Mangrove Deterioration in Tarut Bay on the Eastern Province of the Kingdom of Saudi Arabia

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ABSTRACT
All over the world, coastal environments heavily suffered due to environmental constraints and human activities, particularly on mangrove trees. The deterioration and loss of mangrove communities, which are the evergreen trees that grow in tropical and semi-tropical regions and between regions of tides, represent a major problem for the coastal ecosystem, where mangrove communities have deteriorated and their numbers decreased due to the pollutions caused by factories, littering, and land reclamation; such influence seemed obvious after the Gulf War and it will remain so for a long period of time. Tarut Bay is exposed to many environmental and human pressures such as urban encroachment, pollutants, and land reclamation and if such activities continue, it will cause the elimination of mangrove forests in the region. The current study evaluates mangrove forests deterioration, which mostly centralize in the Eastern Province of the Kingdom of Saudi Arabia in Taut Bay. During the study, we used LANDSAT and SPOT images of different dates to monitor the gradual changes taken place in the mangrove vegetation. The satellite images were taken over a period of 39 years from 1972 to 2011 and they clearly demonstrated that a significantly higher loss in mangrove forests occurred during this time and the decline in mangrove cover estimated during this period in the study area was 55.93%. Keeping in view the importance of mangrove communities in the coastal ecosystem, this study highly recommends stopping the excessive mangroves loss due to multiple factors and establishment of National Center for protecting the remaining mangrove communities from extinction.

Keywords: *Avicennia marina*, Satellite images, Mangrove deterioration, NDVI, Tarut Bay

1. Introduction

Mangrove forests forms one of the major wetland types which have been identified as one of the key life support systems on earth [1] they found along sheltered coastlines in the tropics and sub-tropics [2], the mangrove forests of the Arabian Gulf coast are remarkably tolerant to extreme environmental conditions and are highly productive. Mangroves are very important breeding, feeding and nursery grounds for several types of birds and aquatic animals such as fish, shellfish, prawns, and crabs etc. also it protect coastal regions from erosion due to constant impact of tides, currents and storms [3]. There are several different types of natural hazards include earthquakes, tsunamis and/or tidal waves, erosion from currents in the Arabian Gulf In addition to these hazards, serious problems of groundwater depletion, coastal erosion and loss of biodiversity and mangrove forests have already created serious environmental problems for the region [4]. also The shrimp farming is danger to mangroves cause its

productivity is limited to five to six years due to rapid deterioration to water quality and consequent spread of diseases caused by discharges of water from the farm itself forced the investor to move to another area [5], the Gulf War of 1991 brought serious environmental damage to the region. The world's largest oil spill, estimated at as much as 8 million barrels [6]. Most of the polluted shores of the Eastern Province of Saudi Arabia in addition to the coasts to the borders of Kuwait saturated with crude oil during the Gulf War and has been described the impact of oil spills in the Gulf War in many research [7**,** 8**,** 9**,** 10]**.**

In this paper mangrove communities on Tarut Bay in the Eastern Province of Saudi Arabia were studied. Tarut Bay is characterized by its heavy production and was reported [11] as the most important site on the Saudi Arabian Gulf Coast for wintering and migrating waders and other water birds, with a total of 58,000 water birds.

The ecosystem of Tarut Bay is exposed to many environmental pressures and if the pollution and Urban utilization continues will lead to erosion of the Bay and near in the future will be burden on the environment and not the source of the wealth of fish and the most important site for the passage of winter birds in the Saudi sector on the coast of Arabian Gulf.

Many studies described the formula of Normalized Differences Vegetation Index (NDVI): [12, 13**,** 14] as a formula to determine the biomass and productivity of vegetation.

The development of urban infrastructure, along the east coast of Saudi Arabia during the past 30 years, has caused major disturbance to the coastal environment, Landsat images of 1973, 1987 and 1997 were used to detect of Tarut bay, The analysis of satellite images revealed that the areas of lost mangrove stands from 1973-1987 and 1987-1997 were 196.91 hectares and 63.05 hectares respectively. The total loss of mangrove stands during the past 24 years has been 259.96 hectares [15]**.**

The aim of the study is evaluate Mangrove forests deterioration and the amount of lost over the years to preserve the remaining from elimination.

2. Materials and Methods

The current study evaluates the deterioration of mangrove communities on Tarut Bay in the Eastern Province of Saudi Arabia, where mangrove communities were mostly concentrated. This Bay extends from the northern coast of the city of Dammam and ends at Ras Tanura comprising an area of 41 thousand hectares (Figure 1), the equivalent of 410 square kilometer [16]**.**

After many field trips in Tarut Bay in order to identify the area and to identify the whereabouts of mangrove accurately based on the map of the General Directorate of Military Survey (2001) Number (NG39-6), Figure (2) and using the latest mobile GPS, (Garmin nuvi 205W) GPS points of the study locations were located Table (1).

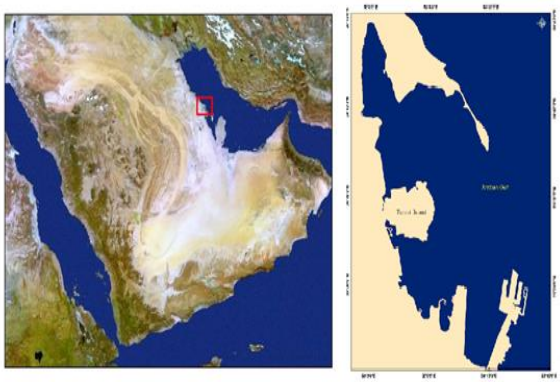

Figure 1–Left. Satellite image showing the Tarut Bay under the study (Picture from King Abdul-Aziz City for Science and Technology).
Figure 1–Right. Detailed map to the location of the study (Picture from King Abdul-Aziz City for Science and Technology Modified by the Researcher).

Figure 2 – Map of the General Directorate of Military Survey (Modified by the Researcher).

Table 1: GPS points of the study sites

Sites	GPS
Site1: Dammam Port	N 26°25.400' E050°09.196'
Site2: Dammam	N 26°27.957' E050°04.376'
Site3: Syhat Road	N 26°29.932' E050°02.467'
Site4: Syhat	N 26°30.335' E050°02.519'
Site5: Darin	N 26°33.025' E050°04.685'
Site6: Rabiayah	N 26°33.025' E050°04.685'
Site7: Snabis	N 26°34.088' E050°05.307'
Site8: Zor Forest	N 26°35.855' E050°03.832'
Site9: Sfwa	N 26°37.705' E050°00.387'
Site10: Ras Tanurah	N 26°44.767' E049°59.615'

The ten located sites where Mangrove trees live as a community are (Dammam Port, Dammam, Syhat Road, Syhat, Darin, Rabiayah, Snabis, Zor Forest, Sfwa, RasTanurah). All of them contain the same type of mangrove species (Shoura, *Avicennia marina*).

2.1 Satellite Analysis Methodology

In the present study used LANDSAT MSS (60m), LANDSAT TM (30m) and SPOT-5 (2.5m) images ranging from the year 1972 to 2011(Table 2), The data been analysis by ERDAS IMAGINE V9.3, The Method used in the present study from: King Abdul Aziz City for Science and Technology (KACST) and [17]**,** The following steps were followed in the present study.

1. Image to image rectification of all the scenes so that they match spatially with each other.
2. Image mosaic and the subset of the study area: The study area falls across two LANDSAT image frames. The images were mosaicked and the subset for the study area is generated.
3. As the mangrove vegetation was the interest of the study, vectors were drawn to delineate the coast line.
4. NDVI was generated for each of the images and the area was then calculated based on the image resolution.
5. Generation of NDVI and identifying the vegetation cover areas.

Normalized Differential Vegetation Index (NDVI) is a numerical tool to identify live green vegetation on the land surface using satellite images. NDVI uses the formula.
(NIR-RED)/(NIR+RED).
Where NIR= Reflective infrared band
Red= Red band

NDVI tool was initially developed for LANDSAT MSS and was later used for different sensors. The NDVI value ranges

from -1 to +1. Positive values indicate vegetation, as the formula indicates it uses the reflectance values of plants in the Near Infra-Red and Red wavelengths. Vegetation green biomass has high reflectance in NIR band and hence appears bright.

6. Generation of the vegetation thematic image

Table 2: Provides the list of LANDSAT (MSS and TM), SPOT images used for the current study

Image	Date	Resolution
LANDSAT MSS	24-08-1972	60 m
LANDSAT TM	05-02-1985	30m
LANDSAT TM	04-03-1991	30m
LANDSAT TM	18-06-1998	30m
SPOT5	18-05-2006	2.5m
SPOT4	20-04-2011	10m

3. Results

LANDSAT and SPOT satellite images have been analyzed to assess the deterioration of the vegetation of Mangrove communities in the selected areas. Satellite images taken in 1972 (Figure 3) have revealed that the area of mangrove trees which estimated to be 12.3 km^2 deteriorated to 8.79 km^2 in 1985(Figure 4), a percent of 71.46 % due to urban utilization, while in 1991 (Figure 5) the estimation of mangrove reached 4.2 km^2 of an exactly 34.15 % as a result of the environmental impact of the Gulf War. However, in 1998 (Figure 6) mangrove rehabilitation increased into 9.2 km^2 of 74.80 %, just to decrease in 2006 (Figure7) by 0.2 km^2 to be generally estimated as 9 km^2 by 73.17 % as a consequence of the reclamation in Ras Tanura, a complete forest in Qatif and the last forest in the coast of Anak. In 2011 (Figure 8), a decrease occurred in the amount of mangrove to become 5.42 km^2 and 44.07 %, due to the failure of mangrove rehabilitation with the exception of Ras Tanura. To conclude, satellite images which were taken over 39 years in the period from 1972 to 2011 reveal a significant deterioration of 55.93 % in the study area.

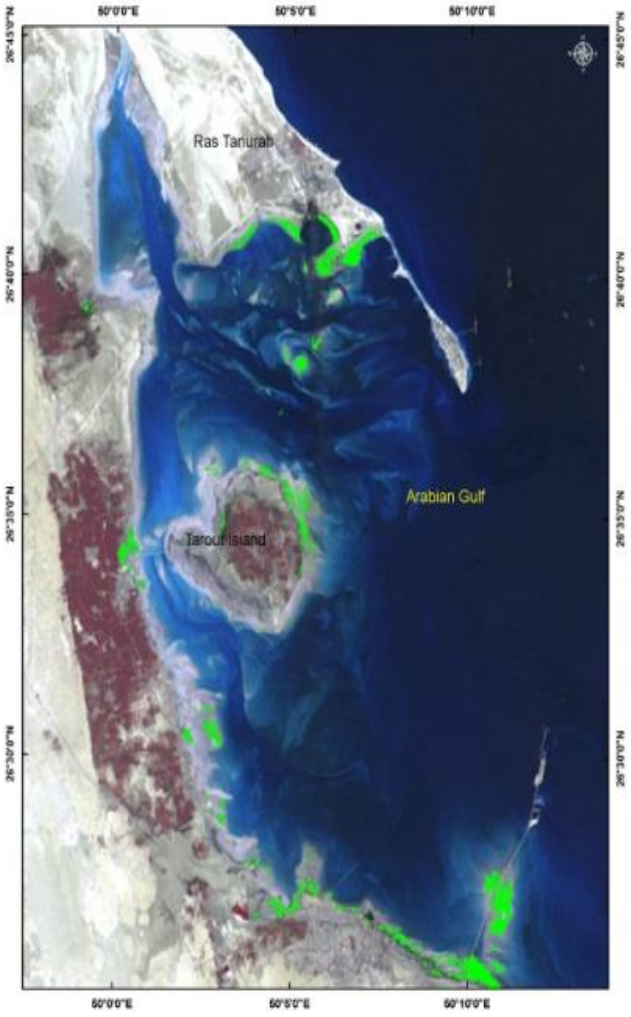

Figure 3: Mangrove vegetation in the year 1972, (Picture from King Abdul-Aziz City for Science and Technology, NDVI was generated by the Researcher).

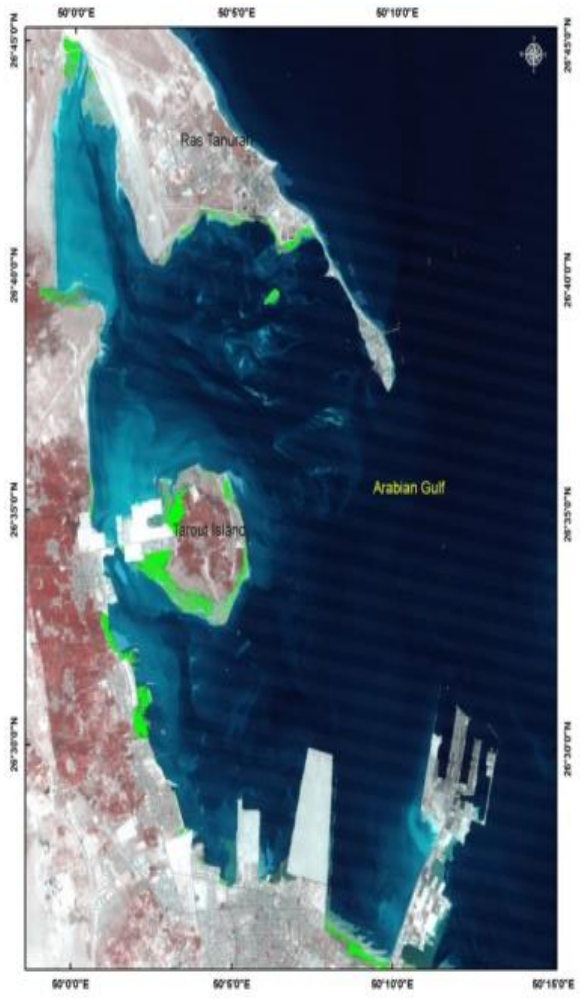

Figure 4: Mangrove vegetation in the year 1985, (Picture from King Abdul-Aziz City for Science and Technology, NDVI was generated by the Researcher).

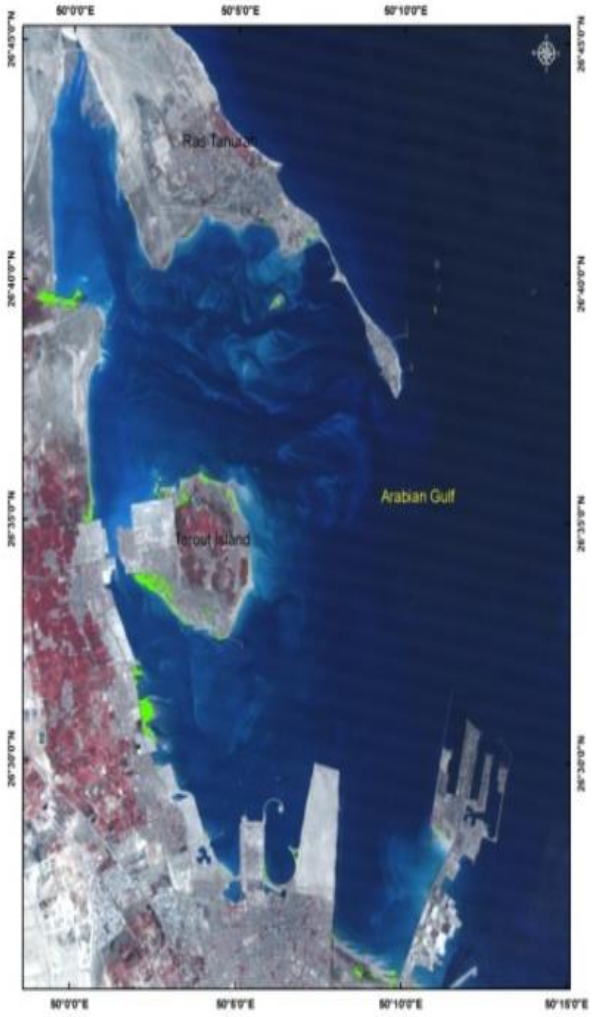

Figure 5: Mangrove vegetation in the year 1991, (Picture from King Abdul-Aziz City for Science and Technology, NDVI was generated by the Researcher).

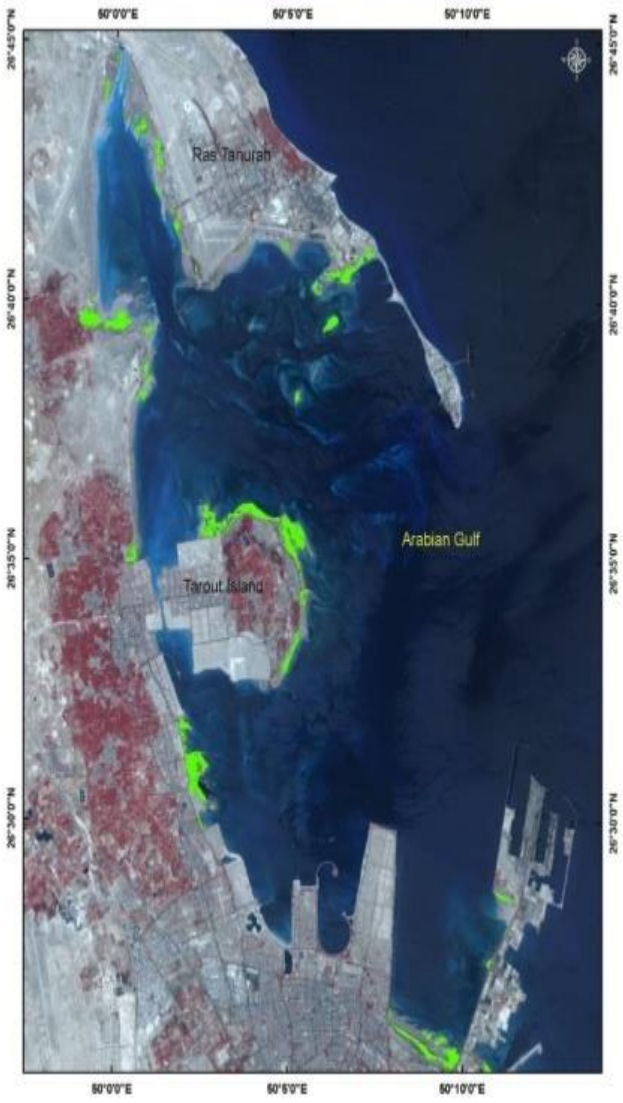

Figure 6: Mangrove vegetation in the year 1998, (Picture from King Abdul-Aziz City for Science and Technology, NDVI was generated by the Researcher).

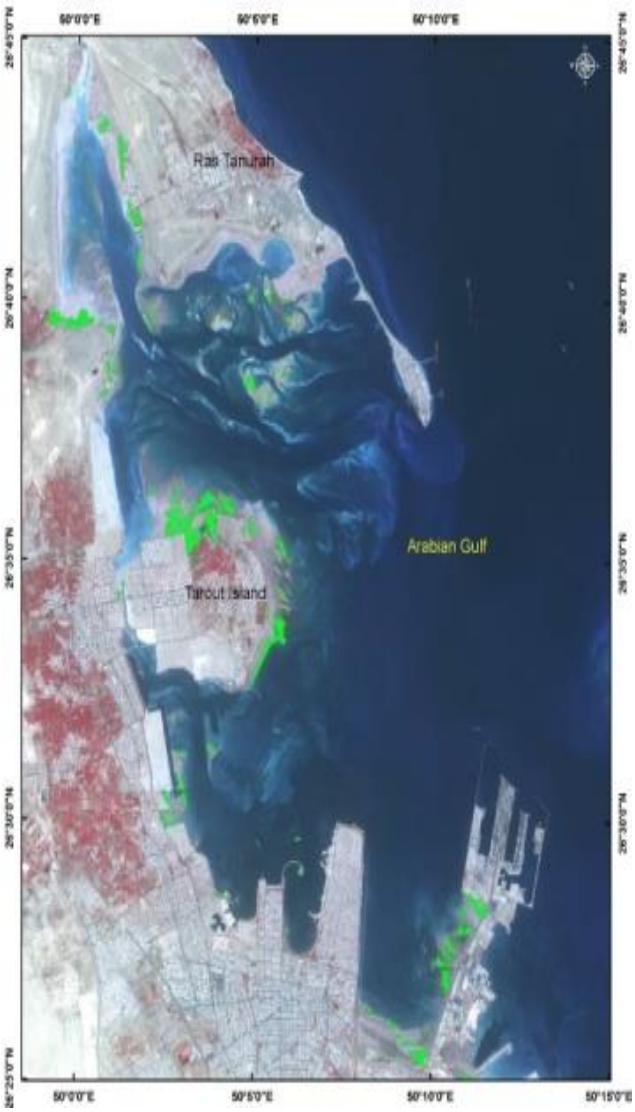

Figure 7: Mangrove vegetation in the year 2006, (Picture from King Abdul-Aziz City for Science and Technology, NDVI was generated by the Researcher).

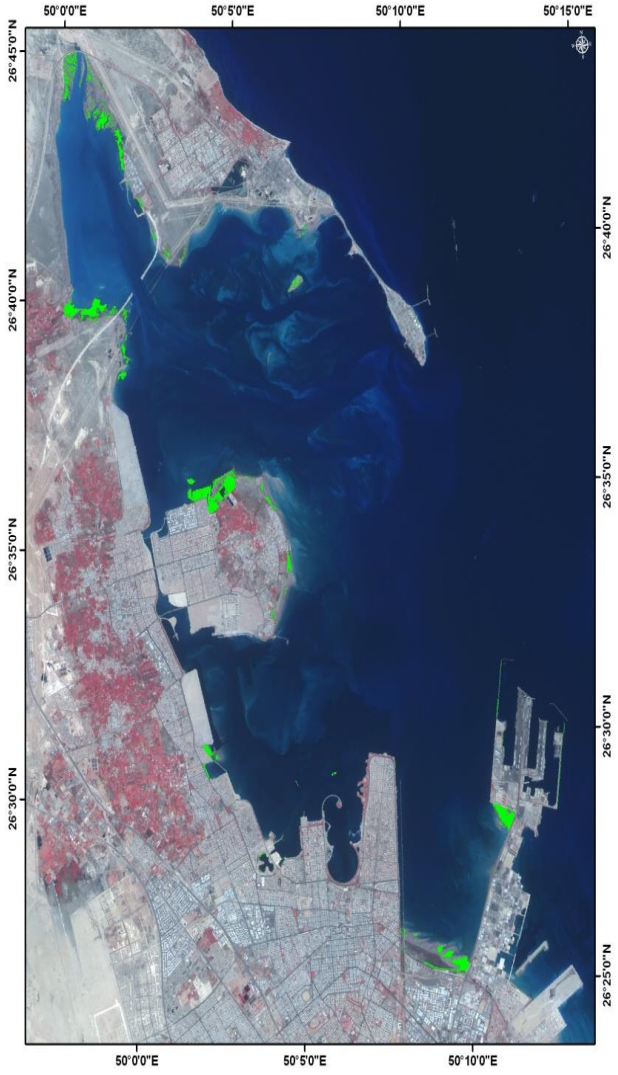

Figure 8: Mangrove vegetation in the year 2011, (Picture from King Abdul-Aziz City for Science and Technology, NDVI was generated by the Researcher).

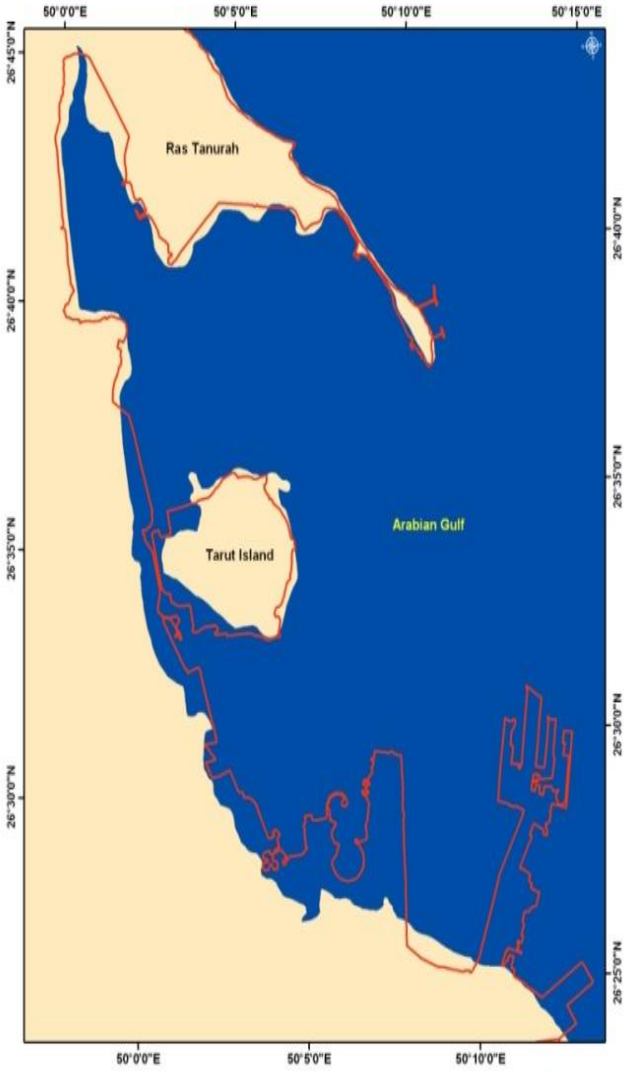

Figure 9: Mangrove vegetation in different years. Line shown in red color is the coast line digitized from the image of the year 1972. It is overlaid on the coast line of the year 2011.

Table 3: Data for mangroves vegetation area (from 1972-2011)

Year	Vegetation area (Sq. Kms)	Vegetation area (Hectares)	Percentage
1972	12.3	1230	100%
1985	8.79	879	71.46%
1991	4.2	420	34.15%
1998	9.2	920	74.80%
2006	9	900	73.17%
2011	5.42	542	44.07%

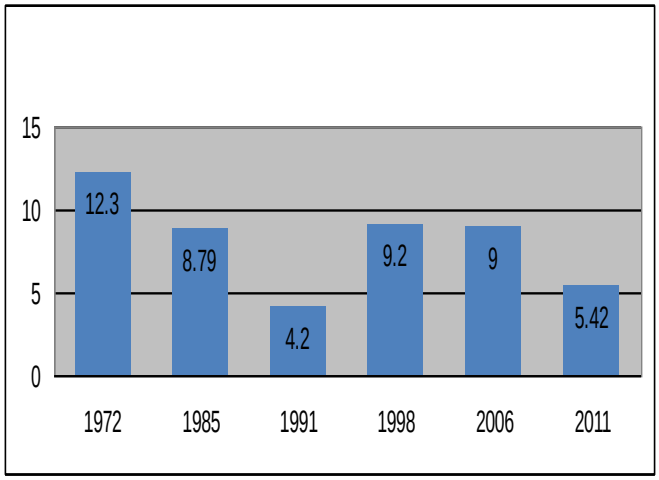

Figure (10): Figure showing mangroves vegetation cover from 1972-2011.

5. Discussions

In the current study satellite images of LANDSAT and SPOT been used to assess the deterioration in the vegetation communities. Satellite images taken in 1972 revealed that the area of mangroves estimated to be 12.3 km^2. It deteriorated to 8.79 km^2 in 1985 by 71.46% due to urban utilization especially that we can notice from the picture that King Abdul Aziz Port does not exists, and also because what [18], found and that in period 1975 burial areas adjacent to housing, especially the region which lies between the island of Tarut and Qatif city leaded to that the island has lost its character as an island because of its contacts in the city.

The mangrove cover estimated in 1991 was 4.2 km^2, while the remaining percentage of vegetation cover was 34.15%, due to the impact of the Gulf War. Some of the oil contaminated mangrove plants on the Gulf coast following the 1991 Gulf War oil spill developed a high number of branched pneumatophores and adventitious roots, if the aerial roots were not totally covered with bitumen. This phenomenon is related to the degree of oiling [19]. Also most of the polluted shores of the Eastern Province of Saudi Arabia in addition to the borders of Kuwait saturated with crude oil during the Gulf War and many researches described the impact of oil spills during the Gulf War [20, 21, 22, 23].

During 1998, the mangroves rehabilitation process began and the Mangrove cover increased as much as 9.2 km^2, to become an area of vegetation cover 74.80%, followed by the period 2006 the area of mangrove in the reign deteriorated by 0.2 km^2 to be estimated with 9 km^2 by 73.17%, due to the disposal of for the Ras Tanura and complete forest in Qatif and the last forest in the coast of Anak city, Also observed in the period 2011, significant decreased in the amount of mangrove where estimated by 5.42 km^2 and become a percentage of 44.07%, and that's due to the lack of success in rehabilitation of the area in the cultivation of mangroves except the city of Ras Tanura.

To conclude from the satellite images taken over 39 years in the period from 1972 to the year 2011 there has been a marked decline in the study area estimated by 55.93%.

Conclusion

Mangroves play a pivotal role in maintaining the ecosystem and provide shelter to marine and land animals. Its role in minimizing soil erosion and its possible role in phytoremediation is also invaluable.

Our study give an insight on the status of Mangroves in the project area and recommends establishment of a National Center for protecting the remaining mangrove communities from extinction, raising awareness among citizens about the importance of mangrove communities, and encouraging further scientific studies.

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