

# Historic Coastal Morphological Landscape Characterization & Assessment (HCMLC&A) to Understand the Coastal Evolution in the State of Kuwait

## توصيف و تقييم شكل السواحل و مناظرها الطبيعية تاريخياً لفهم تطور السواحل في دولة الكويت

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**Abstract:** The Arabian Gulf has seen a lot of coastal development along its shores since the discovery of oil and rise in oil based economy. Kuwait too, for the last five decades (from 1960s), has seen a tremendous alteration of the coastal morphological landscape (CML) from what existed 50 years ago. The study shows that the physiognomy of the coastal landscape created by geological, geomorphologic, biological factors and coastal process was greatly shaped by oil based development. This tremendous change in coastal edge from natural morphology to build up morphology was brought about due to coastal migration, construction, private and public establishments, landscaping, coastal fronts, man-made beaches, ports, marine facilities for petroleum industries, power stations, distillation plants, coastal defensive structures, beach houses, structures of hospitality, etc. Remarkably it is interesting to note that till 2011 certain zone of coast in Kuwait showed priority in encroaching and occupying more than any other parts. These coastal areas have reached to a saturation level thus tempting and forcing humans to invade the virgin coastal areas which were untouched earlier. These limited natural coastal resource areas in Kuwait hold high significance values. The Master Plan of Kuwait show promising coastal land use but it does not seem to protect significantly the valuable natural CML of Kuwait which is seen in this study. Historic Coastal Morphological Landscape Characterization & Assessment (HCMLC&A) represent a new way of historically characterizing the landscape and understanding the coastal evolution. **Keywords:** *Historic, Coastal Morphological Landscape, satellite data, aerial photographs, aerial video, timeline, drivers and human factor, vulnerable.*

**المستخلص:** لقد شهدت سواحل منطقة الخليج العربي الكثير من التطور على امتداد شواطئه منذ اكتشاف النفط و نمو الاقتصاديات المعتمدة عليه. كذلك الكويت - وعلى مدى العقود الخمسة الماضية - قد شهدت تغيراً هائلاً في تشكل سواحلها و المناظر الطبيعية المصاحبة لشواطئها و التي اختلفت بشكل كبير عما كان سائداً قبل 50 عاماً. تبين من خلال هذه الدراسة أن ملامح المظهر الخارجي للسواحل تشكلت بسبب العوامل الجيولوجية و البيولوجية و الساحلية المرتبطة بالمشايخ التنموية القائمة على النفط. كما أن الهجرة الساحلية و ما صاحبها من تقدم عمراني و نموي في المؤسسات الحكومية و الخاصة و المناظر الطبيعية و الواجهة البحرية و الشواطئ الصناعية و الموانئ و المرافق البحرية للمنشآت النفطية و محطات الكهرباء و محطات تقطير المياه و المنتزهات و غيرها كان سبباً في ذلك التغيير الذي طرأ على شكل السواحل و حولها من مظهرها الطبيعي الذي كانت عليه إلى المظهر المبني بالشكل الحاضر. إلا أن هذا التطور لم يشمل جميع السواحل بالتوازي. فمن اللافت للانتباه انه و حتى عام 2011 تشهد بعضاً من السواحل الكويتية أولوية في النمو ووصولها إلى حد التشبع مما أدى إلى إجبار الأنشطة الجديدة

إلى التوجه إلى الشواطئ البكر وتطويرها و من ثم استغلالها. وتعد هذه السواحل موارد طبيعية ذات قيمة عالية. وبالرغم من أن المخطط الهيكلي لدولة الكويت يبين أن هناك خططا واعدة لاستخدام الأراضي الساحلية، إلا أن هذه الخطط تقتصد توفير الحماية لطبيعة السواحل و منظرها الخارجي كما هو واضح من هذه الدراسة. لذا، فإن اللجوء إلى توصيف و تقييم شكل الساحل و منظره الطبيعي من الناحية التاريخية يعد طريقة جديدة لفهم تطور الساحل.

**كلمات مدخلية: التاريخي، تشكل المناظر الطبيعية الساحلية، بيانات الأقمار الصناعية، صور جوية، فيديو جوي، جدول زمني، عوامل مؤثرة و بشرية، قابل للتأثر.**

## INTRODUCTION

Historically, the coastal zones have been the natural living area for a substantial part of the world's population, providing a major contribution to global food production and supporting a large number of economic activities. This has led to a continuing and often accelerating process of intensive development and modification of coastal morphological landscape (CML). These human developments have decreased the resilience of the coastal system by disturbing natural coastal morphological landscape (CML) and associated adverse environmental effects.

The Arabian Gulf has witnessed a lot of coastal development along its shores because of its rich oil resources. As any other part of the Arabian Gulf and rest of the world, one of the most challenging issues the Kuwait coast faces today is rapid coastal urbanization whose implications have yet to be assessed. The physiognomy of the CML created by geological, geomorphologic and biological factors is greatly modified by petroleum based development in the region. In terms of landscape change, it can be assessed that Kuwait has altered its valuable coastline considerably, (with the migration, construction, establishments, and landscaping). As CML is modified and converted, the coastal ecosystem is adversely affected. Compounding these challenges are the prospects of the vulnerabilities these regions face. Among these are climate change, sea level rise, new maritime security needs associated with increase of transportation by sea, and the ever present danger of extreme events.

The land along the sea coast is made up of coastal deposits of a nature less dry and desert-like than the interior, even green and beautiful. These lands are punctuated by medium sized coastal hills from the rest of Kuwait. The mainland is generally flat, dry with the urban population concentrated

in Kuwait City, its suburbs and satellite towns. The total population as per the census of 2005 is 2,213,403 (MOP, 2006). Latest population is not available however, the estimated and projected total population of Kuwait as reported by 'British Broadcasting Corporation' is 3.1 million whereas by 'Lonely Planet Publication' it is 3.4 million in 2010. The bulk of the Kuwaiti population lives in the coastal capital of the city of Kuwait. Smaller populations inhabit the nearby city of Al-Jahrah, smaller desert and coastal towns, and, prior to the Persian Gulf War, some of the several nearby gulf islands, notably Failaka.

## LITERATURE REVIEW

In Vogiatzakis *et al.* (2005), the term coastal landscape implies a relationship between land and sea. Some units such as beaches or rocky islands are defined by both sea and land while others such as mud flats and salt marshes exist somewhere between land and sea. Therefore, to adequately define coastal landscapes, we must define the complex elements that give this specific physiognomy to the zone where land and sea interact. The recent draft on Integrated Coastal Areas Management (ICAM) protocol (UNEP/ MAP 2005) defines coastal zone as: "..... the geomorphological area is either side of the seashore in which the interaction between the maritime and land parts occurs in the form of complex ecological systems made up of biotic and abiotic components, living space for human communities and their socio-economic activities;"

According to the draft ICAM protocol (UNEP/MAP 2005) there are two limits of the coastal zone:

- the seaward limit of the coastal zone shall be the external limit of the territorial waters of States Parties; and

- b. the landward limit of the coastal zone shall be the territorial limit of local coastal administrative units.

Natural and man-made landscapes vary distinctly in structure (composition and structure) and function due to natural and anthropogenic factors. Manmade landscapes vary with the role of human in creating and affecting the patterns and process. Regardless of how landscape is defined, the “concept” of a landscape is unequivocal. All landscapes have a user-defined structure (pattern) that is hypothesized to influence its function (process). In this manuscript the author have added the term ‘morphological’ along with ‘landscape’ to give clear inclusion of the natural features such as coastal marshland, coastal sand dunes, coastal salt crust area, mangroves, etc... and is coined as ‘coastal morphological landscape (CML)’ and referred throughout the text.

Historic Landscape Characterization (HLC) recognizes that the notion of present day landscape is a human construction. ‘The national program of Historic Landscape Characterization’, initiated by English Heritage in the early 1990s (English Heritage, 2008 and Herring, 1998) was to improve understanding of the historic dimension of landscape and, thus better manage the change in the archaeological and historic environmental resources. The method was first developed in Cornwall in 1993-94 (Herring 1998). Over the past decade, HLC has evolved the fabric of the land that individuals and groups use to create their own notion of landscape is the product of thousands of years of human activity, although what remains to be seen today may be very recent, but has undergone successive periods of change and modification.

In the process of literature review, the authors came across many articles, reports and other information, either published or unpublished, related to geomorphology and coastal management topics. However, the authors did not come through well documented technical paper or report which studied the link and correlation between the civilization, political history, discoveries, industrialization and developments along the coast with historic morphological landscape change, evaluation, trends in sprawling land use in coastal edge.

## STUDY AREA

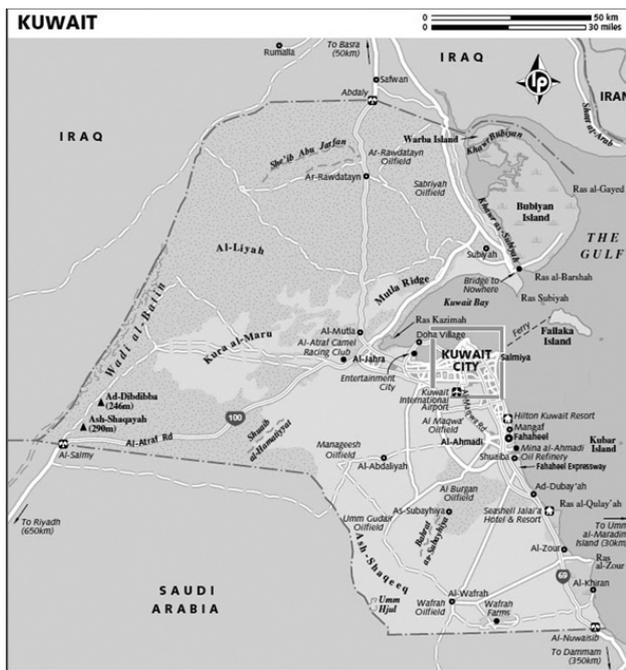
The mainland shoreline of the coast of Kuwait (Fig.1) is about 325 kilometers long. The total shoreline including all the nine islands is about 500 kilometers in length (Neelamani and Khaled, 2005). The nine islands off the coast are – Failaka, Bubiyan, Miskan, Warba, Auhha, Umm Al- Maradin, Umm Al-Naml, Kubbar and Qaruh. Kuwait occupies an area approximately 17,800 km<sup>2</sup> (Neelamani and Khaled, 2005) but according to another literature (Lonely Planet, 2010) it is 17,818 km<sup>2</sup>. Among the islands the most important ones considered for the study are Bubiyan, Warba and Failaka, because of its geomorphology, area and remarkable strategic location, based on high prospect of exploitation in the future and as shown in the KMPR3 (Kuwait Master Plan Review 3) land use.

The most affected morphological landscape along the coastline and coastal area lies in the mainland of Kuwait. Apart from the mainland, the locations of vulnerability in terms of coastal morphological landscape are Bubiyan, Warbah and Failaka. Bubiyan is the largest among all the islands. Warbah Island constitutes the northernmost part of eastern Kuwait. It is composed of soft mud and gypsiferous silty\* sediments. It has several tidal creeks and high tide covers most of the island. Failaka is the only inhabited island among the 9 islands of Kuwait. The island shows no geomorphic complexity.

### *The Objectives*

The objectives of the study are:

1. Analysis of historical CML change and evolutionary trend.
2. Trend in socio-economic, sprawling coastal land use and development.
3. Trend of interaction with CML (land Cover-Land Use).
4. Identify the specific drive and human factors responsible for shaping and evolving the CML in context to Kuwait’s scenario.
5. Categorize coastal area on basis of land resource status.
6. Identify vulnerability of potential coastal areas to future encroachment.



**Fig. 1.** Kuwait map showing the coastal area. (Reproduced with Permission from Lonely Planet. © Lonely Planet, 2010).

## MATERIALS AND METHODOLOGY

In this study “Historic Coastal Morphological Landscape Characterization & Assessment (HCMLC&A)”, is the modified version with ideas and techniques adopted from ‘The national program of Historic Landscape Characterization’ which was initiated by English Heritage in the early 1990s (English Heritage, 2008 and Herring 1998). The HCMLC&A approach is to improve understanding of the historic dimension of landscape and thus better manage change in the historic coastal environment resource.

Historic Landscape Assessment (HLA) has been developed to assess the historic “time depth” of the landscape, which enables its characterization into broad historic landscape character types. This uses both descriptive and prescriptive criteria but their subjectivity is controlled and made transparent. Interpretations and observations are specific to needs and scope. The process of characterization is transparent, with clearly articulated records of data sources and methods used. HCMLC&A represented a new method of historic characterizing of the landscape and understanding the coastal evolution. The methodology has developed from mapping the

land use, land cover, landscapes, conservation area, existing and future coastal activities, a paper-based exercise. The methodology is a broad-brush and desktop-based approach, primarily assessing historical information, maps (current and historic), aerial photographs, documentary sources, and so forth. The criteria used is a robust, definitive, replicable, and meaningful not only to the data creator but to a variety of end users and objectives. However, the landscape types must be sufficiently sensitive to reflect landscape composition, diversity, variability, continuity, and discontinuity, which enable the complex concept of time-depth and palimpsests within the landscape to be assessed.

The methods broadly adopted for HCMLC&A study are:

Information extraction

- Interpretation and assessment
- Visual interpretation of sensor data
- Time and location based assessment of development
- Historic Coastal Morphological Landscape Assessment

The above studies are conducted using the following inputs:

- Literature survey and data investigation
- Historic information and old pictures
- Interviews
- Information gathered from walk-through reconnaissance surveys and on ground field surveys.
- Sensor data: satellite, and aerial photographs.
- Observations from Helicopter real-time video assessment

The methodology as shown in Figure 2 consists of researching and documenting coastal land use development and factors shaping the CML of Kuwait with time and space.

Research on published and authentic literature was conducted for individual themes such history, civilization, migration, occupation, geography, demography, socio-economic conditions, political landscape, oil discoveries and development. Abundant information was found in papers, articles, and technical reports either published or unpublished pertinent to the

coastal morphology of Kuwait which provided baseline information for study objectives. The results of this literature search were indicative.

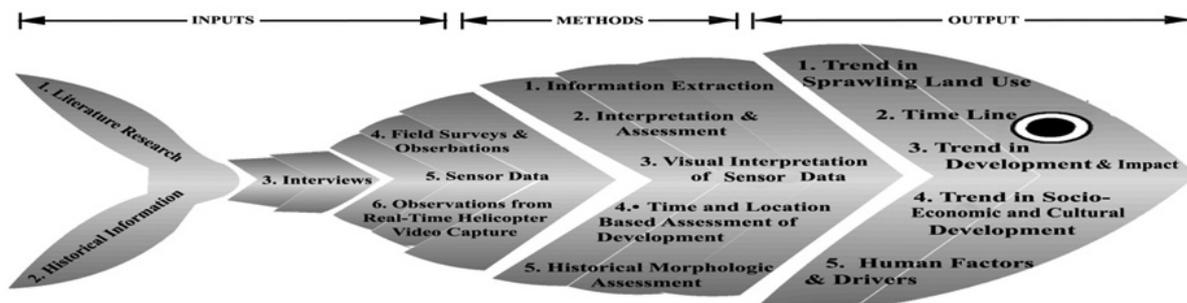
The literature review (Table 1) and interviews have revealed and under-earthed information related to Kuwait's civilization, discoveries, political history, industrialization and developments that proved beneficial and helped in identifying the human factors that is responsible in shaping the coast of Kuwait.

Data from Landsat, Indian Remote Sensing, IKONOS, Quickbird, Google Earth, aerial photographs and helicopter videos (courtesy

to USGS, KISR, Digital Globe, Google Earth, Kuwait University) proved to be good source of information for understanding the changes and land use of the coast of Kuwait. Images generated (Baby, 2003a&b; Baby, 2004; Baby and Misak 2004) from processing Landsat data was a good resource to study the coastal geomorphology of Kuwait.

The timeline shown below (Fig. 3) gives the list of sensor data product, and year of procurement that was utilized for studying.

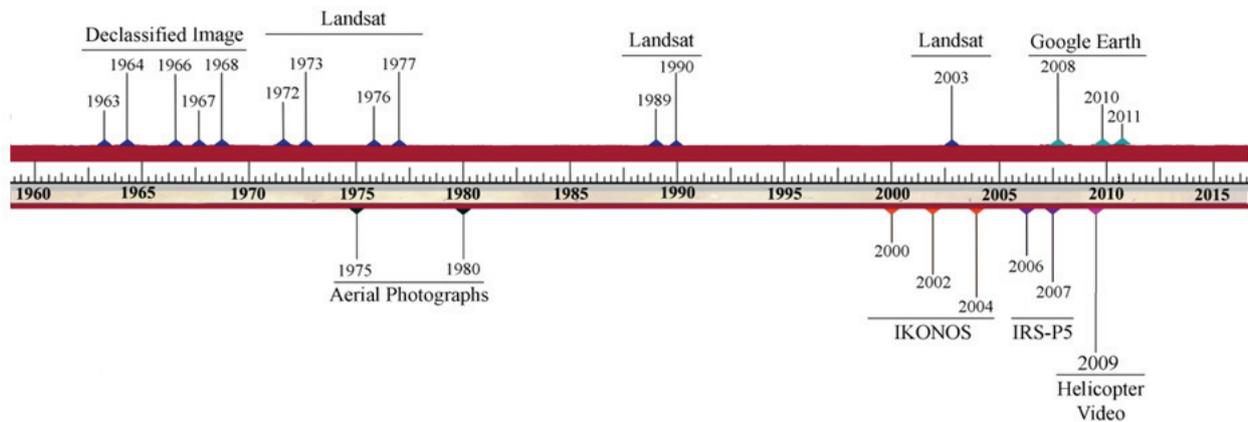
Identifying the morphologic landscape features from the sensor data, from space and air from 1963 till 2011 was the key to interpretation



**Fig. 2.** Methodology Diagram.

**Table 1.** Important literature from which Geomorphologic Information was extracted.

Literature / Data / Report	Information assessed, extracted, interpreted
Al-Sarawi et. al. 1985	Shore, shoreline and coastal morphology types. 10 types of shoreline indentified (Table 4)
Al-Sarawi et. al. 1998	
Al- Sarawi, M. 1995.	Surface geomorphology of Kuwait into four major geomorphic zone: (a) the coastal zone; (b) the wadis and ridges zone; (c) the lowland zone; and (d) the dune field zone
El-Baz and Al-Sarawi. 2000.	Thematic maps: Oil fields, Surface deposits; Geomorphology; Geologic, Relief and; Vegetation community;
Al-Yamani, <i>et al.</i> 2004.	Soil categorization; Physiographic features of the seabed; Biolithofacies map; and Shoreline types.
Neelamani and Baby. 2004	Proposal, methods and methodology for change detection study of Kuwait City. Literature review section of the proposal says that the rapid development in Kuwait since 1970 has dramatically enhanced the impact of human activities dealing with economic, land use/abuse, and resource development and management.
Neelamani, <i>et al.</i> 2007.	Changes of the coast from natural deposit and manmade activities. Most of the area is having accretion which is not qualifying it immediately to modify shoreline but certainly there is tidal flat development and at some places the sedimentation has reached the level, where the area is rarely submerged even at flood tides.
Neelamani, and Saif. 2009.	
MOP, 2007	Information of population, housing and dwelling, roads, and coastal environment
KMPR3, 2005	Existing, ongoing and proposed coastal land use and projects



**Fig. 3.** Timeline for Sensor Data.

and information extraction. The methodology and study here demonstrates the utility of the images generated from different satellites and existing ones from various sources (Landsat, IRS P5, IKONOS, and Google Earth) to derive the information on historic coastal morphological landscape, its assessment, and trends in sprawling land use. IRS P5 Cartosat 1 data have spatial resolution of the dataset is 2.5 meter. Already generated images from Landsat data was used for interpretation. The advantage of using landsat was due to availability of large archives of old archive data procured from sensors on board on different generation of platform in the space, starting from 1972 till 2003. From 2003 onwards the sensor had missing scan lines and was found not suitable for coastal studies. Most of the Landsat data was downloaded from USGS site. Landsat bands give a good multispectral coverage to differentiate different features of coastal geomorphology separating land and water. The details of the program of Landsat satellite data and the declassified satellite imagery is given below:

#### ***Landsat Satellite Data:***

- MSS (Multi Spectral Scanner) -80-meter multispectral data from Landsat 1 to 5 (1972 to 1992).
- TM (Thematic Mapper)- 30- to 120-meter multispectral data from Landsat 4 and 5 (1982 to present).
- ETM+(Enhanced Thematic Mapper Plus) -15- to 60-meter multispectral data (1999 to May

31, 2003)

- ETM+ Scan Line Corrector (SLC)-off) – ETM+ data acquired after May 31, 2003 (no data from June 1, 2003 to July 14, 2003 and Sept 3, 2003 to Sept 17, 2003)

#### ***Declassified Satellite Imagery:***

- Declass 1 - Imagery from CORONA, ARGON and LANYARD satellites (1959 to 1972)
- Declass 2 - Imagery from KH-7 Surveillance and KH-9 Mapping system (1963 to 1980).

Helicopter real time video assessment was conducted for the northern coastal area for Kuwait during the year 2009. The area covered the shoreline from Shuwaikh Port to the border of Iraq, into Warbah and Bubiyan Island. Aerial video and panoramic view of the coastal zone has been demonstrated as an effective method of providing important baseline information for this study. The helicopter survey was conducted to get an experience to the ‘Panoramic View’ of coastline and land use land cover (LULC) of Kuwait. It gave viewer a practical broader image than what would have been at ground observation. These coastal regions in the northern half of Kuwait are the most important eco-morphological coast in the State. Helicopter access for the southern coastal area, with sensitive petroleum refineries, power stations, desalination plants, petrochemical industries and oil exploration well, is restricted because of strategic location. However, all the southern and northern coastal area was visited through

road as well as reconnaissance survey was done for the whole of Kuwait coast including all the Islands by boat. The view from the sea side towards land gave totally a different approach and interpretation in studying the CML.

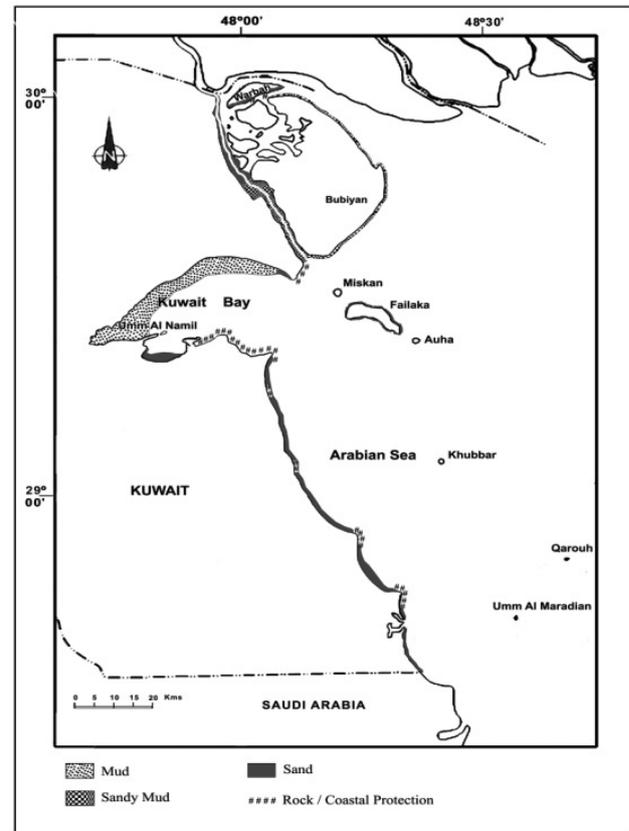
Recognizing the morphologic landscape features from the sensor data was the key to interpretation and information extraction. Observing the differences between morphological landscape and their backgrounds involves comparing different targets based on any, or all, of the visual elements of tone, shape, size, pattern, texture, shadow, and association. It is understood, visual interpretation using these elements is often a part of our daily lives, whether we are conscious of it or not. Examining satellite images or following high speed chases by views from a helicopter are all familiar examples of visual image interpretation. Identifying targets in remotely sensed images based on these visual elements allows us to further interpret and analyze.

Walk-through reconnaissance surveys and on field ground observation was an important task in this study to identify the land use and land cover existing to gather baseline information. The authors association in various different environmental projects for decades has helped in this aspect to cover the areas all along the coast from the northern end to the southern end of Kuwait and along all the 9 islands of the Kuwait stretching 325 kilometers in the mainland with 500 kilometers of the islands. The authors were lucky to get into the restricted coastal area of Kuwait through official permission of authority especially granted for the projects they handled. Important observations were noted for the changes in the landscape, coastal reclamations and the activities currently going on at the coastal areas during walk-through reconnaissance surveys

Applying all the above tools and methodologies, different maps on coastal activities were prepared to demonstrate the coastal information pertaining to HCMLC&A. Timeline (Fig.6) for the developmental trend was plotted based on facts collected from various literatures, articles, report and websites.

## RESULTS AND DISCUSSION

The coastal natural landscapes morphology have changed tremendously interacting with the different shoreline morphology extending from north starting from Iraq border to south till border of Saudi Arabia (Fig.4) from the time of oil discovery till date. Waterfront master plans of the 1970s and 1980s laid the blueprints for coastal redevelopment in Kuwait (Kana, 2002) with a considerable dredging and reclamation activities that have interfered with natural coastal morphological landscape (CML) of Kuwait.



**Fig. 4.** Shoreline Type.

The changes can be attributed to various human induced factors which are being discussed through the discussion of results are given below to lead to the objectives: Analysis of historical CML change, and evolutionary trend; trend of interaction with CML (land Cover -Land Use); study of the trend in socio-economic, sprawling coastal land use and development; identifying the specific drives and human factors responsible for shaping and evolving the CML in context to

Kuwait’s scenario; categorize coastal area on basis of land resource status and; identify vulnerable potential coastal areas to future encroachment.

**A. Historic: Socioeconomic and Cultural Development along the Coast**

The environmental and socio-economic and cultural importance of coastal areas is looked at by examining the commodities and services provided by coastal resources. Coastal areas provide goods and services that contribute significantly to the economic life of the country. The coastal plains in Kuwait were home to the majority of the population of the country and most of the economic activities. The trend in Socio-economic and cultural aspects which have motivated and initiated change in natural CML have been evolving from the time of establishment of Kuwait City dated back from 1630, starting with the settlement of immigrants from Najad to Kadma till date which is shown in the historic timeline below (Fig.5).

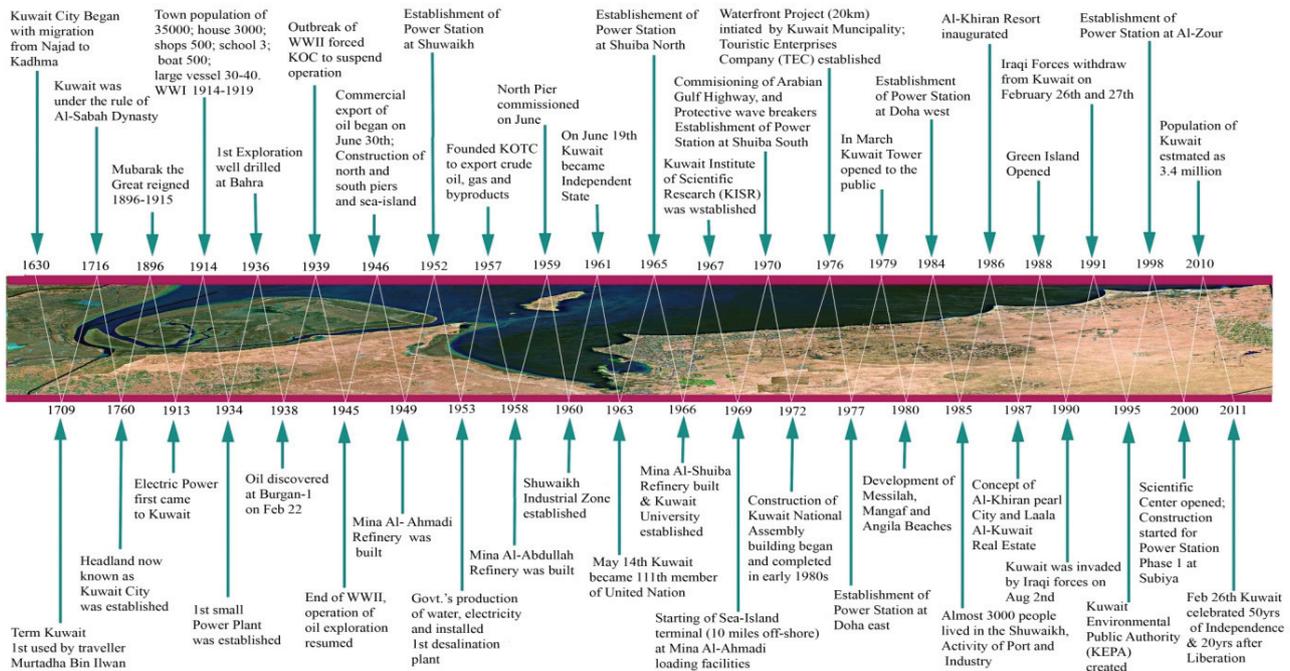
**(i) During Oil**

With the discovery of oil at Burgan on February 22nd, 1938 Kuwait has changed the scenario of coastal land use and occupation. It became the prime natural resource and has altered

the shape of CML through various developmental and socioeconomic activities related to it. In March 2006, Kuwait discovered natural gas (Encyclopædia Britannica, 2011 and KOC, 2007) in commercial quantities. The initial phase of natural gas production began by the end of 2007.

Coastal cities drew an immigrant population of oil workers that required housing and infrastructure. The old walled cities such as Kuwait’s capital were expanded outward from the core. The improvements were done at the cost of land reclamation along the coast. According to Kana (2002) rubble from historical sites was bulldozed into the sea, obliterating the natural character of the shoreline. Beaches were buried. The outcroppings of limestone in the intertidal zone were excavated and used for building materials or shore protection. This first part of the cycle occurred in the 1950s and 1960s and this could be characterized as one of uncontrolled growth.

Economic boom from oil production have attracted various other types of development along the coast to satisfy and meet the growing demand of population. The industry based development can be categorized as oil refineries (3), power stations (7), desalination plant, major harbors, petro-chemical, construction, and manufacturing. Other development



**Fig. 5.** Timeline of the developmental activities in ‘The State of Kuwait’ responsible for evolving the coastal areas.

includes road and transportation, commercial, residential areas, recreational, hospitality industries and coastal protective structures. The map constructed (Fig. 7) for the major development at coastal edge and built up area of 6 governorates (Fig. 6) clearly show that all these development are

along the coast and have remarkably changed the CML from what existed before the oil discovery. 5 governorates out of 6 have direct coastal access. Al-Farwaniya is situated towards the core of the urban area and do not have direct coastal access.

It is interesting to note that the oil

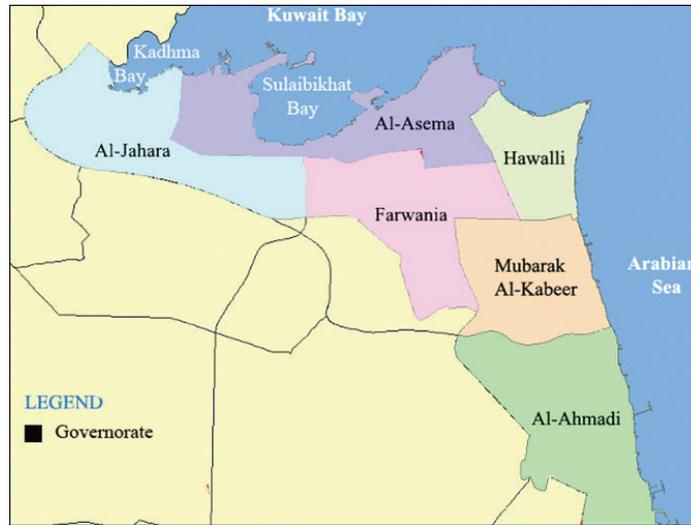
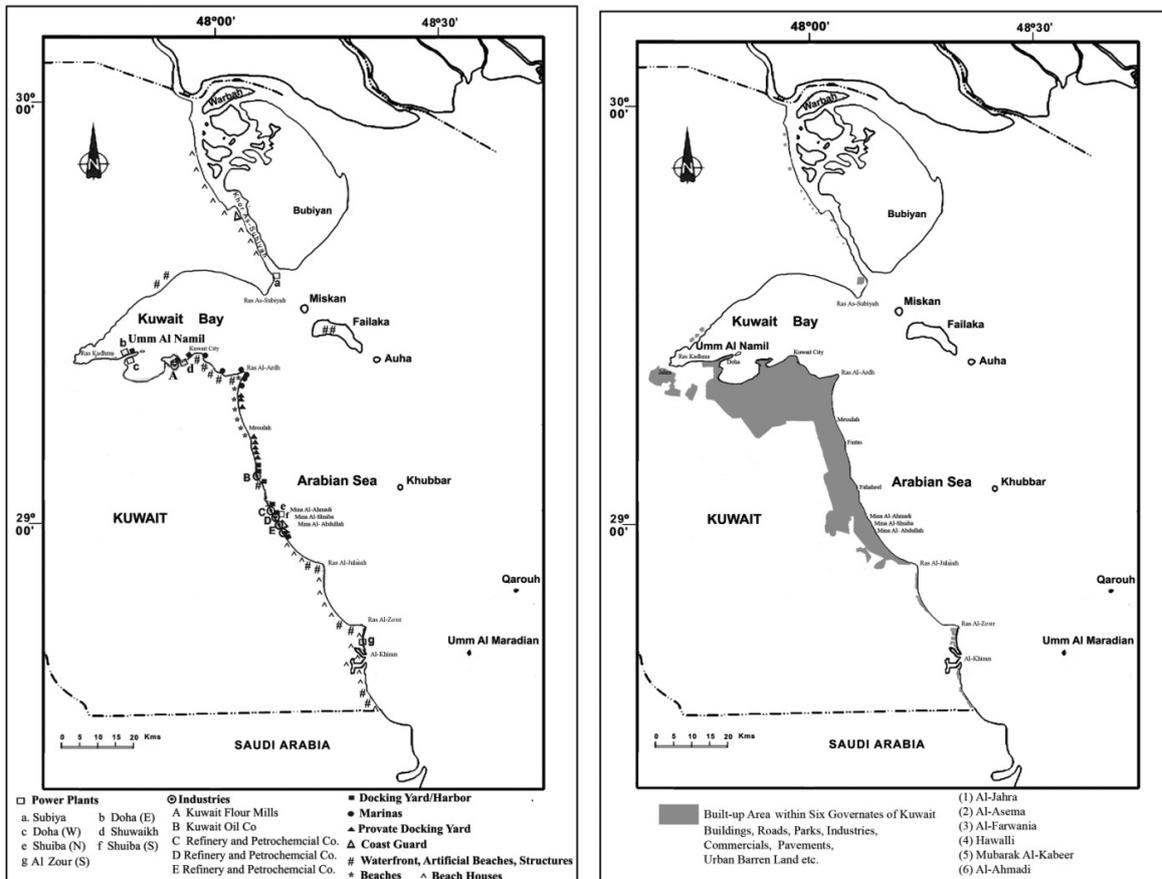


Fig. 6. Governorates of Kuwait.



(a) Developments at coastal edge.

(b) Built-up area at 6 Governorates

Fig. 7. Major Existing Coastal Edge Developments and Built-up Area.

refineries, power stations, desalination plant, and petrochemical industries are located along the coastal edge taking advantage of coastal and marine environment. Harbors along the coast provide the services of trade and commerce. The coastal areas all around the Kuwait City is urbanized with commercial, residential, recreational and roads. The topography has changed considerably. Approximately 97 km of

coastline have been occupied by various land uses occupied by 25 coastal localities (Table 2 col. g) out of 104 occupied localities (MOP, 2006) in the state of Kuwait.

### (ii) Oil to Future

Kuwait has some of the world's richest oil fields with the Burgan field having a total capacity of approximately 70 billion barrels ( $1.1 \times 10^{10}$  m<sup>3</sup>)

**Table 2.** Census data for 2005.

Governorate (a)	No. of dwelling (b)	No of Household (c)	Total Road Area m <sup>2</sup> (d)	Total Road Distance Km (e)	Total Population (f)	Locality with Coastal Access or very near (g)	Population for the locality near to coast (h)	Total (i)
Al-Asema (Capital)	37,090	33,900	66,855,300	5,794	261,013	Dasman	626	89,052
						Sharq	18,100	
						Bnade Al-Qar	20,504	
						Al-Daiya	8,484	
						Faylaka	117	
						Shuwaikh Residence	2,383	
						Health District	1,724	
						Al-Shuwaikh Industrial	897	
						Al-Doha	18,405	
Al-Sulaibikhat	17,812							
Hawalli	119,933	106,074			487,514	Al-Shaeb	6,805	244,323
						Al-Salmiya	145,328	
						Al-Rumaihiya	28,115	
						Salwa	64,075	
Al-Ahmadi	65,045	55,230			393,861	Al-A'queilah	1,877	174,196
						Al-Funtas	21,096	
						Al-Mahboola	29,422	
						Abu Hulifa	23,208	
						Al-Mangaf	43,943	
						Al-Faheheel	51,210	
						Southern Coastal Strip	1,809	
						Al-Zour	1,631	
Al-Jahra	34,755	30,731			272,373	Al-Jahra	28,387	31,817
						West Al-Sulaibikhat	3,430	
Mubarak Al-Kabeer	22,764	21,754			176,519	Al-Messila	460	2,109
						Al-Funtas	1,649	
Al-Farwaniya	88,809	82,933			622,123	-	-	-
<b>TOTAL</b>	<b>368,396</b>	<b>330,622</b>	<b>66,855,300</b>	<b>5,794</b>	<b>2,213,403</b>	<b>25</b>		<b>541,497</b>

of proven oil reserves. The country is reckoned to have reserves of 94.8 billion barrels, about 9.6% of the world's total. This ranks it third in the world behind Saudi Arabia and Iraq (Encyclopædia Britannica, 2011). At current levels of production, Kuwait has enough oil to last for more than 100 years with recent discovery and production of natural gas.

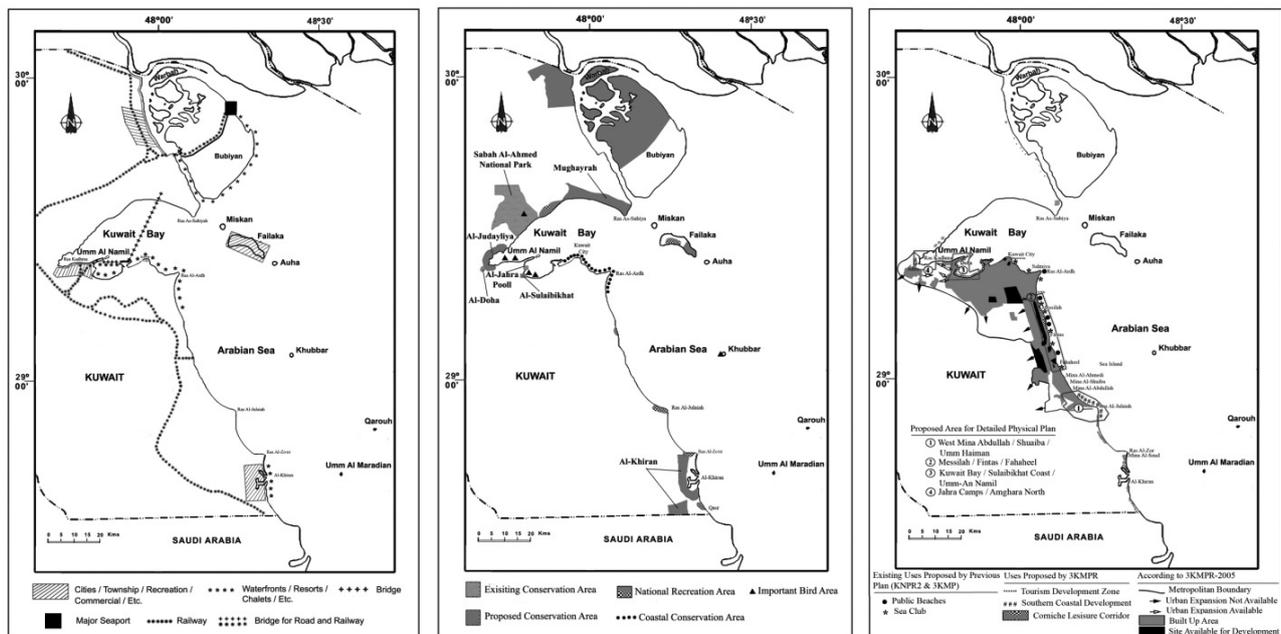
With the future economy still safe, in the hand of oil reserve underneath the geology of Kuwait, and with hope to last for many more years the development is leading new direction with mixed gesture. A positive sign towards the protection of coastal landscape heritage by declaring coastal protected areas (Sabah Al-Ahmed National Park) and bird migratory/habitat location; proposed marine conservation areas; national recreation areas (Fig. 8b) and; On other hand existing and proposed projects (Fig.8a) on railways interacting with the coast; bridges crossing Kuwait Bay; new mega port at Bubiyan Island; coastal townships at Jahra and Al-Khiran; exploitation of Failaka Island and; occupying coastal area for tourism would encroach virgin coastal areas and would alter the CML. Some of the proposed area for detailed physical plan according to Kuwait Master Plan (Fig. 8c) also would encourage the encroachment

and disturbance to sensitive natural CML which is discussed later in the section.

### (iii) Demographic Changes and Analysis

When the Utub tribe arrived in Kuwait there were some families of other tribes already living in the area, and these families joined the new Utbi trading settlement. Other families from the Anaza, were attracted by Kuwait's stability and in 1831 the population was about 4,000. In 1914 the population of Kuwait town (City) located at the headland of Kuwait Bay became 35,000. It can be interpreted that the rest of the present day Kuwait at that time was un-populated or very less populated. The town consisted of 3,000 houses, 500 shops and three schools. There were around 500 boats engaged in pearl-fishing and 30 to 40 larger vessels sailing to India and Africa. By 1922 the total number of Kuwaiti pearl diving boats reached 800 and there were over 10,000 people involved in the profession. There were as many as 300 boat builders; the timber came mainly from India. Table 3 represents the demographic growth data for different intervals of year.

It is interesting to note all the population was inhabited near the southern coast of Kuwait Bay and eastern side towards Arabian Gulf rather



(a) Current & future development (b) Existing & proposed conservation area (c) Kuwait Master Plan land use

**Fig. 8.** Activities at coastal edge of Kuwait.

**Table 3.** Demographic Growth.

Year	Population	Population Density	No. Of Dwelling	No. of Building	Source
1831	4,000				<a href="http://kuwaitpocketguide.com/kuwait-intro.asp">http://kuwaitpocketguide.com/kuwait-intro.asp</a>
1914	35,000	-	-	3503	<i>Encyclopædia Britannica, 2011</i>
1965	465,339	26.2	72,464	-	<i>MOP, 2006</i>
1975	994,834	55.8	137,639	90,712	
1985	1,679,301	95.3	228,814	116,129	
1990	2,086,000	-			<a href="http://ramsar.wetlands.org/Portals/15/KUWAIT.pdf">http://ramsar.wetlands.org/Portals/15/KUWAIT.pdf</a>
1995	1,575,570	88.4	251,682	119,856	<i>MOP, 2006</i>
2005	2,213,403	124.2	326,399	165,029	
2010	3,400,000*	-	-	-	<i>Lonely Planet, 2010</i>
2030	5,300,000*	-	-	-	<i>Estimated by 3KMPR</i>

\* *Estimated or Projected*

than towards the deep desert land. This continued growth trend in population as can be seen from Table 1 resulted in increasing demands for land along the coast, which will increase the pressures on the already sensitive coastal ecosystems. There will be need for more housing construction which may lead to encroachment on beach areas, removal of coastal vegetation (mangroves), improper waste disposal, coral reef degradation, depleting of coastal natural geomorphology and increase man made coastal landscape. Apart from mainland the only island which was highly populated was Failaka with an inhabited of about 5, 000 before the Iraqi invasion (1990). During that time schools, hospitals and commercial area existed at the island. Daily 2025- ferryboat used to sail up and down with inhabitants from Failaka to Kuwait City. Now it is without any inhabitation except government staffs, coast guards and government buildings. Umm Al- Maradin, in the south has a coast guard port.

#### (iv) *Cultural Aspects*

The advent of oil based economic resources has transformed the Gross Domestic product (GDP), a decisive factor in changing the CML. The economic factor has induced directly and indirectly the change in life style of the population and change of occupation from pearl farming, fishing and trading to oil exploration based industrialization and development. People are attracted to the coast as usual but with v different

purpose. Interest in coastal based real estates, housing, coastal roads, beach houses, waterfronts projects, coastal tourism and water sports have rose among the citizens. The construction of infrastructure facilities supporting these interests have significantly altered the landscape of the coastal edge.

#### **B. Trend of Interaction with Coastal Morphological Landscape– Land Cover - Land Use**

From 1760s through 1920s; the interaction with CML started with different purpose during different period of time with different location in the coastal regions of Kuwait. It can be noticed with the settlement of immigrants from Najad to Kadma as shown in historic timeline (Fig.4). The human habitation had to be supported by livelihood directly dependant on the marine resources such as trade, pearl harvesting and travel. They settled near the coast with activities like housing, ship and boat building, processing of pearl, etc. The interaction with natural CML was not severe because of less - exploitation of coastal land, construction, roads, dredging, excavation, reclamation, and human settlement. The development at the coast was for survival of mankind.

However during 1930s, the scenario of interaction with coast changed with the discovery of oil and the petroleum industry's rapid expansion after World War II can be seen at Al-Ahmedi (Governorate) coastal areas. The natural CML

was drastically altered with dredging, excavation, reclamation, and construction to establishment of refineries, oil pipelines, export facilities, major shipping ports and harbors, power stations, desalination plants, sea island terminal, and petrochemical industries. Simultaneously Kuwait city and Shuwaikh underwent a transformation and expanded in three directions to meet the demands of housing and urban structure, commercial buildings, major roads, utilities infrastructures and continues till day.

From 1970s the development took a different turn with more of revenue coming from the oil and continued till end of 1980s. The eastern northeastern coast towards Arabian Gulf was changed with major coastal land use features as Arabian Gulf Highway running parallel to the coastline; Waterfront Projects from Kuwait Water Tower to Ras-al Ard which stretch over 20 km; coastal defensive structures such as sea walls and protective measures; development of artificial beaches at Messilah, Mangaf and Angila from Arabian sands; Artificial Green Island and; Doha power station facing the Kuwait Bay and; Al-Khiran Resort in the southeastern coast.

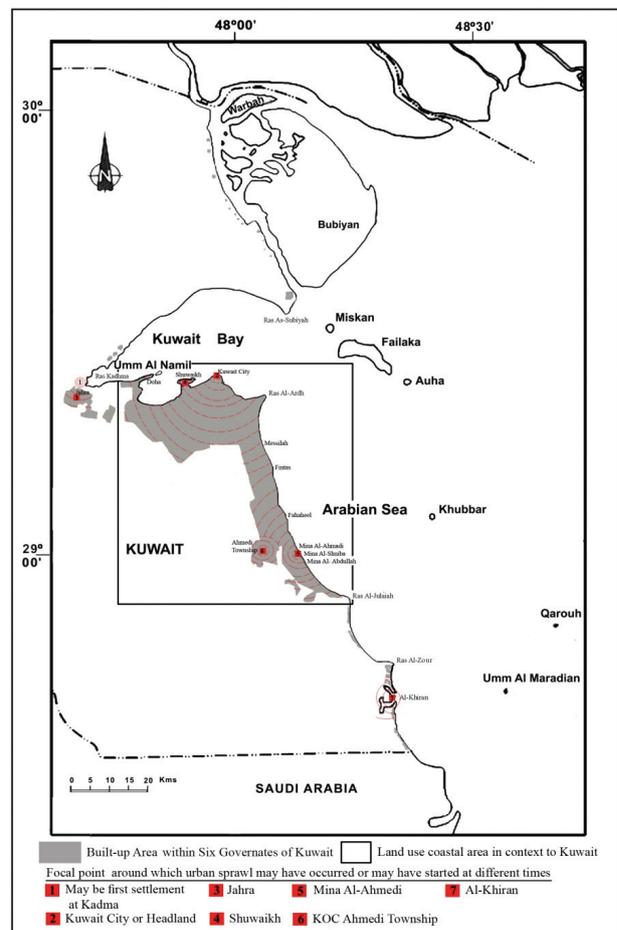
From 1990s after the significant end of Iraqi occupation, the coastal development took place with little progress because of setback brought by Iraqi sabotage, human and health hazards, massive environmental deterioration to air, land, and water. The effort was focused on rehabilitation and recovery. Still the unforgettable scars are left. Other important change at the end of 1990s is the Al-Zour power station coming towards the southern coast.

From 2000 the coastal development gained momentum focusing on coastal real estates and; the concept of Al-Khiran Pearl City coming to reality; initiation of concept of bridge across Kuwait Bay, National and Metro Railways connecting the coast; upcoming of Subiya power station and; Scientific Center and Aquarium at Salmiya coast. By this time the development and the land use at the northern coastal area had become saturated.

It is interesting to note that the present decade exhibits development occurring in the coastal development is not for survival and livelihood as it was in the early 1760s but for growing advanced demand, business, elite life style with GDP growth, comfort and leisure,

hospitality, water sports, and tourism.

It is interesting to note the pattern of urban growth may have started from certain focal point (Fig. 9) such as Kadma, Kuwait City, Shuwaikh, Jahra, Mina Al-Ahmedi, KOC Ahmedi Township, and Al-Khiran during different times. Among them the important decisive growth occurred around and from Kuwait City (with the starting of migration and inhabitation) and later one started from Al-Ahmadi (initiated with oil resource discovery). The sprawling of two focal points started growing towards each other in the opposite direction and merged to form one mega metropolitan boundary in the State of Kuwait.



**Fig. 9.** Focal point around which urban sprawl may have occurred or may have started at different times.

### C. Specific Drives and Human Factors Shaping the Coast of Kuwait

The specific drives and human factors responsible for shaping the coast of Kuwait are documented in the table 4 below:

#### D. Categorization of Coastal Area on the Basis of Land Resource Status

The studies have helped to categorize the coastal areas on the basis of available land resources near to the coastline into three categories: (i) matured and saturated (ii) developing and (iii)

vacant. The locations are plotted in Figure 10 and respective place name mentioned in table 5. The locations and their activities can be viewed from Figures below:

**Table 4.** Specific drives and human factors responsible in altering coast during different periods.

Periods	Specific Drivers	Human factors
Early migration, settlement and inhabitation	Marine rich resources (pearl, fishing) based survival	Pearl industry infrastructures near the coast
	Better climate near shore than harsh climate deep inside the desert away from coast.	Coastal human settlement and construction of houses, streets, shopping centers etc.
	Strategic geographical location and trade route	Construction of small jetties and ports
During the period of oil exploration and oil based revenue	Friendly coastal environment for establishing refineries, power stations, desalination plants, petrochemicals for smooth functioning	Construction activities: dredging, installation, infrastructure, water intake facility, commissioning and operation
	Economical mode of massive transportation, trade (export and import)	Construction of coastal and marine transport facilities, piers, and artificial sea islands
	Creation of oil based employment directly and indirectly. Migration of workers from other countries to the petroleum and other sectors	Coastal Urbanization and structures, commercial centers, and coastal roads
	Protection and security concerns	Coastal establishment to monitor and protect nation and property, coast guard facilities, etc.
	Occupying more coastal area and causing impact such as erosion, and accretion.	Construction of coastal protective structures – groins, sea wall, etc.
Post oil revenue	Adopting pattern of coastal development as similar to the neighboring oil rich gulf countries	Concept and construction of coastal real estates, and coastal lagoons
	Increase in GDP and change in life style	Construction of coastal Island (Green Island), recreation areas artificial beaches and waterfront projects, resorts, hotel, beach houses and reclamation along the coast.
	New vision of development	Concept of mega harbors and ports, bridges across Kuwait Bay, National and Metro Railway interacting with coast.

Matured / stagnant / retarding – these coastal areas have reached the level of saturation and the development is retarding. Some of these areas are seen with coastal renovation after demolition of old structures or upgrading of existing ones.

Developing – these areas are still on the course of developing and occupy the available spaces in-between.

Future prospective sites / vacant coastal sites / conservation area / proposed as per Master Plan – these places are either available for development or it is an existing conservation areas or reserved for specific development as per the Master Plan of Kuwait (KMPR3).

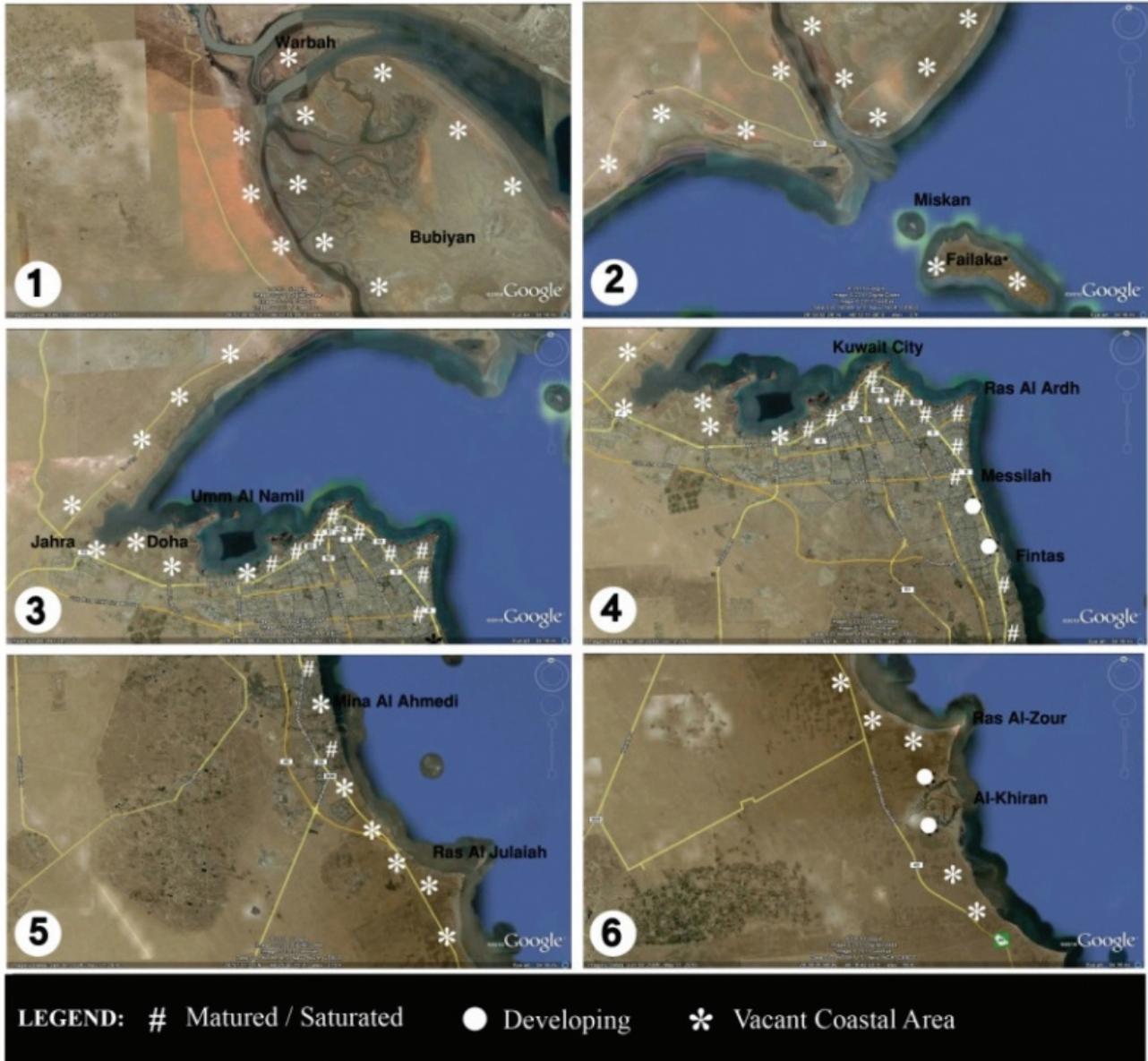
#### E. Vulnerability of Potential Coastal Areas to Encroachment

Vulnerable potential coastal areas to encroachment may be due to the less buffer distance between them and the activities identified, referring the information from:

- i. Work done by Al-Sarawi *et al.* (1985, 1998 and 2006), Baby *et al.* (2006 and 2010), and Al-Sarawi (1995).
- ii. Image generated for identifying geomorphologic features from processing of Landsat data (Baby, 2003a&b; Baby, 2004; Baby and Misak 2004).
- iii. Maps constructed (Figures 4, 6, 7, 8 & 9).
- iv. Tables 4 & 5.

These areas are in the northeastern side of Kuwait mainland facing Khur Al-Sabiyah, northwest coast of Kuwait Bay, coast of Kadhma Bay including north of Jahra, Sulaibikhat coastal area, and south of Al-Khiran till the boundary of

Saudi Arabia. Islands prone to vulnerability are Warbah, Bubiyan particularly the northern half, Umm Al-Namil, and Failaka. These areas have lots of chances to be infected by urbanization and associated impacts.



**Fig. 10.** Location of different Coastal Land resources and status (Courtesy: Google Earth).

**Table 5.** Areas depicting the coastal land resource status.

Near coastal land resource status	Near coastal areas from north to south of the mainland
Developing	Jahra, Messilah, Fintas, Mahboula, Mangaf, and Al-Khiran Pearl City (Lagoons) and Al-Khiran City.
Matured / Stagnant / Retarding	Shuwiakh, Kuwait City, Shuwaikh, Dasman, Sharq, Beneid Al-Gar, Shab, Hawally, Salmiya, Rumathiya, Al Beda, and Salwa
Future prospective sites / Vacant Coastal Sites Conservation Area / Proposed as per Master Plan	/Al-Bihayth, Al-Sabriya, Al-Bitanah, Al-Maghasil, Al-Sabahiyah, Umm Al-Ghirban, Al-Alaymah, al-Mutla, Sulaibikhat, Al-Julayah, Ard Az Zur, Nuwaysib

## CONCLUSION

It is seen that the discovery of oil, the rise of economy on its basis has affected the CML of Kuwait from the natural landscape that existed 50 years ago. Each year coastal regions experience the pressure of developments like increase in migration, commerce, changes in demography, and a general trend to retire to coastal habitat. As a result many coastal areas in Kuwait are continuing to experience unprecedented levels CML change that is a shift from natural morphologic landscape to manmade landscape. The trend and evolution is better understood by studying the HCMLC&A.

The trend in socio-economic, cultural and demographic aspects has evolved from the time of migration from Najad to Kadma till date. The specific drives and human factors responsible for bringing the change in CML differed from the period of early migration, settlement and inhabitation – to the period of oil exploration and oil based revenue - to post oil revenue. Oil based economic resources have transformed the GDP, a decisive factor in changing the CML. The uncontrolled growth have changed CML with activities such as rubble from historical sites was bulldozed into the sea, obliterating the natural character of the shoreline, beaches were buried ,the outcroppings of limestone in the intertidal zone were excavated and used for building materials or shore protection and all this occurred in the 1950s and 1960s.

The economic factor has induced directly and indirectly the change in life style of the population and change of occupation from pearl farming, fishing and trading to oil exploration based industrialization and development. Interest in coastal based real estates, housing, coastal roads, beach houses, waterfronts projects, coastal tourism and water sports have rose among the citizens. The construction of infrastructure facilities supporting these interests have significantly altered landscape of the coastal edge. It is well noted, with the developments and urbanization of the Governorates along the coast has tremendously changed the natural CML from what existed before the discovery of oil. The coastal areas all around the Kuwait City is urbanized with commercial, residential,

recreational and roads. The topography has changed considerably. Approximately 97 km of coastline have been occupied for various land uses by 25 coastal localities out of 104 occupied localities (MOP, 2006) in the state of Kuwait.

Coastal areas such as Kuwait City and all the northern urban areas that have reached a saturation level would tempt and force humans to invade and encroach virgin coastal areas such as Al-Bihayth, Al-Sabriya, Al-Bitanah, Al-Maghasil, Al-Sabahiyah, Umm Al-Ghirban, Al-Alaymah, Al-Mutla, Sulaibikhat, Al-Julayah, Ard Az Zur, and Nuwaysib. These are limited natural resource areas that hold high significance of ecological values. Among the matured areas near the coast are Shuwiakh, Kuwait City, Shuwaikh, Dasman, Sharq, Beneid Al-Gar, Shab, Hawally, Salmiya, Rumathiya, Al Beda, and Salwa. The coastal areas currently on the course of development and would alter the CML are Jahra, Messilah, Fintas, Mahboula, Mangaf, and Al-Khiran

The studies have identified the areas of northeast side of Kuwait mainland facing Khur Al-Sabiyah, northwest coast of Kuwait Bay, coast of Kadhma Bay including north of Jahra, Sulaibikhat coastal area, and south of Al-Khiran till the boundary of Saudi Arabia have lots of chances to be infected by urbanization and associated impacts. Island prone to vulnerability are Warbah, Bubiyan particularly the northern half, Umm Al-Namil, and Failaka. Existing and proposed projects such as: railways linking the coast; bridges crossing Kuwait Bay; new mega port at Bubiyan Island; coastal townships at Jahra and Al-Khiran; occupying coastal area for tourism would encroach virgin coastal areas and would alter the CML.

The Master Plan of Kuwait shows a promising coastal land use but it does not seem to be able to protect significantly the valuable natural CML of Kuwait as seen in this study. The Master Plan evolves continuously from time to time with changing aspects in various fronts dictated with the economic values rather than values of preserving the limited natural CML in the State of Kuwait. The details are discussed in the later section.

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