latitude and environmental setting.

Site	Latitude Deg. Min. Sec. (range)	Mangrove area in hectares	Environment
38	16 21 47 to 16 12 04	108	Lagoons, Bay, Intertidal environments
39	16 12 00 to 16 04 43	133.6	Bay, Intertidal environments
40	16 03 59 to 15 50 58	282.8	Intertidal environments
41	15 49 44 to 15 36 43	413.3	Lagoons, Bay, Intertidal environments, offshore island
42	15 30 36 to 15 08 26	506.7	Lagoons, Bay, Intertidal environments, offshore island
43	15 09 58 to 15 01 58	14.5	Bay
44	14 56 32 to 14 48 32	37.1	Bay, Intertidal environments, offshore island
45	13 33 01 to 13 26 05	63.1	Lagoons and Bay
46	13 19 16 to 13 12 38	11.5	Brackish water coastal lake
47	13 09 06 to 13 02 28	19.5	Intertidal environments
48	12 46 52 to 12 39 13	20.2	Estuaries and Intertidal environments

Figs. 6 through 16 are satellite images of mangrove cover along the Yemen Red Sea coast and their environments at sites 38 through 48 respectively. Mangrove distribution along this coast is more like the southern Red Sea coast of Saudi Arabia (Khan *et al.*, 2010). Here too their cover remains patchy and they occur along the coastal regions of lagoons, bays, intertidal environments, offshore islands, brackish water coastal lakes and estuaries (Table-2). The mangroves of the Yemeni coast are denser and cover larger areas than the mangroves of the northern coast of the Arabian Peninsula because of the reasons given by Saifullah (1994) and listed by Khan *et al.* (2010). Almost all the mangrove forests along the Red Sea coast of the Arabian Peninsula are under threat due mainly to a variety of human activities that involve cutting and overgrazing by domesticated animals. Mandura and Kafajii (1993) reported on the human impact on mangroves in the Farasan Islands off the southern Saudi Arabian coast. However, mangroves of the Yemeni coast are less impacted because anthropogenic activities along this coast are minimal.

During past few decades there is a general decline in the mangrove cover all over the Arabian Peninsula but this decline has been accelerated during the past few years due mainly to land filling and costal infrastructure and urban development (Kumar, 2009; Kumar *et al.*, 2010). There is a growing realization in this region about significance of mangroves as

nurseries and sheltering areas of fishes, birds, shellfish, crabs and many other types of fauna, natural buffers against coastal and tidal erosion and storms. In the past mangroves were also source of timber, camel fodder and fuel in this region. Saenger (1993) discusses management issues of mangroves in Saudi Arabia. Now efforts are also going on to plant new areas for mangrove cover and rehabilitate the existing ones especially in Egypt, UAE, Saudi Arabia and Oman (UNEP Report, 1985; Spurgeon, 2002; Macintosh and Ashton, 2003; PERSGA, 2004). Both the Arabian Gulf and the Red Sea have very heavy traffic of maritime trade, thus, large numbers of ships including the gigantic ships carrying oil pass through these water ways every day. There have been accidental leaks of oil from these ships causing immense damage to mangroves by asphyxiating the breathing pores and causing death due to toxicity of the sediments (IPIECA, 1993; Hoff *et al.*, 2002). Climate change and its impact on biosphere, atmosphere and environment is probably the most discussed issue of our times. McLeod and Salm (2006) discussed ways to protect and manage mangroves under these environmental stresses because they will be of great help in stabilizing coast against storms and tsunamis.

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