Geomatic study of Shatt Al-Arab delta , southern Iraq

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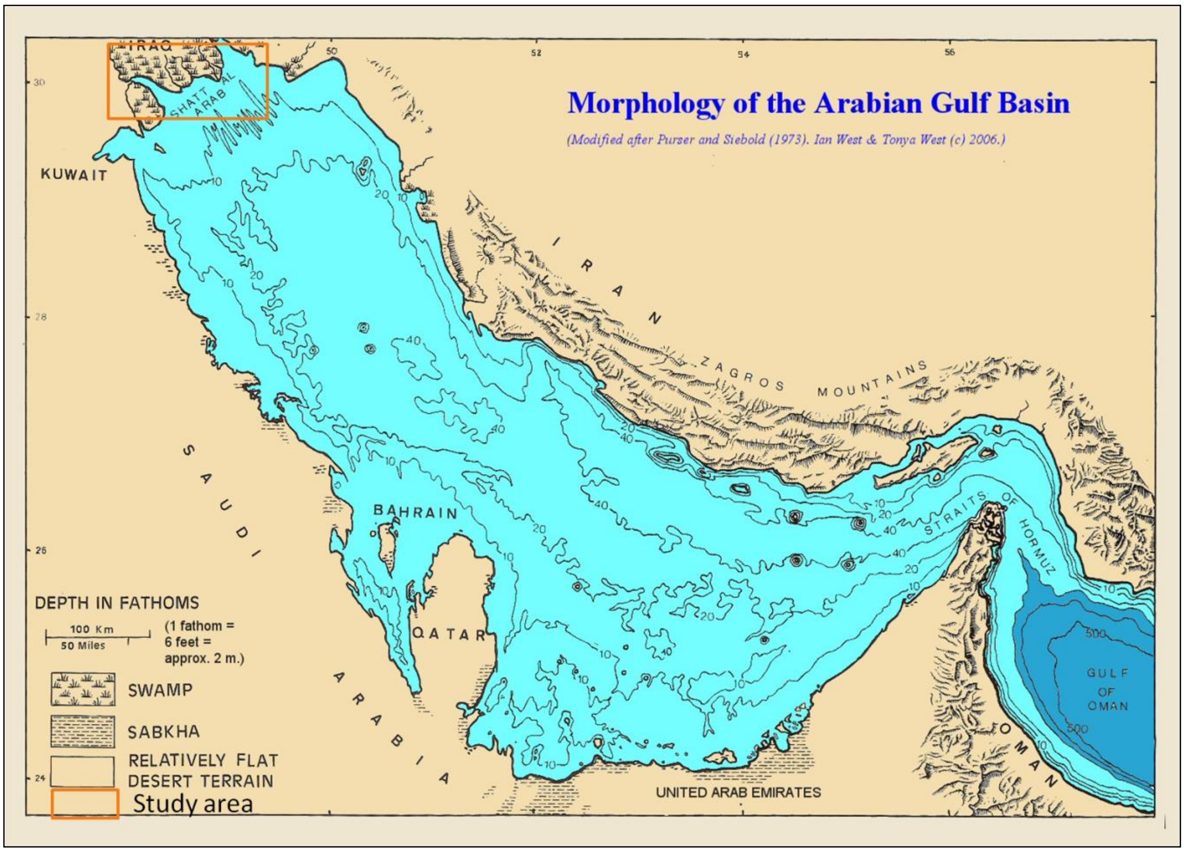
Abstract

The present research aims to monitoring the environmental changes in shatt Al-Arab delta area southern Iraq . Remote sensing and Geographic information system (GIS) were used to achieve the objectives of this study . Satellite images of Landsat were used to study the coastal landforms for the years of 1972 , 1985 , 2006 and 2014 . Change detection is the main approach in this study were the differences in area are calculated . The result showed the shores of the delta is gradually Changed, perhaps because of the decline in river discharges of Tigris and Euphrates , and thus a decline in volumes of suspended deposits that contribute for construction the beaches and deltaic marine barriers . the study showed a progress in areas of marine sabkhas and supratidal flats. as shown in satellite Images there is widening in cross section of the Shatt al-Arab channel with gradual drift towards the Iraqi beaches.

Keywords : Geomatic , Delta geomorphology , Change detection , Shatt Al-Arab

1. Introduction

The term "Delta" refers to one of the most complicated sedimentary environments due to geological and physical variables that belong to its creation(Ana et.al,2009) .As it is known , the delta characterized of high sedimentation rates which make the form of delta is changed continuously . It is result from natural balance of the processes that interact with each other near river mouth . The Shatt Al-Arab delta is considered as a part of Arabian gulf within Iraqi border and it has coordinates of (48° 21′ 0″) to (48° 45′ 0″) longitude and (29 °45 0′ 0″) to (30°0′ 0″) latitude ,fig.(1)



Fig(1), bathymetric map of Arabian Gulf

The most controlling factors of the delta of Shatt Al-Arab are tidal currents ,waves and winds , in addition to the physiography of the area . Delta is also affected by fluvial upstream suspended and bed loads . this type of delta is characterized by the longitudinal sediment bars , which are deposited in the channel near the river estuary . The only tributary of Shatt al-Arab river is Karun river , and most of the former sediments are supplied from the local sites (Albadran,2005)

Geologic setting

The Shatt Al Arab river flows in the Tertiary and Mesozoic northwest-southeast trending Zagros fold belt. The river is formed by the confluence of the Tigris and Euphrates Rivers, which flow through central and eastern Iraq. A third river, the Karun River, which flows in west-central Iran and drains the Zagros mountains joins the Shatt el Arab waterway just north of the modern delta, With a total length of 192 km, the Shatt al Arab widens over its course, expanding from a width of 250-300 m near the Euphrates-Tigris confluence to almost 700 m near the city of Basrah and more than 800 m as it approaches the river mouth. An area of 45,190 km² drains directly to the Shatt al Arab region downstream of the Euphrates-Tigris confluence (excluding the Euphrates and Tigris

Basin areas). Several tributaries join the Shatt al Arab during its course, most importantly the Karun Rivers. The Shatt al Arab Delta area is classified as estuarine-deltaic because the river's sediment seeps into a shallow, narrow part of the Arabian Gulf, (Bundesanstalt ,2013) . The Tigris and Euphrates Basin , the Arabian Gulf, occupies a zone of subsidence depression surrounding by mountains and desert,fig (2),This elongate depression was formed during an era of mountain building initiated early in the Tertiary that continues with the movement of the Arabian plate against the stable landmass of Asia. The drainage basin of these three rivers covers an area of 793,600 sq km. The average annual river discharge is 1,966 cu m/sec with a maximum of 3,299 cu m/sec and a minimum of 849 cu m/sec The main channel is some 2,658 km long and debouches into the Arabian Gulf, (Oscar K. Huh, James M. Coleman, 2004) . Different estimates have been provided by several authors for the yearly averaged transport of this group of rivers: from 160 m^3/s to 3150 m^3/s . a value of 1400 m^3/s is usually retained for this average transport. Furthermore, the transport is quite variable with seasons (from 700 m^3/s in October to 5700 m^3/s in April) . Along the Iranian coast, rivers Hendijan, Hilleh and Mand would carry 2034 m^3/s . this should be confirmed and their variability should be determined, so that further studies could take them into account. For the moment (Pous et.al ,2013). The annual water discharge of the Tigris and the Euphrates Rivers has been significantly reduced for the last 50 years. Figure (3) shows the annual water discharge of the Two Rivers into the Mesopotamian marshlands from 1940 to 2007. The regression line shows the graduate reduction of the Two Rivers' water discharge during the recorded period. Generally, the figure indicates two periods of water discharge reduction. The first period was during the 1970's, in which many dams were constructed at the Tow Rivers' upstream in Turkey . The second period was late 1990's, when the Iraqi government started drains the marshlands. During the pre-dam, the annual water discharge of the Two Rivers into the Mesopotamian marshlands from 1940 to 1970 was about 84.6 × 109 m3. After this period until 1990's, the Mesopotamian marshlands lost more than 30% of their annual water discharge. The situation of water shortage become more complicated overtimes, unfortunately, the current annual water discharges of the two Rivers are still decreasing, and its average value from early inundation in 2003 to 2007 was about 13.8 × 109 m3. This indicate that the Mesopotamian marshland have lost more than 80% from their historical water input. This situation is dramatically affecting the current hydrological conditions of the re-flooded marshes. This also indicates that the existing quantity of water in the Two Rivers is not enough to re-cover the historical Mesopotamian's size. On the other hand (AlMaarofi *et.al* ,2012)(Purser,1973)(fig , 3).

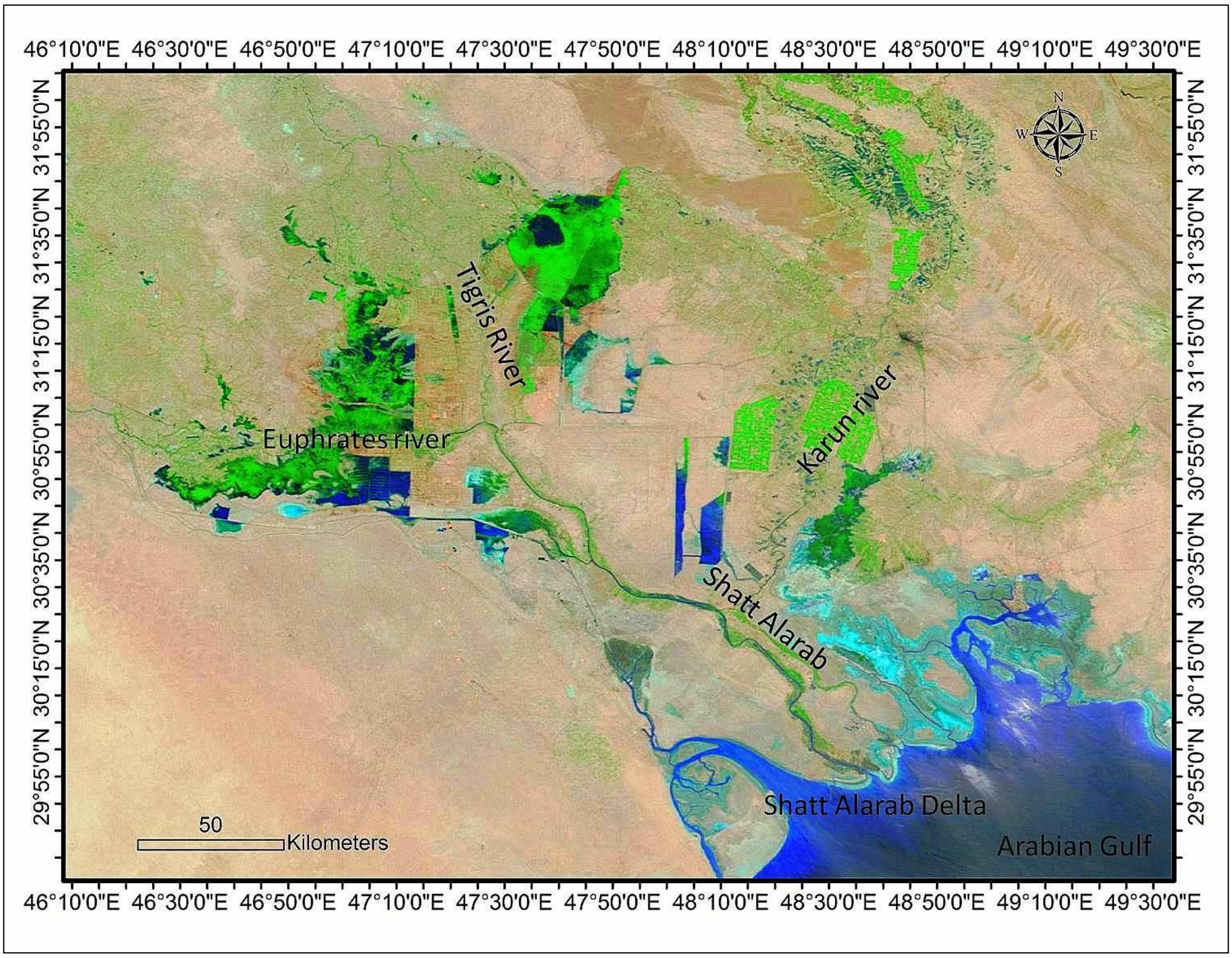


fig 2, multispectral satellite image of study area & surrounds

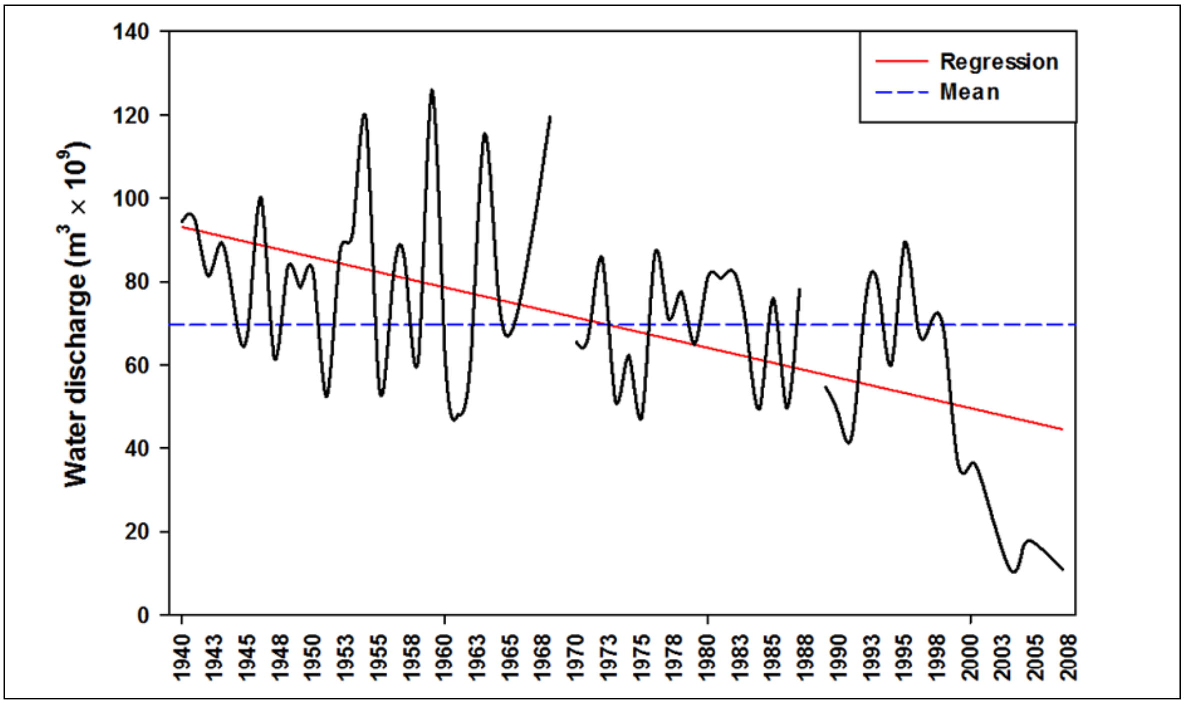


Fig 3. Annual water discharge of the Tigris and the Euphrates Rivers (AlMaarofi , Douabul , and Al-Saad , 2012)

Climate

The climate in the Shatt al Arab region is hot and arid. Based on data from the city of Basrah, average temperatures in the Shatt al Arab region vary from 9°C to 41°C; temperature lows occur in January, highs in July. Annual precipitation rates range from 100 mm in the western part of the delta to about 200 mm in the east. The city of Basrah has a mean annual precipitation of about 100 mm.By contrast, cold winters and mild summers are the norm in the northern, more mountainous areas. Temperatures across the basin vary from a minimum of -25°C in winter to a maximum of 50°C in summer ,(Bundesanstalt,2013). Winds over the Arabian Gulf are dominantly northwesterly with an annual mean of 5 m/s. This dominant wind is called Shamal and it blows regularly in summer, while wind bursts can occur in winter. These bursts are preceded by episodes of southerly winds called Kaus. The precipitation rate is very weak in the Gulf: it amounts to 7 cm/year for the whole Persian Gulf, which is 4 times smaller than the river discharge . Evaporation is very strong but its estimates are quite variable, from 144 to 500 cm/year . a value of 200 cm/year has been used in recent work . The deficit in freshwater for the whole Persian Gulf is therefore on the order of 416 km^3/year which confers characteristics of an evaporation basin to this gulf. , (UNEP,2011).

Tides

In the western part of the Gulf, the surface current is mostly southeastward in the shallow areas near the coasts and northwestward in the deeper area (fig ,4).This forms a double gyre system. In the eastern part of the Gulf, the cyclonic gyre becomes dominant. A southeastward current exists along the Iranian coast despite the presence of this cyclonic structure. This circulation is controlled by the wind, by bottom topography and by the shape of the basin. The current is surface-intensified, with maximal amplitudes larger than 10 cm/s, along the coasts and in shallow areas of the southeastern part of the Gulf (where depths are smaller than 30 m).

Bottom currents are weaker than their surface counterparts and do not exceed a few cm/s. Close to the coasts and in shallow areas, the bottom currents are southeastward or eastward (like the surface currents), and in the central, deeper, part of the Gulf, , (Pous et.al ,2013).

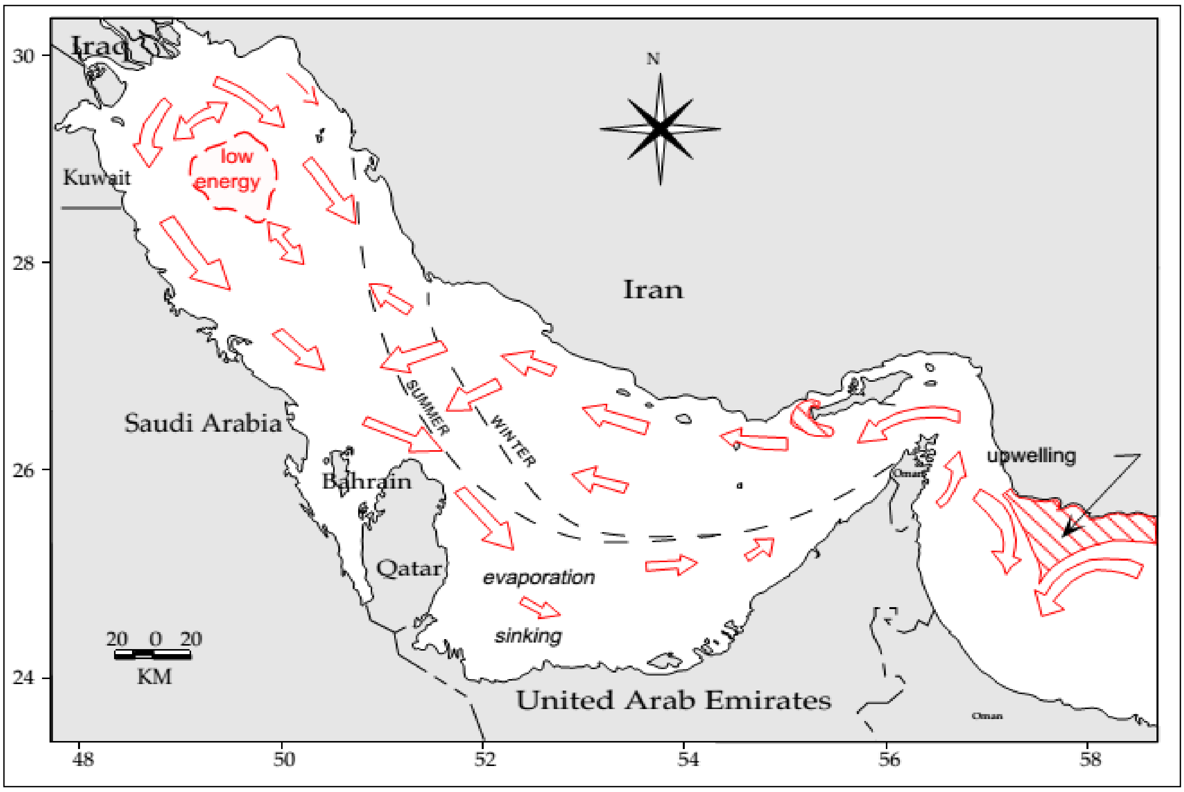


Fig (4) the surface circulation in the Arabian Gulf , (Reynolds,1993)

Delta morphology

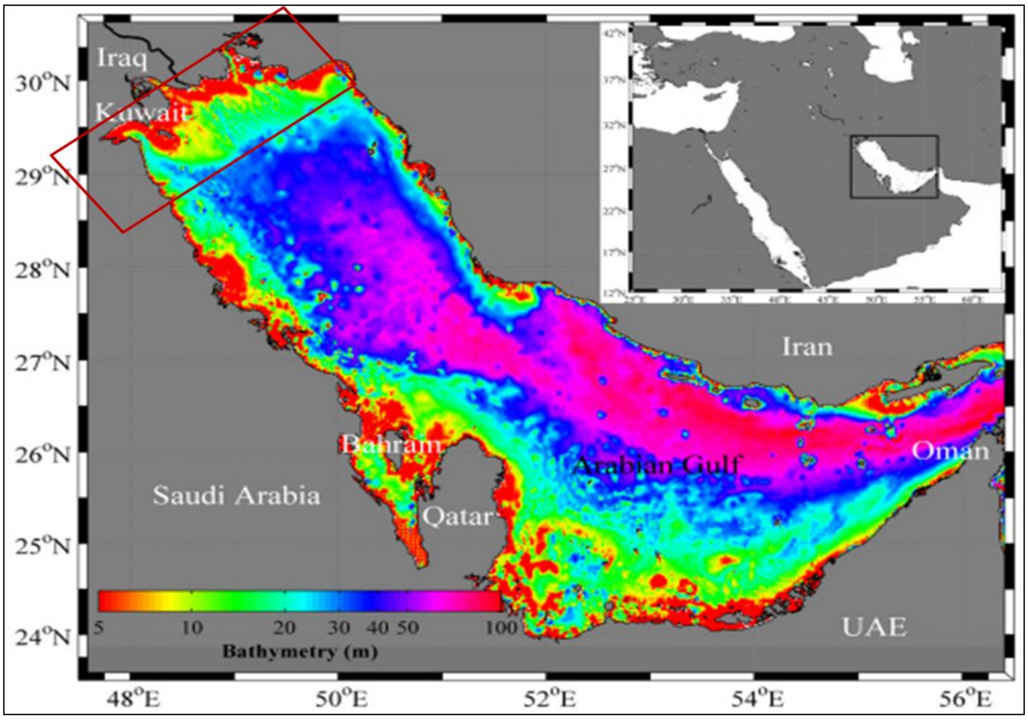
The alluvial valley of each of the three rivers are fairly well defined and the channels display a meandering tendency, with stretches of braiding where tributaries enter the main channels.. controlled mainly by topographic variations outside the delta. The Shatt el Arab delta is located at the northern end of an elongate shallow sea where semidiurnal tidal variations reach about 2.5 m. Although much of the delta is made up of broad marshes and associated lowlands that are valuable as agricultural lands, most coastal regions are tidal flats and sabkhas devoid of extensive vegetation where salts are deposited (fig 5). Dark gray areas that border the bell-shaped river mouths and tidal channels correspond to new fine-grained sediment deposits that periodically experience tidal inundations. They support a growth of salt-tolerant vegetation (mainly blue-green algal mats). Freshwater wetlands just north of the active delta support fresh water vegetation. and this area is actively subsiding, but receives a large percentage of the sediments of the Tigris and Euphrates Rivers forming delta morphology , **(**Goddard earth science data,2009).

Fig (5) multispectral scene 2,5,7 for Shatt Alarab and surrounds

Delta characteristics

The shatt Alarab delta has only two active distributaries, and in its lower course, the natural levees are covered with mangrove vegetation. The inter distributary areas consist predominantly of salt flats. The delta area is some 18,497 sq km in area , (fig 6). much of the modern delta plain is inactive or abandoned. Immediately to the north of the modern delta is a large tidal basin displaying intricate tidal channels and broad unvegetated tidal flats. The delta depths ranging between (1) - (-15)meter.The wave energy along the delta shoreline is extremely low, the low wave energy, only narrow beaches and small dune systems lie along the dominate the prograding delta front. average wave power being 0.014 x 10^7 ergs/sec/m coast and the average leading edge of the delta. Mudflats and sandbars dissected by tidal channels root mean square wave height is 0.99 m ,).the main tidal range 2.5 meter Due to Where seawater is trapped during very high (storm) tides, salt pans develop. White areas in the scene are barren regions of salt deposition along with gypsum/anhydrite. Offshore from the river mouth are broad elongate subaqueous tidal ridges that form in response to tidal , (Oscar et.al 2004).

figs (7,8, 9,10) shows the main deltaic



Fig(6) Shatt Alarab Delta & Arabian gulf bathymetry by (Zhao et.al ,2014)

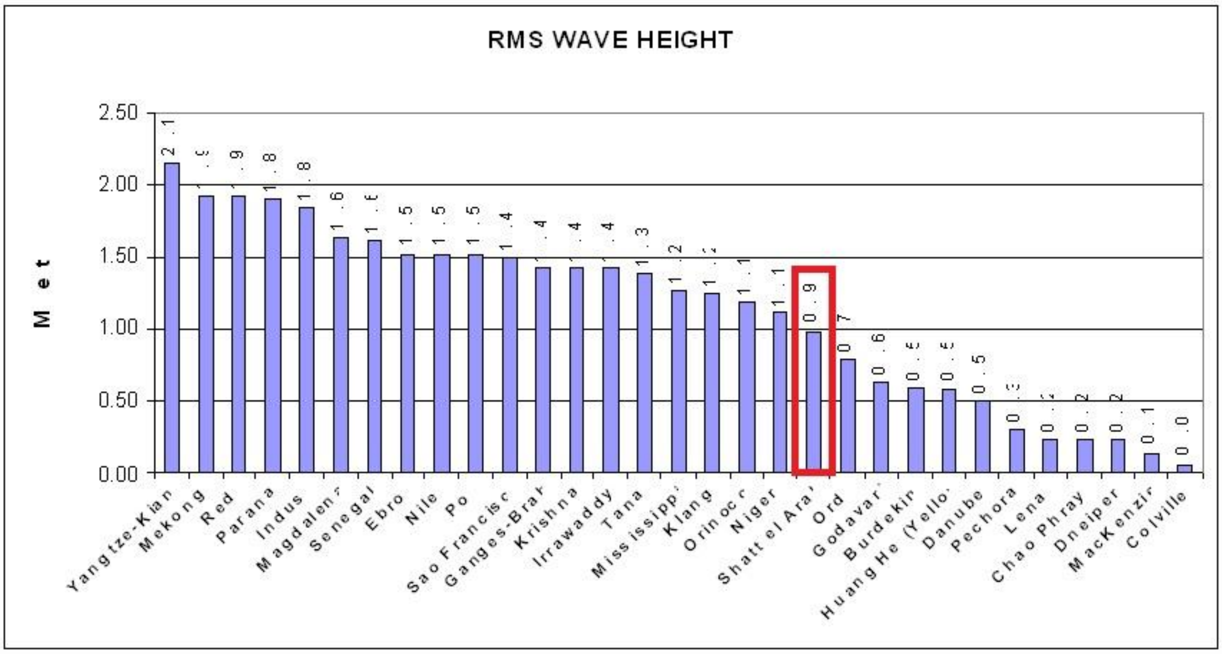


Fig (7) illustrate the main delta wave height properties compare with other deltas in the worlds, (Oscar *et.al* 2004).

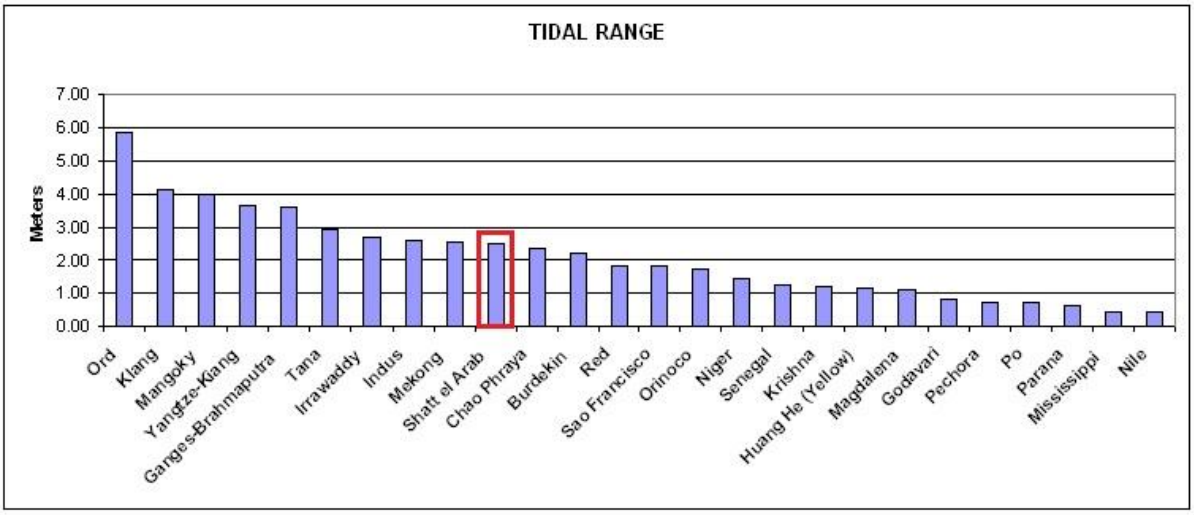


Fig (8) illustrate the main Delta Shatt Al-Arabs′ tidal range properties compare with other deltas in the worlds, (Oscar *et.al* ,2004).

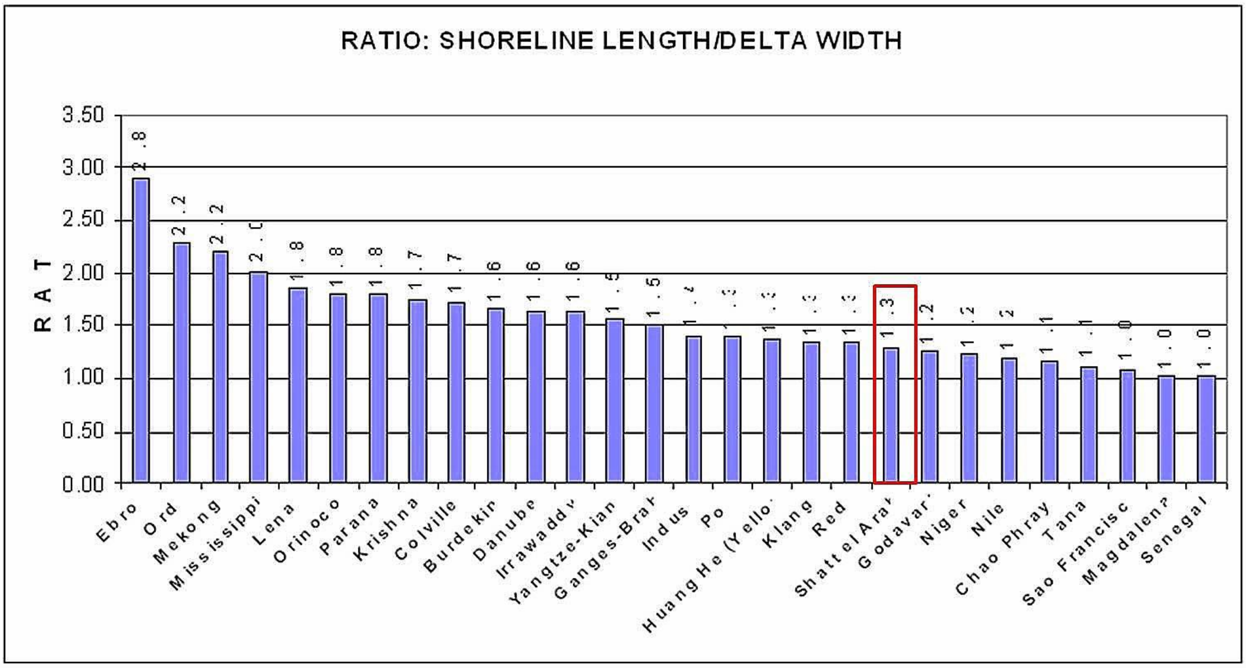


Fig (9) illustrate the Delta Shatt Alarabs′ shoreline length/ width compare with other deltas in the worlds, (Oscar *et.al* ,2004).

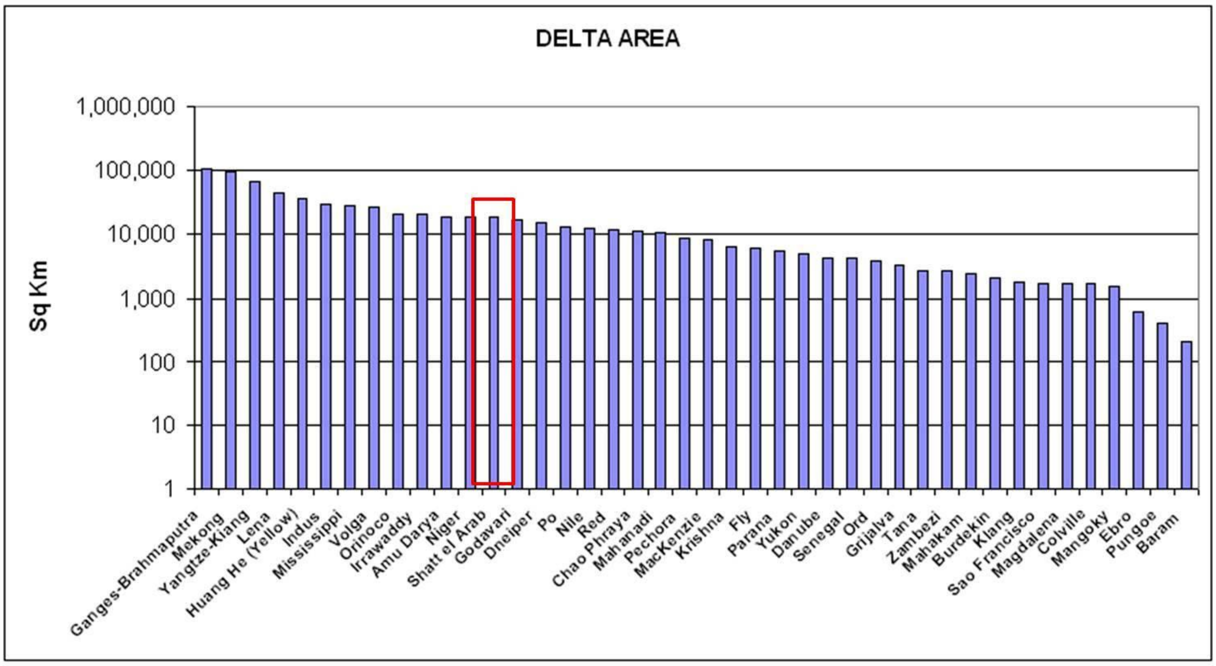


Fig (10) illustrate the main delta Shatt Al-Arabs′ Delta area properties compare with other deltas in the worlds, (Oscar *et.al* ,2004).

Methodology

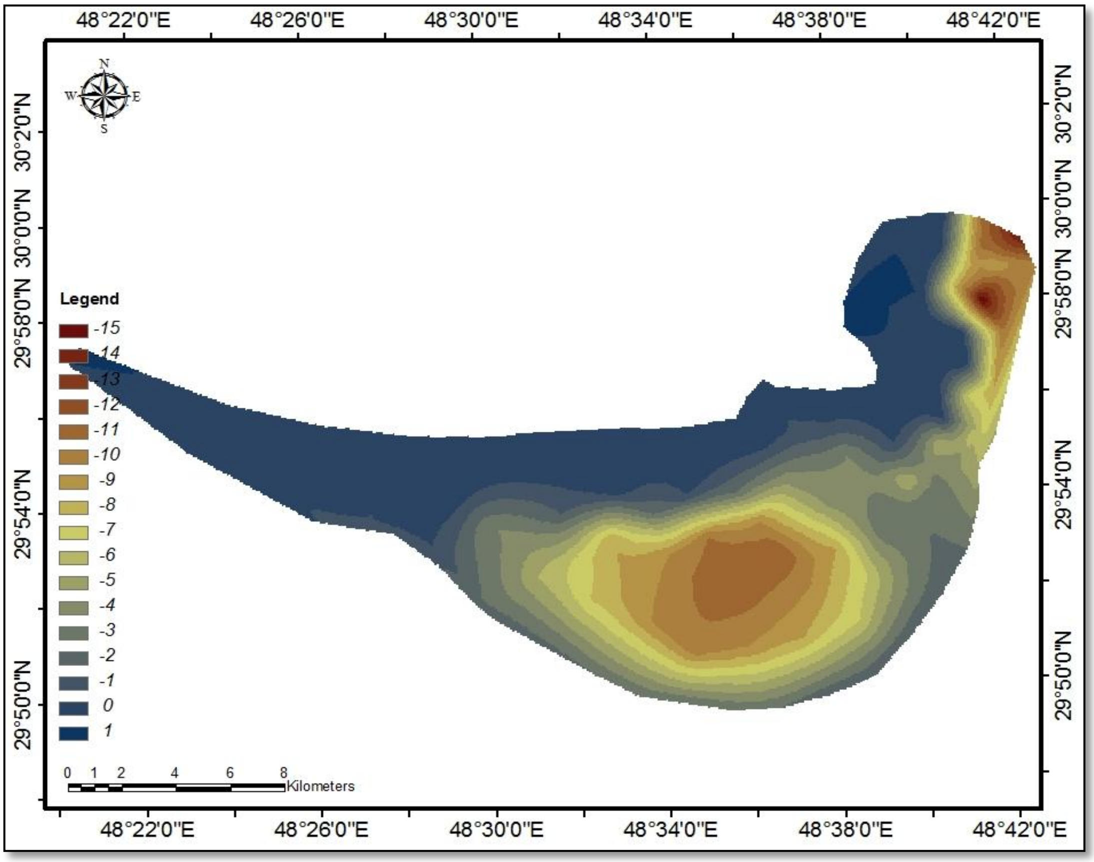
Remote sensing data are mainly used in this study for land cover monitoring of both surface and sub surface landforms . The data used for delta monitoring were acquired by landsat from the time period of 1972 , 1985 , 2006 and 2014 , Table(1).

Table(1) Satellite images criteria

No.	Date	Sensor	Resolution
1	1972	MSS	60m
2	1985	MSS	60m
3	2006	TM	30m
4	2014	OLI	30m

1.1 Data processing

By using Erdas Imagine 9.1 software , a land cover maps were classified using un supervised classification (Maximum Likelihood method) . The extent area for each item in land cover maps were calculated . The composite image 7,5,2 bands in landsat ETM+ , 3,5,7 ;landsat OLI as R,G,B format were used to enhanced the objects and recognized clearly between vegetation , mud , clay , soil and water . The files of bathymetric analysis maps were interpolated in shape file format using Arc tool box of Arc Gis 9.3 software (Idw method).fig (11) and by quantities charts (12,13,14).



Fig(11) Idw interpolation method for the shatt alarab bathymetry by arcgis 9.1

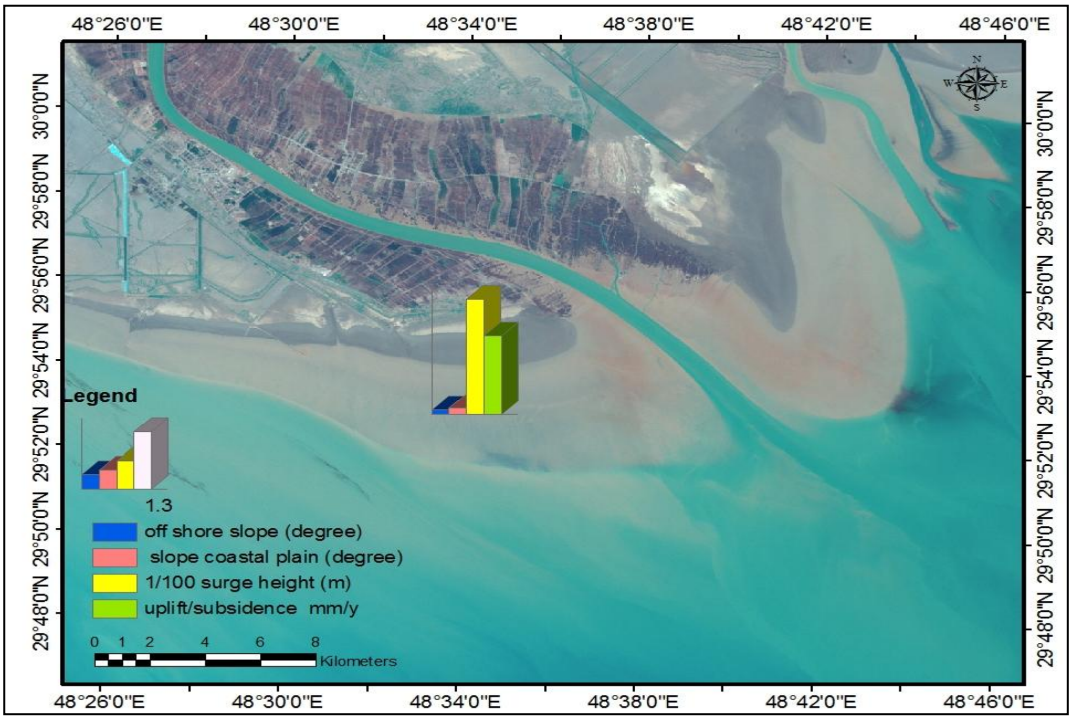


Fig (12) illustrate the main shatt alarab delta coastal properties by arcgis 9.3

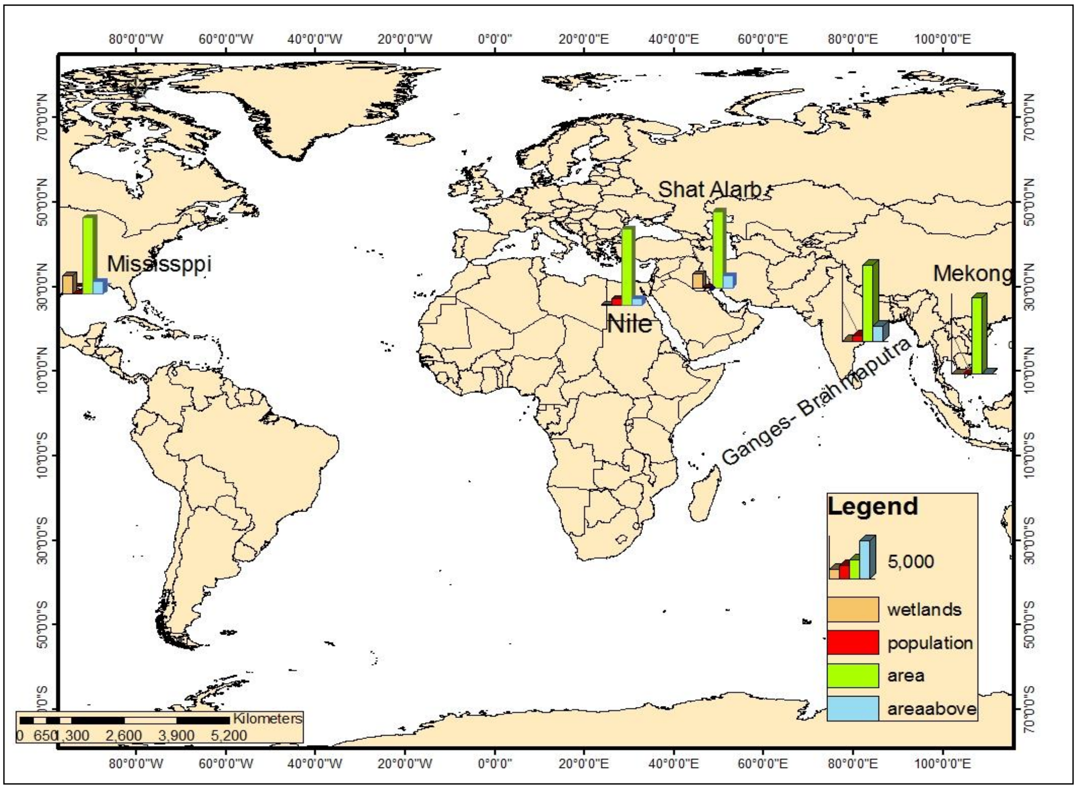


Fig (13) shatt alarab delta coastal properties compare with other world's major delta

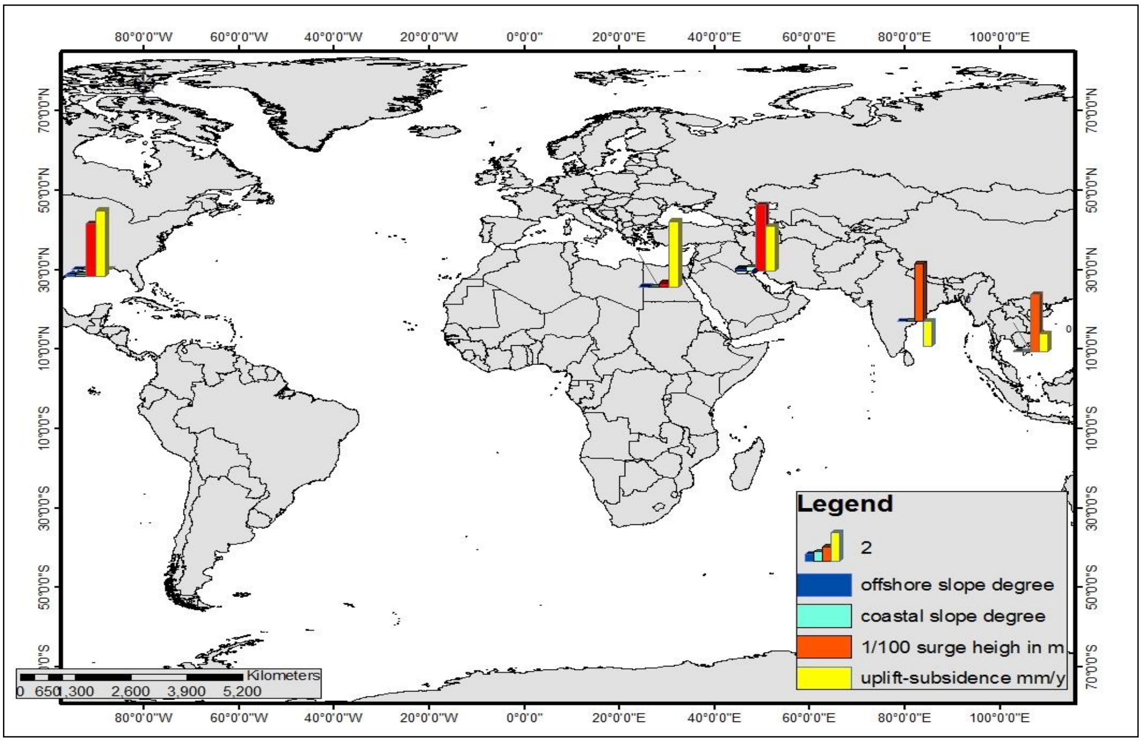


Fig (14) shatt alarab delta coastal properties compare with other world's major delta

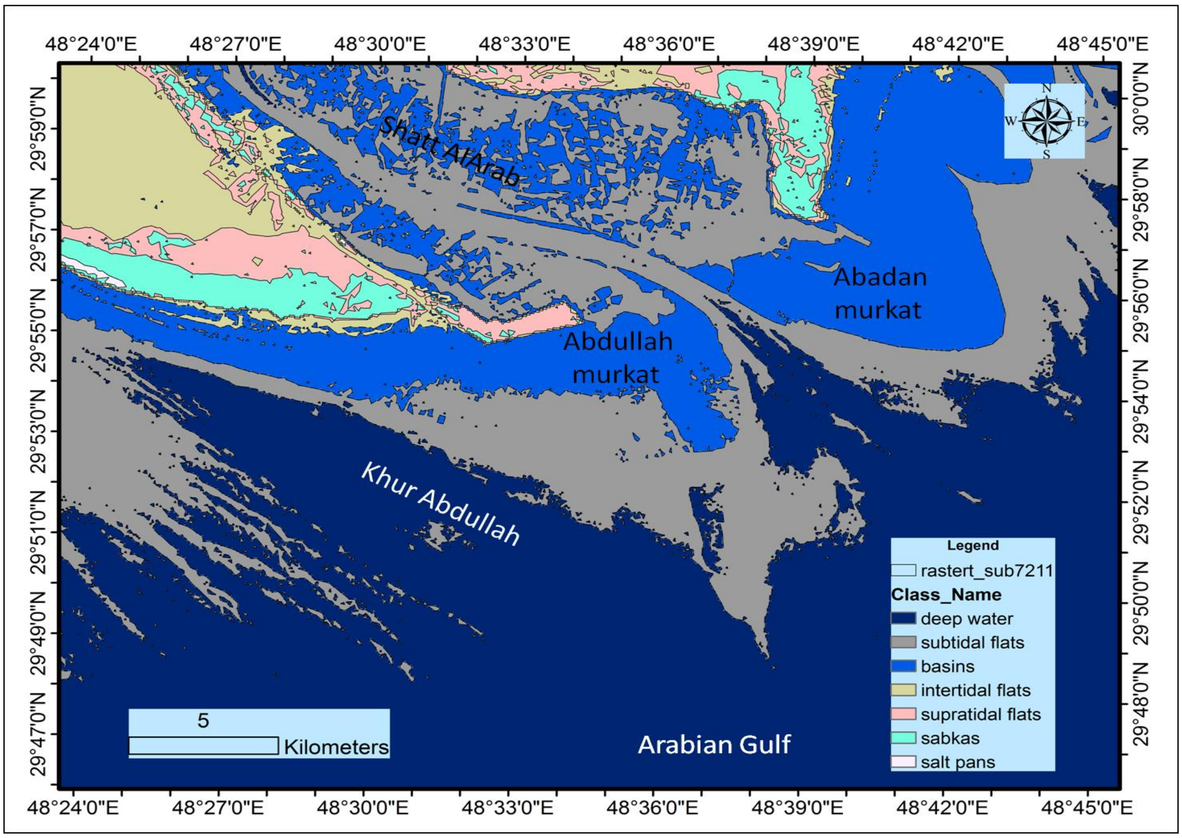
Change detection and Image classifications

Four photo maps of land cover and sub surface landforms were created using un supervised classification . The area of each object were calculated for the years of 1972 , 1985 , 2006 and 2014 respectively , concluded in Table(2) fig.(16,17, 18, 19). The results of the digital classification of satellites Images clearly showed a decline in wetted tidal flats areas (the intertidal flats and subtidal flats) with an increase in the areas of subratidal flats tide and coastal sabkas This is a sign of affected of Delta Shatt al-Arab with the environmental and hydrological changes in the Upper Delta, as well as the results of classification for the successive years show there is an openings at the entrance of Shatt al-Arab channel in gulf side clearly in satellites of the period from 2006 to 2014 and the decline in the areas and

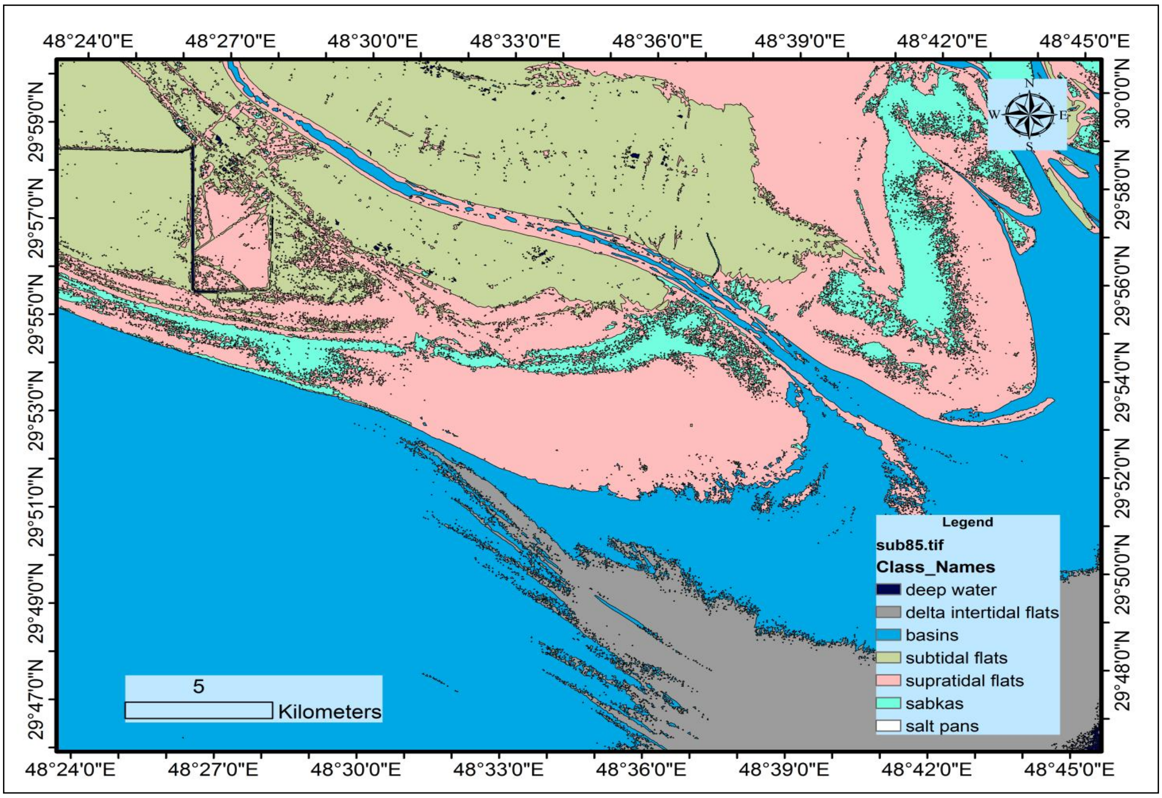
extensions of murkats Abadan in the east and Khawr Abd Allah westward , with the clear coastal erosion of longitudinal barriers and the islands that were adjacent to two murkats in the channel entrance in the satellite images of the period from 1972 to 1985. slowly curvature also showed clearly in outer limits of delta murkats as a result of waves erosion, with slowly creep of Murkat Abadan westward. Table (2),figs (15,16,17,18).

Table(2) Results of Digital classification (area in km^2)

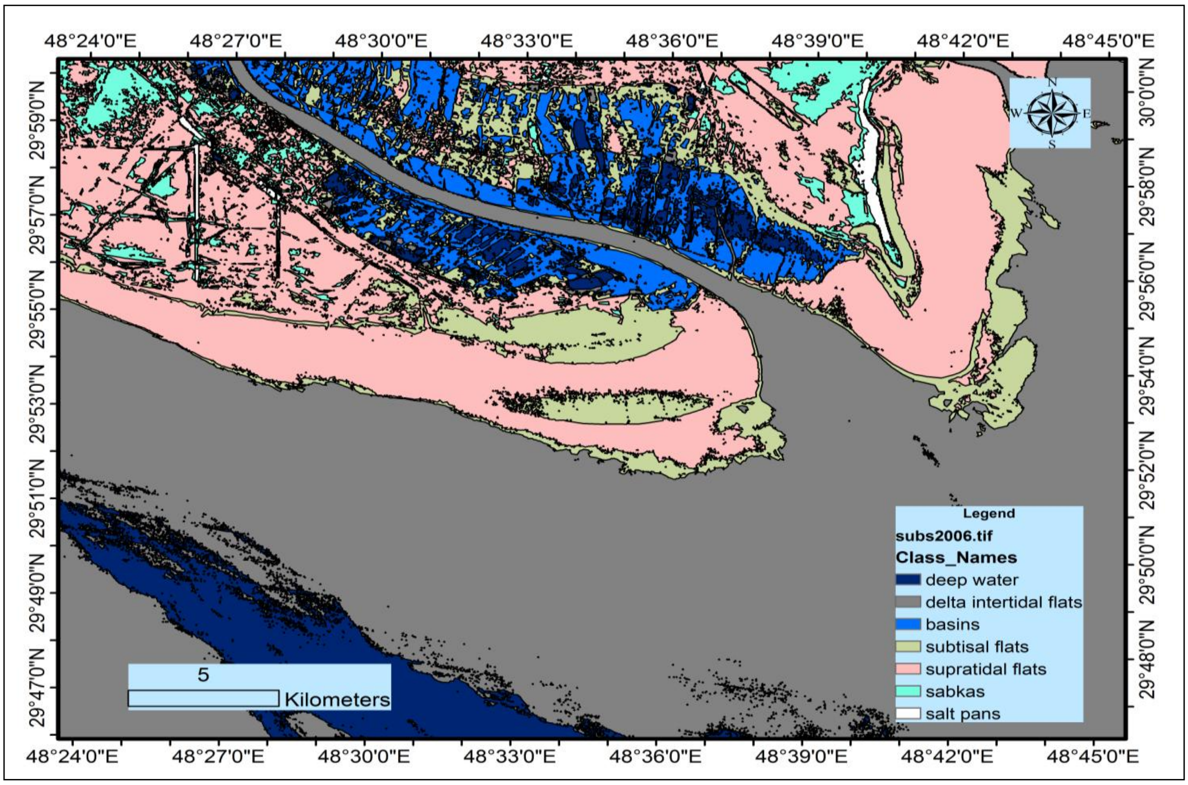
Year	Salt pans	sabkas	Supratidal flats	Intertidal flats	basins	Subtidal flats	Deep water
1972	54.328	141.48	193.547	160.355	251.687	437.905	1233.52
1985	1.659	163.944	427.542	328.1	809.09	504.886	425.144
2006	85.964	145.033	393.61	108.2	63.017	1085.973	487.256
2014	6.629	86.876	335.54	178.767	184.305	220.029	1757.058



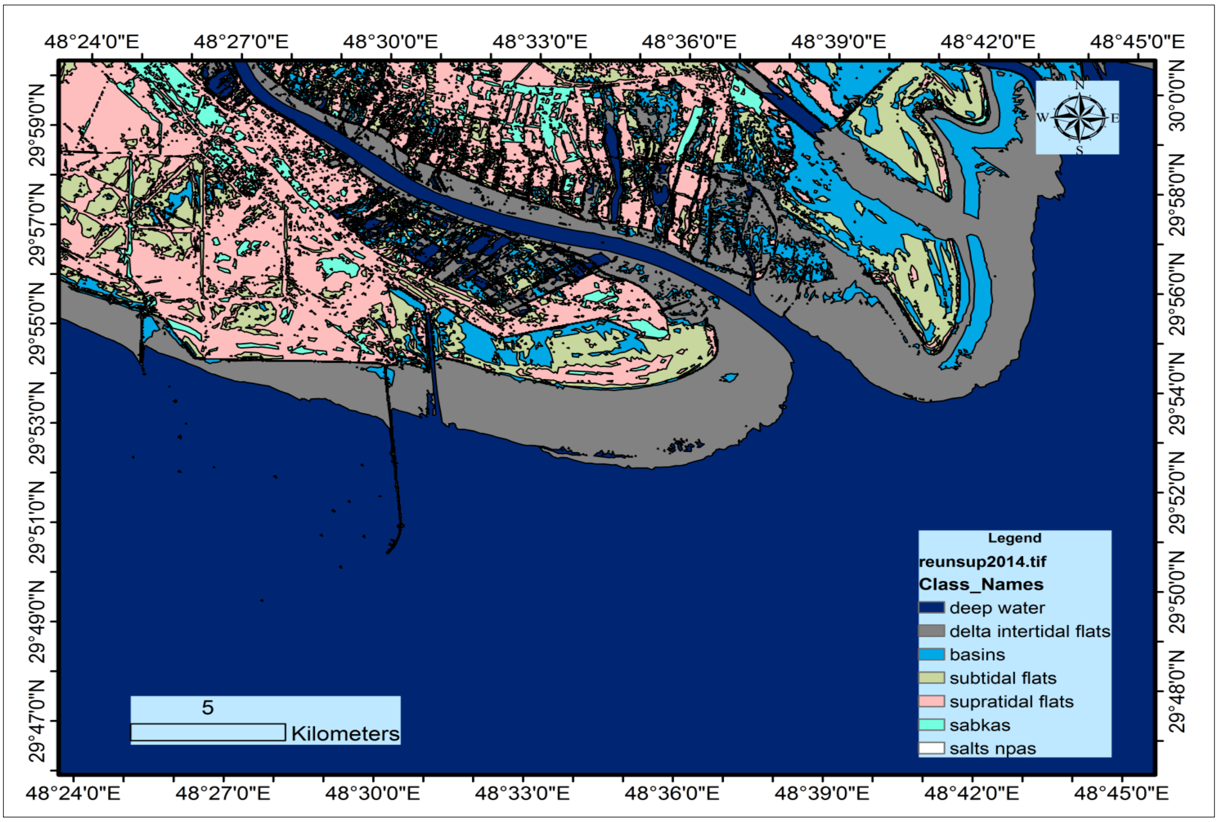
Fig(15) unsupervised classification of Shatt Al-Arab delta for 1972



Fig(16)unsupervised classification of Shatt Al-Arab delta for 1985



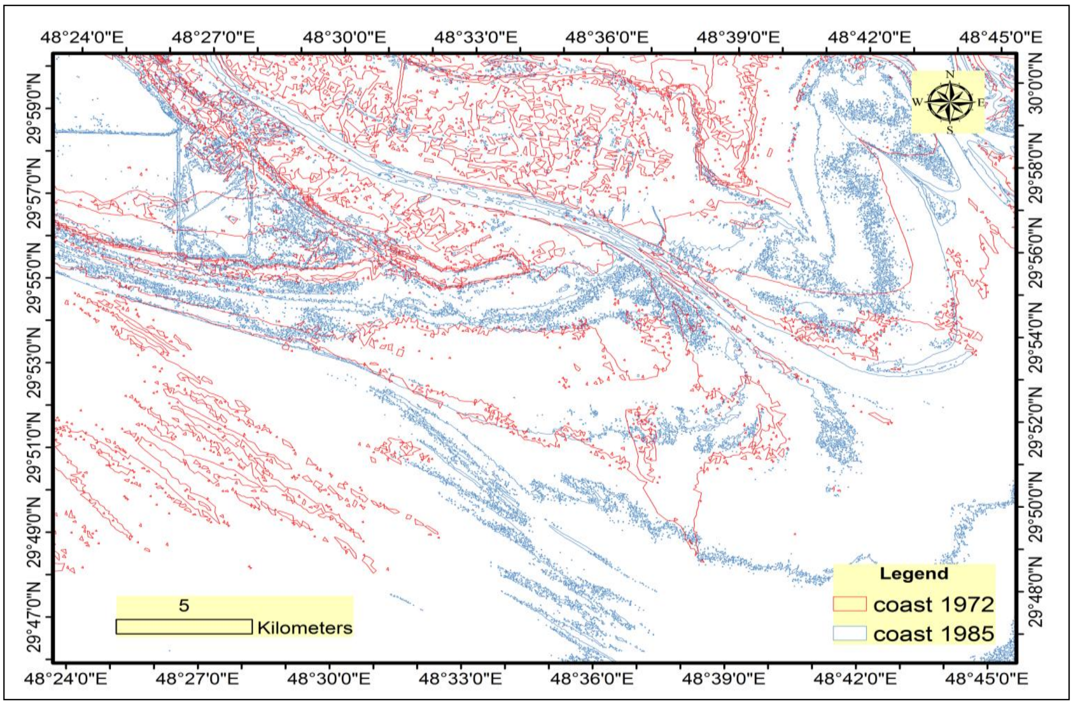
Fig(17)unsupervised classification of Shatt Al-Arab delta for 2006



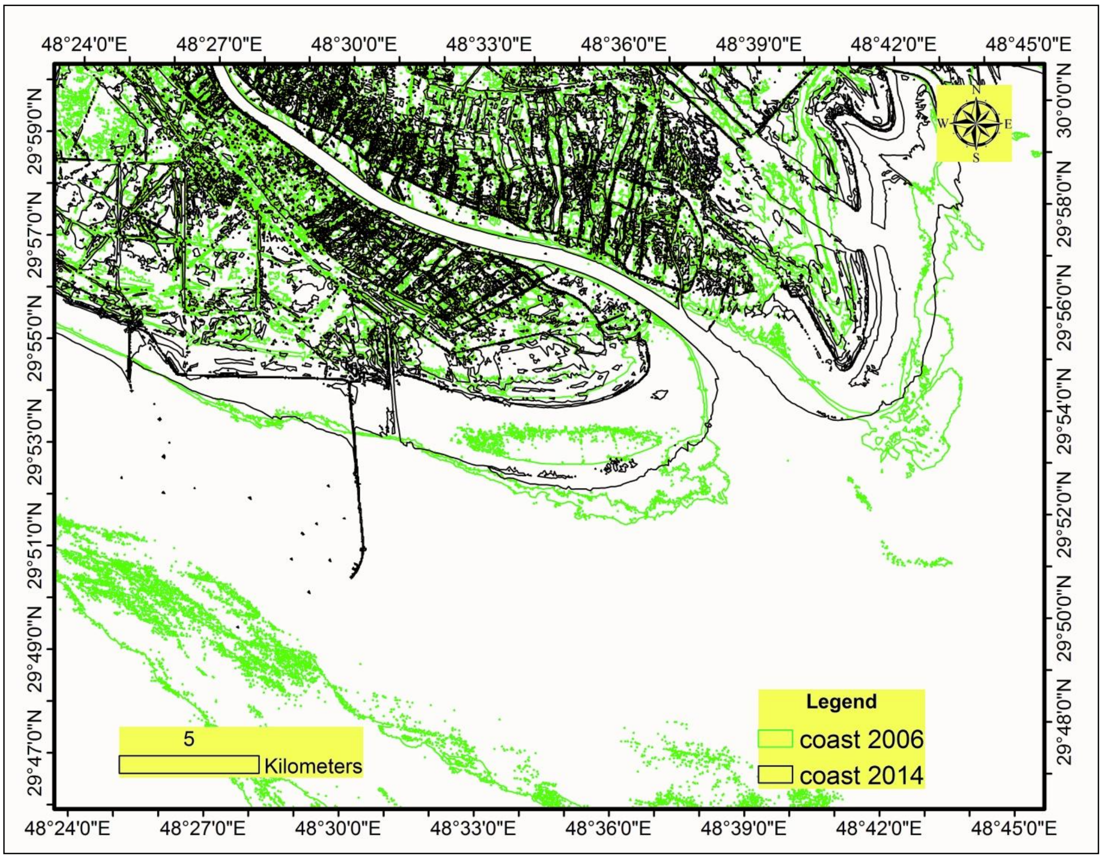
Fig(18)unsupervised classification of Shatt Al-Arab delta for 2014

Digital Change detection

Another digital method is for monitoring the changes in study area, by convert the Raster files to polygons in Arc GiS program in order to statement the changes in the boundaries and areas of the coastal units in a successive periods of time. For example, for the period between years 1972 and 1985 as well as between the years 2006-2014 . The comparison between the time visualizations for digital image process showed that the most important changes in the region was in the expansion in the cross-section of the Shatt al-Arab channel, as well as it's the advance and changes in the channel direction that have occurred in it . the digital change detections showed the intensification of sedimentation, especially in flats of Khawr Abd Allah, as well as the breadth of areas of Marqat Abadan and Marqat Khawr Abd Allah that make up the main wings of the Shatt al-Arab Delta. The same thing applies to the period between years 2006-2014, as shown gradual widening in delta Marqats mentioned above , as well as increasing in drift of Shatt al-Arab channel to the West toward Iraqi coast. It is interesting to consider the Narrowed that has occurred in cross-section of the Shatt al-Arab channel in the lower part of it in a year 2014 compared to year 2006, Due to the low volume of river discharges across the Tigris , Euphrates and Karun in recent years and increased the fluvial sedimentation process .figs (19, 20).



Fig(19) change detection in delta coasts & areas of years 1972- 1980



Fig(20) change detection in delta coasts & areas of years 2006- 2014

Conclusions

Delta Shatt al-Arab subject to numerous operations contributed to the formation . the most important factors , tides, coastal currents , river discharges and gradual slopes of the Mesopotamian Continental shelf , Through digital interpretation of satellite Images for a successive years observed the shores of the delta is gradually declining, perhaps because of the decline in river discharges of Tigris and Euphrates , and thus a decline in volumes of suspended deposits that contribute for construction the beaches and deltaic marine barriers with advances in areas of marine sabkhas and supratidal flats. as shown satellite Images there is widening in cross section of the Shatt al-Arab channel with deviation gradually towards the Iraqi beaches.

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دراسة جيومعلوماتية لدلتا شط العرب جنوبي العراق

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المستخلص

هذا البحث هو دراسة جيومعلوماتية لمنطقة دلتا شط العرب، يهدف إلى رصد التغيرات البيئية في منطقة الدلتا جنوب العراق. استخدمت تقنيتي الاستشعار عن بعد ونظم المعلومات الجغرافية (GIS) لتحقيق أهداف هذه الدراسة. تم استخدام صور الأقمار الصناعية الاميركية لاندسات بمتحسساتها (MSS,ETM+,OLI) لدراسة التضاريس الساحلية للدلتا لسنوات متتابعة من 1972 و 1985 و 2006 و 2014. كشف التغيير الرقمي يمثل المنهج الرئيسي المعتمد في هذه الدراسة لحساب التغييرات البيئية . أظهرت النتائج حدوث تغيرا تدريجيا لشواطئ الدلتا ومسطحاتها المدية ، يعود السبب الى تدني التصاريف النهرية لنهري دجلة والفرات وانقطاع مياه نهر الكارون عن شط العرب ، وبالتالي انخفاض في حجم المياه والرسوبيات مع التي تسهم في بناء الشواطئ والحواجز البحرية الدلتا. وأظهرت الدراسة تقدما في مجالات السبخات البحرية ومسحات اعالي المد والجزر .كما بينت مرئيات الأقمار الصناعية ان هناك اتساع في المقطع العرضي لقناة شط العرب عند مصبه في الخليج العربي.

الكلمات المفتاحية: الجيومعلوماتية , جيومورفولوجية الدلتا , رصد التغير , شط العرب