Findings and Discussions on Coastal Evolution of Kuwait, Review of Laws and Perspective of Developed Strategies

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***Abstract*—The development, life style and supportive system have exploited the coast more rather than the interior offshore land of Kuwait, thereby altering the morphological landscape through built up structures, population migration, coastline change, habitat change and land use apart from natural process. As a result Kuwait's coastal landscape has been subjected to tremendous evolution which was studied from remotely sensed images, historical pictures, aerial video survey and various visuals. Each of the section documents the research result in itself that was accomplished with specific purpose that takes the entire studies to the ultimate goal of exploring the trend in coastal evolution. The important tool used for the study was Remote Sensing Techniques, Geographical Information System, Interpretation of Images, Analytical Hierarchical Procedure, Rapid Impact Assessment Matrix, and Carrying Capacity Model.**

***Index Terms*—Images and photographs, mesopotamian marshland; demographic; coastline; challenges and conflicts; interrelationship diagraph.**

I. Introduction

Coastal zones extending from coastal plains across the continental shelves are regions where the landmasses, oceans and atmosphere interact. They are characterized by strong gradients in environmental and ecological assets and provide valuable living and non-living resources which are often exploited by humans on a non-sustainable basis[1]. This zone has the highest biological diversity and productivity compared to any part of the sea[2]. Kuwait is no different from this, but shows a spectacular and diversified arid coastal environment. The study was conducted with the motive of investigating the trend in evolution of Kuwait coastal morphological landscape (CML) and coastline from 1960s to 2012, to understand coastal landscape degradation and deterioration happening in Kuwait, to develop management strategies to protect the coastal environment and suggest mitigation measures.

Objectives: The research was conducted with a motive of investigating the unstained coastal morphological landscape evolutionary changing trend from human interference along the coastal area in the 'State of Kuwait'. The study targets to portray and explain the nature of CML transformation from human intervention that took place in the coastal zone of Kuwait since early 1960s i.e. more than five (5) decades. During these interlude of time the natural coastal landscape have undergone tremendous change.

II. Research Methods and Framework

Here are general techniques and tools (referred from Baby (2010) [3] that were utilized for the research:

Data and Input Information:

1) Primary information: (a) field work (b) reconnaissance survey with ground and aerial (flight) survey and (c) remotely sensed data.
2) Secondary and collateral information.
3) Literature review.
4) Interviews, questionnaires and discussions.
5) Tools and Techniques:
6) Application of Remote Sensing, Geographical Information System (GIS) and processing software.
7) Geographical Positioning System (GPS).
8) Choropleth mapping with exploratory data analysis.
9) Ground Truthing.
10) Ground and Aerial (Photography and Videos)
11) Visual Interpretation.
12) Zoning and Segmentation (urban coastal areas and coastline).
13) Carrying Capacity Model
14) Vector Analysis
15) Modeling
16) Fractal.
17) Analytical Hierarchical Procedure (AHP).
18) Rapid Impact Assessment Matrix (RIAM).
19) Strengths, Weaknesses, Opportunities and Threats (SWOT) Analysis.
20) Statistical Analysis.
21) Software and Hardware.

The above data and input; and tools and techniques were implemented for the following studies:

1) Collection of Background Information about coastal morphology.

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2) Literature review for gathering information on similar studies in the 'State of Kuwait' if any and review coastal laws, standards, policies and regulations.

3) Historic coastal morphological landscape characterization & assessment.

4) Perception and interpretation of visual data

5) Demographic trend and analysis.

6) Land Use Land Cover (LULC) changes studies from Remote Sensors and Images.

7) Coastline change studies from Remote Sensors and Images.

8) Carrying Capacity studies.

9) Studies on coastal sensitivity, vulnerability and coastal setback.

10) Impact assessment of anthropogenic activities on CML.

11) Building coastal management strategies

12) Mitigation measures and suggestions to protect coastal landscape.

Fig. 1 illustrates the research investigative-link diagram to summarize the concept and goal of the study. However, in this paper all the critical findings are being linked scientifically and logically to put radiance on the risk of coastal landscape resources being deteriorated.

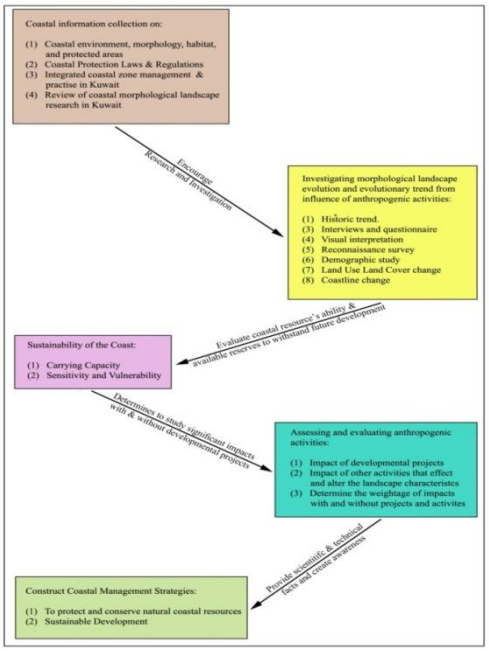

Figure 1. Research and investigative-link diagram

This paper furnishes the consolidated and comprehensive discussions on the results of four major stages of the entire research work:

1) Baseline studies on – coastal morphological landscape (CML) information collection, previous research, historic data and coastal protective legislations.

2) Investigation on coastal evolutionary changes limited to – coastline change, land use land cover change (LULCC),

3) Impact evaluation by – identifying anthropogenic activities and impact, carrying capacity, sensitivity / vulnerability and setback distance

4) Conservation and protective measures i.e.– strategy building

III. Significant Results and Discussion

This part lists the significant findings of the research and is discussed in the perspective of unearthing CML evolutionary trend and initiating efficient strategies to protect and conserve coastal landscape habitat and heritage of Kuwait.

II. A. Coastal Morphological Landscape (CML) Management

The great concern to protect the marine environment against pollution from various sources, prompted the State of Kuwait to propose in 1973 to the United Nations Environment Programs (UNEP), and has initiated an inter-governmental meeting of the States of the Region in order to develop necessary measures towards the matter. This has strengthened the development of organization which was later known as ROPME (Regional Organization for Protection of Marine Environment). With a view of strengthening governance in the region, ROPME has developed protocols addressing the critical areas of environmental management. It is the dedicated organization involved in coastal and marine management for entire ROPME Sea Area (referred to as the Kuwait Action Plan Region in the past) is the sea area surrounded by the eight Member States of ROPME: Bahrain, Iran, Iraq, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates. But, it has limitation under the set of rules in getting involved in the regional matters related to sea and coastal area. It was found that even Kuwait

Municipality has limited control over the coastal development. Apart from ROPME and Kuwait Municipality's involvement, Kuwait Environmental Public Authority (KEPA) is the only environmental agency in Kuwait established under Law No. 21 of 1995 and Law No. 16 of 1996 that holds set of laws and standards to protect and conserve coastal and marine environment.

All though it is well understood for the desert country like Kuwait the coastal and marine resources are the boon to the socio-economic development, there are no adequate integrated coastal management principles or any dedicated organization or institution solely engaged with coastal management[4, 5]. Judicious management of coastal resource has been realized to be a dire necessity to ensure the protection of vulnerable and sensitive landscape. In protecting there should be clear understanding of nature's endowments, resources, and reserves. Resources may be defined as the means of supplying human wants and which occur naturally are often called as natural endowment. They are the gifts of the nature. Reserves are the stocks of natural resources that are available over a period of time and should be exploited and preserved wisely. Sustained association of tangible coastal resources and intangible resources are primary important on our technological advanced civilization.

B. Evaluating the Capability of Applicable Laws and Standards

1) Kuwait Environmental Public Authority (KEPA)

The efficiency and effectiveness of law and current environmental organization (Law Decree No.62 of 1980) says about the protection of the environment in Kuwait. The explanatory note on establishment of Kuwait Environmental Public Authority (KEPA) says - the non-compliance with the existing legal obligation and shortage of implementation procedures are considered two main factors causing worry to the public and further the response to different environmental issues led to establish Environmental Public Authority (EPA), not only for limiting the environmental pollution but also to safeguard the different natural resources and administer the same with a more rational way to achieve sustainable development and involve the environmental elements in the planning structures in order to test the environmental options and environmental impacts.

Review of KEPA (2001)[6] for environmental requirements and standards in the State of Kuwait shows there are standard norms for to improve the environmental quality and maintain the natural resources of the environment. CHAPTER V refers to 'Protection of Marine and Coastal Environment. The first part of the Chapter consists of Article 58 to 62 for 'Protection of Marine Environment'. Articles 58 refers to the standard of ambient sea water quality that must be preserved according to specifications listed in Appendix (12) of this regulation. Other Articles refers the liquid-effluent discharge quality (Article 59-Appendix 13), industrial liquid discharge quality (Article 60-Appendix 14), treated liquid waste water quality (Article 61- Appendix 15) and quality of un bottled water (Article 62-Appendix 16). All of which is related to the pollution aspects of the coastal water. The second part of the Chapter consists of Article 63 to 70 for the 'Protection of Coastal Environment' is related to coastal land degradation and protection.

All the Articles do not directly target or prohibit or restrict the alteration of morpho-ecological and sensitive landscape from industrial and non-industrial land use, urban sprawl, encroachment, mining, reclamation, dredging and so on. The above legislations and standards are inadequate to manage, protect and monitor the coastal morphological landscape (CML) from being disturbed for developmental purpose under pressure and influence. The process adopted by KEPA for any projects is requesting Environmental Impact Assessment (EIA) (Chapter 1 of KEPA, (2001))6 before any project is implemented for any developmental activities as prerequisite for protective and mitigation measure to reduce the negative impacts.

Article 3 of Chapter 1-KEPA, (2001)[6] mentions that the studies of the environmental impact of the projects will deal with the direct or indirect outcome that would led to environment pollution, natural imbalance, impact on public hygiene, or how they may have effect on life, enjoyment, private or public properties, natural biological and non-biological resources in permanent way, and how they may have effects on historical, cultural, natural territories and the game parks.

Article 4 (point 5) of Chapter 1- KEPA, (2001)[6] says that client have to submit an environmental impact study initial report to the Authority to study and to give its opinion. Such a report should include the following details: Evaluation of negative, positive, accumulative and non-accumulative, direct and indirect impacts on the short-term and long-term stages, on the environment during the various phases of the project execution (as from the preparation stage, execution, operation, maintenance, accomplishment till after the expected age of the project or cancellation thereof), as well as the scientific illustration applied in assessment of these effects.

2) Kuwait municipality

Kuwait Municipality guides the construction related development at coastal area based on the 'Kuwait Master Plan' (amended from time to time), building guidelines and coastal protection criteria. The important aspects of the guidelines that are related to coastal morphology are:

a) The guidelines for building that is held by individuals on their own land along the coastal strip says about the construction ratio, number of floors (storey) and height, number of rooms, height for the roof wall and outer wall, components of building, permitted building area within the coastline, etc.

b) Adopt compatible filling, do not use beach sand with high sensitivity, development of marine barriers.

c) Get approval from competent authority to establish marina,

d) Do not build marina near mangrove,

e) For waves and breakers adopt concrete walls and rocky in line with the speed and direction of the waves and ocean currents, and prohibits the use of construction debris.

f) Prohibits rock and gravel extraction or removal of beach sand without permission from the relevant stakeholder,

g) Obtain license to set tourism projects from the concerned authorities.

h) Must move away coastal installations distance of not less than 150 m from the line of sandy beaches and around creek distance of not less than 50 m from the coast with stable nature and after approval of Environmental Public Authority and competent authorities to set up with a commitment in the design and construction of facilities and accessories in line with the nature of the site and environment.

3) Implication

The review indicates standards and guidelines are inadequate, not competent, to protect the coast. Guidelines does not say stringently about the buffer, set-back, sensitive, vulnerable coastlines. The land use pursues arbitrary set-back from coastline depending upon the coastal type and location of the site. Unfortunately, there are cases where the available guidelines are also violated. There is no transparency and the loop holes open doors favoring the clients, developers and stakeholders. Political pressure and legal draw-backs give developer the chance to ignore relevant environmental laws. On the other hand KEPA does not have any standard policies for holistic Coastal Zone Management (CZM) till date even though they have National and International mandate.

Dr. B. Al-Awadi, Director of 'The Arab Regional Centre for Environmental Law' during his address for "Global Judges Symposium on Sustainable Development and The Role of Law" at Johannesburg, South Africa (18-20 August 2002) that:

The survey of the existing Environmental Laws and Regulations in the State of Kuwait indicates that there is evidence that some progress have been achieved during the last decade in the field of environment in general. However, these advances have been inadequate in particular in the area of the enforcement of environmental law by the executing Authorities and also due to the reluctance of the judiciary system to play a leading role in the interpretation (open versus conservative) of the present laws pertaining to environment and to the judges' capabilities in the field of environmental law.

Furthermore, in his concluding statement says strengthening environmental Law programs in Kuwait is probably the most cost-effective way of achieving support for better management of Kuwait environment. In addition, co-operation between the various responsible Authorities involved in the enforcement of the environmental Laws and Regulations is also essential to unify their policies and to develop more effective national programs for the protection of the environment and to enhance environmental law.

C. Need to Study on CML Evolution and Developing Strategies?

The literature review considered from Baby (2011a)4and baseline under standings from Baby (2011b and 2011c)5,7provide sample support for the following:

1) Emphasizing the need for depicting and undergoing evolutionary studies of CML to 'protect and conserve' the depleting natural coastal resources and that would shift towards extinction.

2) Formulating strategies because of shortage of coastal management strategies that could help in develop and establish stringent and policies to frame dedicated regulations to protect non-renewable coastal resources of ecological importance from degradation and destroying.

The study helps in alerting and considering the situations which has been left unnoticed. It helps in overcome the crisis of depleting natural coastal resources and stress on morphological landscape in the 'State of Kuwait'. Let me restate once again why an understanding of evolution of CML is important –for the reason that the evolution of CML has a crucial influence in natural and human environment, because it is the template on which a wide range of biophysical and social processes act and interact.

D. Fundamental Information Retrieved from Historic and Recent Visuals

This part addresses the historical perspective of the human forces that drive coastal development, the processes and stages of alteration from natural shorelines to artifacts in the attempts to maximize human values. The information retrieved from studies depicted in Baby (2011c)7 and information gathered from visual data (satellite images, maps, photographic archives, videos, sketches, etc.) throws light on long-term and large-scale transformations of landscapes happening along the coast of Kuwait (referred from Paper 'Visual Interpretation of Pictorial Data and Reconnaissance Survey to Extract Information on Kuwait's Coastal Landscape' from authors Saji Baby and Mohammad A. Al-Sarawi accepted for publishing in Indian Journal of Geo-Marine Science from 'National Institute of Science Communication and Information Resources', India. It gives indication of the behavior and culture of the coastal development.

The trend demonstrates oil discovery at Burgan Oil Field on Feb 28th 1938 have great influence directly and indirectly in shaping and changing the history of the Kuwait coast (Fig. 2) through spontaneous development. The coastal development[7] can be sequenced as: - the construction of North and South Pier and Sea Island for exporting oil (1946-59); establishment of Mina Al-Ahmadi Refinery (1949); Shuwaikh Industrial Zone and Port (1960); power station at Shuaiba North (1965); Mina Al-Shuaiba Refinery (1966); Arabian Gulf Highway and protective wave breakers (1970); power station at Shuaiba South (1970); construction of Kuwait National Assembly building (1972); power station at Doha East (1977); Kuwait Tower (1979); development of Messilah,

Mangaf; Angila Beaches and other beaches along Waterfront Project (1980-2010); power station at Doha West (1984); Al-Khiran Resort (1986); Green Island (1988); power station at Al-Zour (1998); Scientific Center and power station at Subiya (2000); Al-Khiran Pearl City also known as Sabah Al Ahmad Sea city (2003/4); Bubiyan Railway and Road Bridge (2010) and Mubarak Al-Kabeer Port (2010). The location of development (Fig. 2) clearly indicates the correlation between the cultural aspects and settlement showing more affinity to the coastal environment and that too it was highly polarized towards Kuwait City along the edge south of Kuwait Bay merging with simultaneous development along the shores of the northern half along the Arabian Gulf.

Spectacular event was noticed from satellite image procured on 15th of June 1964 compared with image of 1st of August 1963, that the Mesopotamian marshland was flooded with water and the tributaries have carried the water downstream which have caused massive flooding, and submerged the low laying areas of Warbah and North Bubiyan (from LANDSAT images).The island of Warbah was completely disappeared. Subsequently, in the later images of 1964 and 1966 shows the land was recovered. After that, such events were not at all observed. Such events should be well thought-out in the future development along the coastline; history can / may repeat at anytime.

Accompanying important observations from LANDSAT images of 1966, 1967, 1968 and 2000 were for the coastal development trend along the Sulaibikhat Embayment, Governorates of Al-Asema, and Hawally. In the image for 1996 the Ring Road # 1, 2, 3 and 4 were not developed or did not stretched for longer distance as we could see from the image of 2000. During 1966 it was seen there was land use development and built-up at coastal areas of Al-Asema Governorate. The areas covered were Shuwaikh, Shamyah, Kaifan Murgab, Dasman, Mansouriya, Abdula Al Salem, Zuzha, Faiha, Kaldiya, Adailya, Rawada and Hawally. Images of year 1966, 1967 and 1968 showed the existence Kuwait City was mainly intense near Sharq and Murgab. Image of 1966, 1967 and 1968 reveals interesting observations, the existence of Al-Akaz island, the 10th Island of Kuwait and is no longer there. It was understood from 2000 image the area around this location the land was reclaimed for construction of Shuwaikh Port by merging with Al-Akaz Island. Yet another observation was the existence of sabkha (wetland) near the Kadhma Bay that was highly submerged during 1966, 1967 and 1968. Later on, much of the sabkha at Kadhma coast which was seen on images of 1966, 1967 and 1968 was seen dried (not existing in 2000 image).Built-up environment of 2000 image indicated the presence of Seif Palace, Sultan Center, Fish market, Kuwait Tower and Green Island.

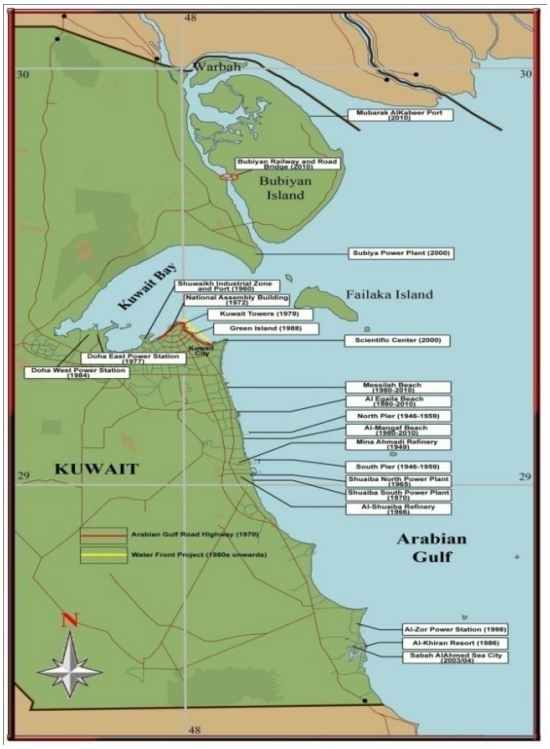

Figure 2. Sequence of major coastal development and location after oil discovery

E. Land to Sea and Sea to Land

Trends in shoreline reclamation intended for artificial beaches, coastal protection, artificial islands and; construction and inland dredging designed for ports, water inlet for power station, and lagoons have evolved (net increase of) the geographical area and/or the coastline of Kuwait.

Land use change study illustrates Shuwaikh Port, Kuwait Assembly building, Seif Palace, Sharq fish market, Sultan Center, Kuwait Tower and Green Island, Scientific center, artificial beaches (Messilah, Mangaf, Angila Beaches, etc.), Al-Khiran Lagoons, etc. is developed from reclamation (land to sea) or dredging (sea to land).The port of Shuwaikh serves the venue for sea-going-coming vessels at its deep-water berths. It is the country's most important commercial port and covers 320 ha of land and 120 ha of water surface. The stability of artificial beaches in Kuwait is fortified through coastal structures and nourishment. Artificial beaches especially along the 'Waterfront Projects' from Kuwait Water Tower to Ras-al Ard, which includes Green Island stretches over 20 km have extended land to sea through various coastal defensive management programs, techniques and coastal structures. Al-Khiran Pearl city is also known as Sabah Al Ahmad Sea city is located along the artificial Al-Khiran Lagoons where the sea is brought to land. These sites and establishment is moreover coastal landmarks of Kuwait born from coastal morphological landscape evolution.

F. Impact of Mesopotamian Marshland on Kuwait Coastal Landscape

One of the reasons behind the evolution in the coastline particularly in the northern half of Kuwait coast is brought from indirect impact of the changes in Mesopotamian Marshland region (from LANDSAT images of 1972, 1990, 2007 and 2011). In this context the major contributor in the changes of erosion and accretion are caused due to dynamics of Mesopotamian Marshland and the tributaries of Tigris and Euphrates which nourishes it.

Al-Qazweeni and Baby (2004) [8] have reported that significant part of the sediments is mainly originating from Shatt Al-Arab and Shatt Al-Basrah. Sediment-transport pathways drifted by the tide-induced currents and patterns of sediment accumulation along the coast of Kuwait are not static, but change over geological, historical, and seasonal time scales. Other factor that bring changes in the sediment budget are the result of natural cycles such as long-term changes in sea level, or of short-term fluctuations such as in wind, wave directions and long shore currents. Changes in pathways and sinks in the sediment budget are from the result of human influences.

The major human influence which was interpreted from coastline changes studies undergone for a period 1970 to 2011 in three different phases 1970-1990-2007-2011 shows the disturbances of Tigris and Euphrates and the planned drainage of the Mesopotamian marshlands. It depicts the region's worst environmental disaster in the history of human civilization that took place in two decades. The main reasons are meddling to natural system from Saddam Hussein's regime, diverting the water by building canals, blocking the water by dams. Saddam Hussein's regime began using water as a weapon, and a weapon of mass destruction during the period of Iran-Iraq war (1980 until 1988) and end of the first Gulf War in 1991. In the 1980′s, however, Saddam drained the marshland to punish the Marsh Arabs who rebelled against him and turned their green lush wetlands into dusty deserts. Following the second Gulf War (2003), a unique opportunity emerged to restore the marshlands in what has since been dubbed as 'the largest habitat restoration project in the world'. Water which was diverted away from the Iraqi Marshlands under Saddam was re-routed to the marshlands and with indication of new hope. In additional, dams built in at higher altitudes of Turkey and Syria for the purpose of regional development has significantly decreased the natural water flow to Tigris and Euphrates depriving the nourishing of Mesopotamia.

All these events had fluctuated the free flow of sediments downstream reaching the Shatt Al-Arab and Shatt Al-Basra showing symptoms of impact on coastal landscape and coastline through deposition or erosion, change in net sediment budget along the shores of Warbah, Bubiyan, Failaka, Miskan, Auha, Sabriyah, Subiya, and the coast of Kuwait Bay. These changes of evolution of coastline were clearly noticed in the visual interpretation of historic satellite images and change detection studies of coastline (from LANDSAT images 1972, 1990, 2007 and 2011).

G. Aesthetics and Visual Intrusion: Indicators of CML Natural Conditions

It is trend now days in Kuwait in some of the Environmental Impact Assessment to include visual intrusion assessment and is recognized as a significant aspects and components of environment. The coastal morphological landscape can be studied in the context of aesthetics and visual intrusion. The evolution of coastal areas showed the mixed sign of variation of aesthetics and visual effect at different geographical location. The cultural landscape aesthetics created at the cost of receiving natural morpho-ecological landscape is difficult to be graded as positive because of the opinion differences and one's own way of beauty perception. Visual intrusion has all-together a different meaning. Visual intrusion is similar to creating disturbance through blocking or opacity or translucent atmosphere in between the human eye and the target of observation. In this case the target of observation is coastline and sea. Aesthetics and Visual intrusion both refers to the human eye, sight and psychology. Aesthetics is the concept of beauty where as visual intrusion is the concept of obstruction along the eye sight (path of view). The appeal of aesthetics vary from person to person for example, a person who is not oriented to nature aesthetics would view urban and architectural design as aesthetics whereas to the person who is more inclined to ecology and nature would view it as less aesthetic and would appreciate the natural marshland, desert dune vegetation, coastal mangrove, and such type of landscape more.

From the scientific point of view landscapes is in the way considering a mosaic of "interacting ecosystems" [9]. The concept of 'landscape', encompasses both natural and cultural elements i.e. the natural landscape is the fabric that integrates settlement, agriculture, industry and ecology. Although landscape and visual are interrelated,

it is instructive to briefly explain the difference between 'landscape' and 'visual': 'Landscape' refers to the appearance of the land (its shape and color for example). It is not just a visual resource but is also shaped by a number of factors, such as the topography, geology and ecology of the area and any existing development or land uses. Generally, landscape impacts are changes that affect the character and quality of a landscape, due primarily to development.

Coastal landscapes and seascapes are an important and highly appreciated factor in our identity. The relationship between humans and coast is a topic that engenders much debate. They make a major contribution to our economy, tourist industry and quality of life. A specific aspect of the environment that engenders conversation is the coastal landscape: its beauty, its purpose, its abuse, and its future. Progress and expansions in terms of economic and commercial gain vary greatly in scale and in their potential for aesthetic and visual intrusion impact on the landscape. The aesthetics and visual impact was studied through reconnaissance survey and coastal field visit all along the coast that gave the judgment for evaluating aesthetics and visual intrusion at different geographical location.

Based on the sediment nature and morphology, the coastal zone of Kuwait is classified into two main provinces: northern muddy (material finer than 62.5 microns) province and southern rocky/sandy (coarser than 62.5 microns) province. These provinces are again subdivided into several zones [10]. Among the two, the Northern Province is described more by morpho-ecological aesthetic landscape. The northern coastal area is characterized by the presence of Khor Al-Subiya, which is a long tidal channel at 60 km long and 1.5 km wide, separating Bubiyan and Warba islands from the mainland. The coastal strip of this area has a muddy intertidal flat 300-1300m wide. The intertidal zone in this area is bound landward by a wide coastal Sabkha (low land occasionally flooded by water by high tide).

But there are places where momentous changes in the maritime environment are leaving a visual scar. The negative one is scars left due to the sand mining, illegal dumping, waste disposal, off-track vehicle movement, coastal reclamation along the coast of Kuwait Bay. The high rise building along the south coast of Kuwait Bay have disturbed beautiful visuals across the Bay to view the tidal flats and sandy area on the other side of the Bay through changing the natural landscape shape.

In the north-southern province along the Kuwait City-Salmia adjoining Kuwait Bay-Arabian Gulf, not only has the 'Waterfront Project' and beach nourishment, stabilized the foreshore and backshore areas but also promoted artificial aesthetic landscape buildup in this shore environment. Through these wise programs socio-economy of Kuwait was elevated. This is the place where you will find most people of Kuwait in the late afternoons. The projects of creating artificial lagoons at Al-Khiran would also have similar effect. This has a positive approach for all inhabitants, visitors and tourist. Most of the coastal areas in waterfront region are allotted or designated for urban land use. Such development quantitatively and qualitatively well balanced and proportional to the ecological landscape shows good sign supporting coastal human in as sustainable manner. Even such development exceeding the limit would bring more cumulative impacts. In case of Al-Khiran Pearl City, the primordial lagoon is on the course of development to enhance and exaggerate to bigger artificial lagoons penetrating deep into the land swapping natural morphological landscape with manmade landscape for the benefit of economy based on real estates.

A normal healthy eye can see almost an unlimited distance; normally vision is interrupted by something in the line of sight like condition of atmosphere, buildings, trees, the earth's curve, slope forward, and any other obstructing object. While, looking at the horizon, the curve of the earth stops from being seen farther and even on a very clear night, the Triangulum Galaxy can sometimes be seen. In the coastal governorates of Al-Asema (Kuwait capital) in the areas of Kuwait City from the location at distance ranging from 25 m to 250 m away the view towards seas is obstructed at an angle from ground level because of in between high rise and dense built-up environment. Coastal tour along the Doha indicates the rare locations showing good signs of negative visual intrusion exceeding for more than 7 km, the view range depends upon the slope of the land. Similarly larger coastal areas of Northeastern coast Kuwait in Al-Jahra governorates (covering Bubiyan and Warba coastline) is open from disturbances of visual intrusion for a distance may be more than 7km. In the hawally governorates, the range in the visual intrusion may vary from 50-200m for most places along the coast. In Mubarak Al-Kabeer the range may vary from 75 m to 1 km and Al-Ahmadi 50 m to 5 km. Visual intrusion varying from positive to negative is an indication of the level of dense and high rise urbanization along the shore. This symbolic study indicates that the most heavily visual intrusion affected coastal governorates and areas of Kuwait are the Al-Asema and Hawally governorates. The least is Al-Jahra and followed by Al-Ahmadi.

It can be said that the socio-economic development along the coast had increased the built-up landscape aesthetics at the cost of encroaching and destroying the natural aesthetics of the nature. Similarly built-up environment has increased the visual intrusion and put curtain before the eye through high rise and dense building on the natural landscape.

H. Demographic Influence on Coast

The dramatic socio-economic transformation and urban population between 1965 to 2010 took place during the last half century have led to a quick demographic increase and a displacement of population (from inland to the coastland emigration) and as a consequence on one side the exacerbation of the landscape resources, on the other side the abandonment barren desert land for coastal settlement. This combination of factors accelerated the unplanned and low sustainable coastal land transformation for urbanization, industrial development,

waterfront projects, beach houses, and real estates and in the same time the low quality sub-urban sprawl.

The 'Choropleth Spatial Interpolation Maps' referred from Paper 'Choropleth mapping and interpolation technique to analyze the demographic influence on Kuwait's coastal morphological landscape' from authors Saji Baby, Laszlo Nagyvaradr and Bettina Balassa (Accepted for publication in Environmental Engineering and Management Journal from 'Gheorghe Asachi Technical University' of Iasi, Romania) rationalize the density of people responsible for coastal land uses and causes alteration of morphological landscape. The maps for 1965-1985-2005-2010 show the demographic trend of the Coastal Governorates and the coastal conglomeration. Indefensible and unchecked consumption of coastal land resources by a large growing human population is at the center of most environmental problems facing in the Kuwait. Fortunately, at present all the islands of Kuwait are uninhabited even the Failaka which was once populated before the Iraq War. But in future in the trend of development, the master plan for Bubiyan and Failaka has provision to accommodate population which would trigger uncontrolled expansion in long run. It is crucial that human population numbers and coastal land consumption patterns be brought within Nature's ability to support human impact.

I. Implications of Coastal Changes: Coastline and Land Use Land Cover (LULC)

Coast and Coastline evolutionary trend and pattern noticed from land use land cover and coastline changes from LANDSAT sensor data (1972, 1990, 2007 and 2011) have yielded substantial facts that have supported the understanding about evolution of coast in relation to anthropogenic impacts. The activities such as dredging, land reclamation, coastal industrialization, urbanization, protective structures, waterfront projects, artificial beaches, artificial lagoon, artificial islands, coastal socio-economic development, coastal road, bridges and indirect influence from Mesopotamian marshland episodes. The changes area also caused from hydrodynamics process. The coastal landscape and coastline of Kuwait have tremendously been changed in the last half a century. Large change in coastline of mainland was noted from GIS computation for different years from 1972 with initial length of 339.1284 km changing to 339.8261 km in 1990 to 428.0973 km in 2007 to 479.0862 km in 2011(Fig. 3) An error of around +- 15 to 20% is assumed due to digitizing of coastline from Landsat images, vague in deciding the coastline due to low resolution satellite data, and variation in tidal condition. However, irrespective of error the optimization result indicates with no doubt there is an increase in coastline and particularly it was greatest from 2007 till 2011.One of the main reasons behind it is from development of manmade lagoon at Al-Khiran.

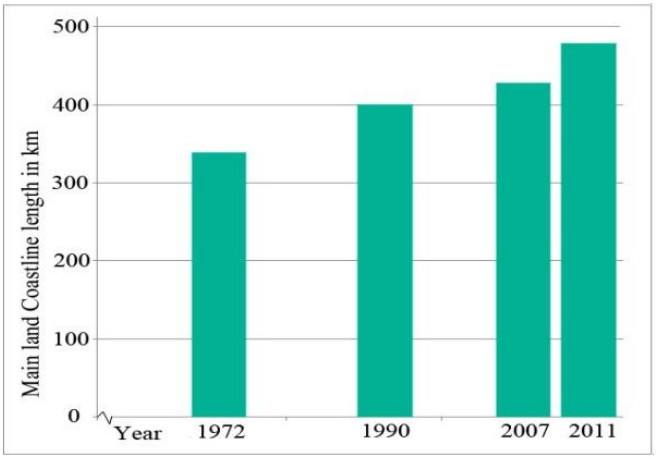

Figure 3. Coastline length for 4 different years (1972-2011)

The study clearly indicated that the northern half of the Kuwait shoreline covering shores of Warba, Bubiyan, Failaka, Miskan, Auhu Islands, shores of Kuwait Bay indicated massive change in coastline shape and dimension. Suspended plume distribution and sedimentation, have played main role in deposit in the areas of northern coast of Kuwait to change the shoreline and is more vulnerable. Whereas the southern coast starting from Kuwait City and towards the border of Saudi Arabia all along the Arabian Gulf is less effected and is more stable than the northern shores. The artificial beaches have added to the shoreline sand budget.

The erosion has been shifted to deposition along the coast as it moved from 1972-1990 to 1990-2007 and 2007-2011 (Fig. 4). Irrespective of that, the net erosion still remained higher for the entire period from 1972-2011. The erosions could not been compensated by deposition. It can be explained as such- apart from the contribution from natural process of erosion and accretion, land area reclamation for artificial beaches, islands, coastal protection measures, ports and dredging for ports, lagoons, etc. activities occurring during different times and years, have been reason behind increase or decrease.

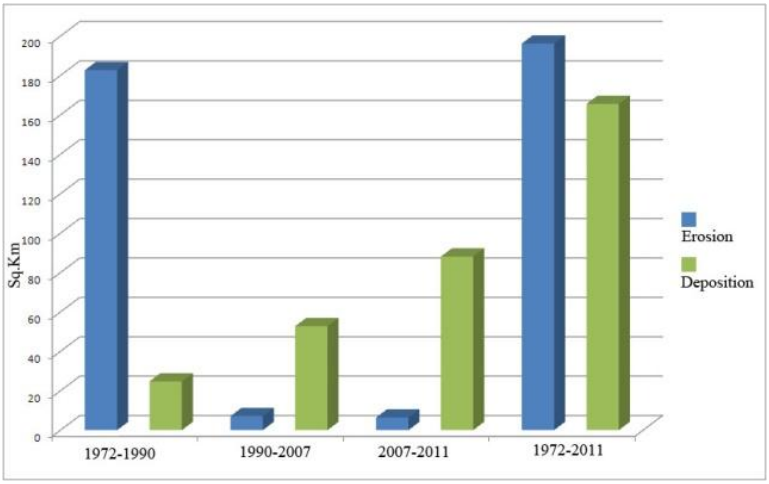

Figure 4. Erosion and deposition changes for different periods

The coastal erosion and accretion is an 'indicator' that measures changes in shoreline dynamics and efforts to directly counteract the adverse effects of those dynamics i.e. natural and human caused. Detailed monitoring of these changes is very important, especially if we take into account that the effects of climate change could increase substantially in the next 100 years in future. Information on shoreline changes can help to predict future changes and to prepare coastal land use planning, setback distance and develop adaptation policies.

The built-up area in Kuwait is more towards the Kuwait City along the shore of Kuwait Bay. The built-up area covers about 5% of the entire total area of Kuwait. The coastal area in direct contact with urban jurisdiction is approximately 159 km. The authors undocumented studies on coastal land use land cover indicated that 269.48 km2 of coastal land conversion (i.e. interfered) have taken place within decisive 5 km buffer inland from coastline during the period 1972 to 2011. For the first 18 years from 1972 till1990 the changes were 173.13 km2 i.e. approximately double the area than what was noticed from 1990 to 2011 for a period of 21 yrs with 96.35 km2. It should be noted that the changes due to erosion/ deposition are not accounted in LULC change studies. In these studies the ultimate goal was to track urban sprawl inland along the coast and hence the changes in coastline were excluded especially that was caused from erosion and accretion. Interpretation from other satellite images (IKONOS, Quick Bird, and Google Earth) and statistical information clarifies that the urban-built-up have not decreased but increased during the second phase and beyond. More buildings and structures have come up in the vacant land within the common boundaries in additional to new areas occupied. The study has demonstrated that the coastal land is the favorable place for development and adverse impact on natural landscape would increase to adjacent coastal area, if timely measures are not taken to avert the threat.

The quantified results from the changes of coastal land sue land cover and coastline can be properly applied for protecting coastal environment and this will in turn help in planning purposes for coastal community and avoid any sort of loss in property and natural heritage. As revealed in the previously done authors studies on coastline and land cover, the information on evolutionary trends along the shore and identifying coastal sectors of varying carrying capacity and sensitivities (Referred from Paper 'Determination of morphological landscape Carrying Capacity for coastal areas in Kuwait' from author Saji Baby accepted for publishing in 'Indian Journal of Geo-Marine Science' from National Institute of Science Communication and Information Resources) can be a guidance in declaring more sensitive protected area and better land use planning.

J. Connecting Carrying Capacity, Vulnerability and Setback

Carrying capacity is not fixed. It can increase or decrease depending on various factors. The pattern and extent of resource usage serves to be the primary factor that affects the carrying capacity a lot. This indeed depends highly on the socio-economic status of the people. Secondly, the use of technology also influences the carrying capacity, i.e. if technology is used in a positive manner then the carrying capacity can be improved whereas indiscriminate use of technology might degrade the carrying capacity. It can be altered by improved technology, but mostly it is changes for the worse by pressures which accompany a population increase. As the environment is degraded, carrying capacity actually shrinks, leaving the environment no longer able to support even the number of people who could formerly have lived in the area on a sustainable basis. No population can live beyond the environment's carrying capacity for very long.

The most vulnerable coast of Kuwait is around the Kuwait Bay, KhorSubiya Creek, lslands of Bubiyan, and Warba. The limited natural CML resources in Kuwait would be extinct within few decades if such an acceleration of coastal exploitation goes on without control, preservation and conservation strategies. The ecosystem of Island Bubiyan and Warba is highly vulnerable and complex, the response and impacts from any type of development would be unpredictable. In case

of the landscape south of Kuwait Bay, Kuwait City and southern shore of Arabian Gulf till the border of Saudi Arabia, the carrying capacity is very low near to the coast because of sensitive ecological landscape or high built-up environment (near saturation) or high population density.

The potentiality of morphological landscape carrying capacity for the coast of Kuwait was judiciously studied in Paper 'Determination of morphological landscape Carrying Capacity for coastal areas in Kuwait' from author Saji Baby accepted for publishing in 'Indian Journal of Geo-Marine Science' from National Institute of Science Communication and Information Resources. The category from Grant (2006)11 with modification were adopted to decide the distance factor i.e. setback for the development away from coast:

1) Areas where there is no potential for the landscape to accommodate development due to high morpho-ecological vulnerability.

2) Areas where there is already too much development in landscape terms, and where it might be appropriate to consider removal of development should the opportunity arise in the future.

3) Areas where existing development already reaches capacity in landscape terms and there are no further opportunities for development.

4) Areas where there is low potential for the landscape to accommodate development.

5) Areas where there is some potential for the landscape to accommodate development.

6) Areas where there is high potential for the landscape to accommodate development.

Studies by the author (manuscript "Determination of morphological landscape Carrying Capacity for coastal areas in Kuwait" accepted for publication in 'Indian Journal of Geo-Marine Science' from National Institute of Science Communication and Information Resources, India) demonstrates that the percentage of area covered by each carrying capacity classes with in each 1 km buffer zone continued till 10 km from coastline shows the increasing trend of carrying capacity when the distance increases. 20% increase can be seen compare to the first buffer zone (Buffer zone at 1km) and the last buffer zone (Buffer zone at 10 km). But 60% of the land is under "Low" to "No carrying capacity classes". It was observed that the ecological sensitivity was more near the coastline and keep reducing when the distance increase for the coastline. In the 1 km buffer zone nearly 80% area were considered as highly sensitive area whereas in the 10 km buffer zone only 60% area were coming under medium to high sensitivity classes. Within 3 km buffer distance from coastline, nearly 65% to 75% areas were occupied by medium to high ecological sensitivity classes.

This obviously clarifies that the carrying capacity and sensitivity increase or decrease is based on the distance from the coastline on land plus it is dependent upon the population density, the available land, landscape features, ecology and underneath fuel resources (oil and gas fields). In case of the west of Kuwait Bay and northwest of Khor Al-Sabiya the carrying capacity of coastal land is reduced due to vulnerable nature of the coastal topography which extend to 5 km from shoreline and beyond till the extent of JalAz-Zor coverage. JalAz-Zor is located northwest of Kuwait Bay, provides excellent basis for protection of biological resources that are under natural and human stress. It is observed that the distribution initiates with xerophytic communities that inhabit the non-saline depressions, ridges and end with the hygrophilous halophytic species that inhabit the salt marshes near the Arabian Gulf. Based on these factors the safe distance that would prevent from further deteriorating the ability of coastal landscape to carry would range from 3 km to more than 10 km perpendicularly from coastline.

The concept of carrying capacity can be easily understood from the below diagram (Fig. 5) modified from UNEP and PAP/RAC (1997)12-13 which was adopted to carry studies on tourism carrying capacity. Map constructed by Saji Babyfor carrying capacity, sensitivity and net carrying capacity observed at larger size and scrolled on computer screen for different coastal areas would indicate the ranking and grading for grid that would aid in coastal zone planning and development.

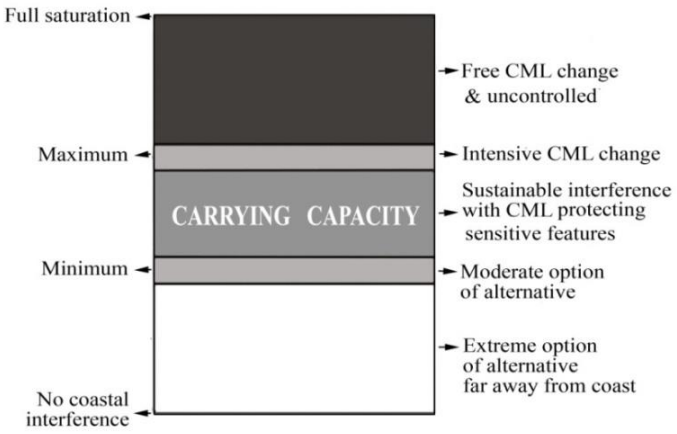

Figure 5. CML Carrying capacity model (modified after UNEP (1997) and PAP/RAC (1997) [12-13].

K. Intangible Cause

Rapid Assessment Procedure (RAP) through the application of RIAM14have identified 5 major anthropogenic activities in Kuwait distressing 5 major environmental components. These activities are recognized as the 5 'ultimate factors': i) Pipeline, outfalls, and intake (ii) Dredging, dumping, reclamation, shore and beach nourishment, beach repair, and construction (iii) Oil refineries complexes, oil terminals, petroleum industries, power stations, and desalination plants (iv) Beach sand mining and (v) Sewage treatment plants and other establishments. The 5 'environmental components' are: (i) Coastline and shore (ii) Site view (iii) Coastal land Cover (iv) Human habitat and urban sprawl (v) Coastal land degradation.

Fig. 6 illustrates the intermediate factor the 'intangible reasons' (1) Population dynamics (2) Economical and commercial aspects from oil exploration and production (3) technological revolution (4) Policies of Political and economical institutions (5) attitude and belief of modernization and advancement without the perception and realization of sustainable development (SD) have acted as two way gate in the process of rapid development. In one direction it gives opportunity for the 'ultimate factor' to exploit and consumes the 'proximate factor' the 'coastal land'. In other direction the 'coastal land use' environment provides the suitability for 'ultimate factor' to thrive because of weak 'intangible control'. These delicate dynamics between them is detectable on the status of the 'environmental components' which are the components that shapes the 'coastal morphological landscape (CML)'.

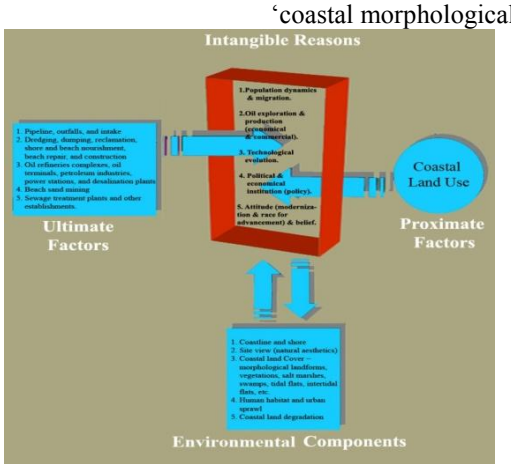

Figure 6. Intangible reasons pave way to ultimate factors responsible for coastal land use (proximate factor)

L. Coastal Crisis: Challenges and Conflicts

The crisis in the coastal zone is worldwide but is especially alarming in Kuwait where the natural coastal resources in dimension are limited. More than 95 percent of the population in Kuwait lives within approximately 845.22 km^2 area (out of total 17,800 km^2) and bounded by approximately 158.880 km coastline (out of total 500 km) and those numbers are only expected to increase. The study is committed to raising awareness of the importance of improving coastal resiliency in order to better protect and insure coastal regions. Human interference and development have posed considerable damage to the dynamic coastline of Kuwait since the last fifty years. The entire studies on coastal morphological evolution and trend have indicated some imperative challenges and conflicts Kuwait encounters:

Challenges

1) *Conservation and development policies.*
2) *Uncontrolled development.*
3) *Coastal land reclamation and dredging.*
4) *Coastal populations and shoreline degradation.*
5) *Coastal healing.*
6) *Controlling the boom in Waterfront Projects.*
7) *Conflicts*
8) *Evolution versus resources.*
9) *Socio-economic land use versus environmental.*
10) *Land reclamation versus natural landscape.*
11) *Occupancy of Small Island versus depletion of natural landscape.*
12) *Coastal development versus public access and visual intrusion.*
13) *Coastal protective structures versus negative aspects.*
14) *Growing population and demand for land.*

M. Anthropogenic Impacts, Morphological Indicators and Mitigation Measures

If we look the studies in Baby (2011d)[14], RIAM was utilized to study with motive of assessing the anthropogenic factor (i.e. human induced) that influences the coastal morphological landscape change (CMLC) (i.e. physical shape and dimension), and rapid evolution further determining the importance of human induced activities that affects and alters the coastal shape and dimension.

Whereas, in yet another study was conducted with an intention to assess the impacts from anthropogenic activities on the carrying capacity of landscape and come up with potential mitigation and preventive measures to protect the carrying capacity. The input components were same as that of RIAM analysis [14] but were reorganized and grouped (tuned to evaluate impacts on carrying capacity of landscape). The components are the same,

without any deviation binding integrity and consistency.In the study twelve major anthropogenic activities were grouped as existing, ongoing and future, and were evaluated for impact on six CML indicators and have indicated 10 potential reasons behind the impact. Impacts were evaluated with respect to type and magnitude allotting positive, negative, significant, insignificant, reversible, irreversible, direct, indirect, and grading from slight to very high. Entire process was performed with review of previous analytical and measurement reports of coastal EIA (Environmental Impact Assessment, Monitoring and modeling project undertaken; opinion gathered from experts; and response obtained from questionnaire distributed to stakeholders and environmental NGOs.

The results have indicated that 'existing activities' have permanently and significantly changed the coastal landscape whether it is positive or negative. It also gives the impression that the 'ongoing and future' project will have negative impacts from high to very high level of impacts from roads, bridges, railways, port and industries interfering with the coastal morphology of Kuwait Bay, at Subiya, at Sabiya, at Bubiyan Island and at Al-Khiran. The human interference which had brought or will influence significantly the coastal morphological is discussed in below paragraphs.

'Waterfront Projects' from Kuwait Water Tower to Ras-al Ard is the major coastal urban projects, proved to be success in enhancing the coast interfered by human activities. Mortan (1988)[15] mentions the following about the engineering structures such as groins, breakwaters, seawalls/bulkheads, and revetments. They are designed to control coastal land loss, but they can and accelerate land loss of adjacent beaches by changing wave refraction patterns and depleting sand supply. Shore-parallel structures cause erosion by narrowing the beach as the shoreline retreats. Some shore-normal structures contribute to erosion by either trapping sand that would normally move alongshore or directing the sediment-laden currents offshore causing permanent losses of beach sand. Seawalls and bulkheads can contribute to incomplete storm beach recovery by limiting the onshore transportation and deposition of sand. The structures can decrease the effective width of dry beach needed for aeolian transport and prevent the progressive transfer of sand from the fore beach to the back beach. As a result of this interference with the sand budget, natural dune restoration is prevented or prolonged and the total beach recovery is either incomplete or delayed. Conversely in case of 'Waterfront Projects' in Kuwait, Bou-Olyan and Al-Sarawi, (1993) [16] says that the stability of artificial beaches have rapidly adjusted to an equilibrium platform and profile. Yet, the fact cannot be denied that such structures disturb natural landscape morphology, associated ecosystem, carrying capacity and cannot recover from the previous lost one.

Deep-draft navigation channels for ports in Kuwait Bay or in case of future port in Bubiyan Island have the engineering practice of constructing from artificial inlets or converted from tidal inlets. Regardless of their origin they always create large sediment sinks that remove some beach-quality sand from the littoral system. On other hand, harbor, port, marina and jetties protecting the navigation channels can compartmentalize the coast changing the hydrodynamic process such as disrupting the flow of littoral drift and preventing the exchange of sand between adjacent coastal compartments. Historically specifically during the last 50 years, the sediment dredged for the purpose of constructing industries, refineries, desalination plants, power station, commercial and residential township along the edge of the coast has been placed in disposal sites located either near coastal land (replenishing or beach nourishment) or in relatively deep water on the continental shelf. The prominent impact is coastal morphological landscape change.

Newly constructed channels inlets at Al-Khiran Lagoon have chances in future to intercept currents and redirect flow altering the hydrodynamics of coastal water bodies and sediment dispersal patterns. In turn these modifications can initiate land area loss or gain by locally changing the erosive forces, water levels, and sediment supply.

Other important activity, such as mining along Kuwait Bay or elsewhere which includes beaches and near coastal areas for the purpose of construction aggregate (sand) can accelerate erosion as a result of dredging and excavation. Mining sand near the shore can cause additional land losses by altering wave refraction patterns and concentrating wave energy on the beach as a result of the depression created.

Fourteen mitigation and control solutions were suggested to shield the carrying capacity from negative impacts as identified from Baby and El-Sammak (2010); Baby et al. (2010); GEO (2010); WES (2007); WES (2009a&b); and WES (2010a&b)17-24. The predicted residual impact shows that the negative impact from existing activities can be improved. In case of ongoing and future projects the mitigation and control measures suggested gives hope of significant improvement and protect the coast from severe deterioration.

N. Interrelationship Diagraph (ID)

The 'Interrelationship Diagraph (ID)' was used as a visual tool that: (1) helped in the study to make use of team knowledge in the absence of hard facts and data; (2) display or plot the complexity and multi-variability of causal relationships among fourteen interrelated imperative solutions (mitigation and control measures); (3) allowed the expert team to help in depicting a web of related mitigation and control measures and (4) builds team consensus on priorities. It ended up with:

1) Which one is 'Drivers' the fundamental elements of a system that 'drive' the other parts.

2) Measures (elements of the plan that can be used to measure success of fourteen mitigation and control).

3) Systems understanding of the causal relationships between the mitigation and control measures.

4) Clearly indication that "Building of coastal management strategies" is the place to begin.

5) Pointed towards interesting solution—"Transparent EIA studies, EMP plan developed and implementation" provides scientific control over the solution "Strict statutory, rules, regulations and implementation".

The '**Building of coastal Management Strategies**' will have the largest positive impact and will go farthest in ensuring the success of all the other mitigation and control measures, to protect the intrinsic morphological landscape carrying capacity from human interference at the coastal interface.

O. Coastal Management Strategies Developed from SWOT and AHP Modeling

'Interrelation Diagraph' point to '**Building of coastal Management Strategies**' is the place to begin. This signified that it will have the largest positive impact and will go farthest in ensuring the success of all the other mitigation and control measures. This sign has laid strong foundation for groundwork in building coastal management strategies (CMS) through tools like SWOT (strength, Weakness, Opportunity and Threat) Analysis and AHP (Analytical Hierarchical Process) Modeling.

The strategies25derived from SWOT (Strength, Weakness, Opportunity, and Threat) - QSPM (Quantitative Strategic Planning Matrix) was optimized and rationalized (Baby 2013) with the concept of AHP (Analytic Hierarchy Process) /ANP (Analytical Network Process) modeling. The new priorities generated by optimizing and rationalizing by AHP/ANP Model was the best fit strategies for effective policy construction to tackle the coastal deterioration. Table 1 lists the top 5 strategies from 24 'Optimized and Rationalized Strategies' from Baby (2013) [26]

TABLE I. OPTIMIZED AND RATIONALIZED STRATEGY

Str.01: Involving EIA and its mandate, as supporting resource to create awareness methods and convince the importance of preserving the coastal morphologic landscape
Str.02: Solve conflict in the land cover and human interference through visioning process of environmental sustainable development and long-term programs.
Str.03: Meeting the demand of more land for urbanization and developmental activities, create buffer distance or set back from the coastal edge to protect coastal land cover and focus development away from the coast.
Str.04: Take advantage of the existing standard environmental laboratories, research centers, KISR, ROPME, KU and environmental consultancies in opening the door for doctorate studies in Kuwait with research topics related to sustainable development in Kuwait.
Str.05: Foreseeing the trend in human attraction towards coast, interest in having real estate on coastal areas, urge for luxury, increase in coastal urban encroachment; build coastal and marine management programs, rules, regulations and standards and based on obligatory EIA reports declare the sensitive coastal geomorphology as protected and restricted areas.

What we examine from the 5 top strategies is highlighting the significance of environmental impact assessment, severity in conflict of land cover and human interference; intensifying demand of more land for urbanization and industrialization; decisive need of standard buffer distance and set back from coastal edge; persuade more future research at doctoral level inside Kuwait; and declare the sensitive coastal geomorphology as protected and restricted areas based on obligatory EIA reports abiding by coastal and marine management programs, proper laws, regulations and standards.

P. Coastal Evolution Trend and Future Scenarios

As the pace of development and population pressure intensifies the coast, the landscape supporting the biodiversity is increasingly at risk. Developmental trend studies have revealed increased consumption of coastal land resources and with expanding population. The trend graph (Fig. 7) is constructed from the integrating and interpreting the historical data analysis, coastal demographic dynamics, detection of changes in coastline and coastal land use. A number of worrying trends are already visible in Kuwait. Rising consumerism will precipitated a serious threat of coastal land resource crunch. The trend indicates that unmanaged, non-scientific and non-technical use of coastal land will keep increasing in future in the next decade if it's not handled properly. Observing the graph (Fig. 7) it can be noticed at the crossroads of 2012 about 40-45 percent of the coastline is interrupted by the development and coastal activities. The year from 1980 to 2012 have undergone highest coastal development (20 - 30 percent coastline interrupted) as compared to the previous years or more than equivalent to what have happened in the last 70 years. If we consider years 1980 to 2012 the last decades from 1990 to 2012 have undergone tremendous development. If such trend continues unchecked there would be more demand on Kuwait's coastal area and marine resources and would be at the threshold of coastal ecosystem collapse.

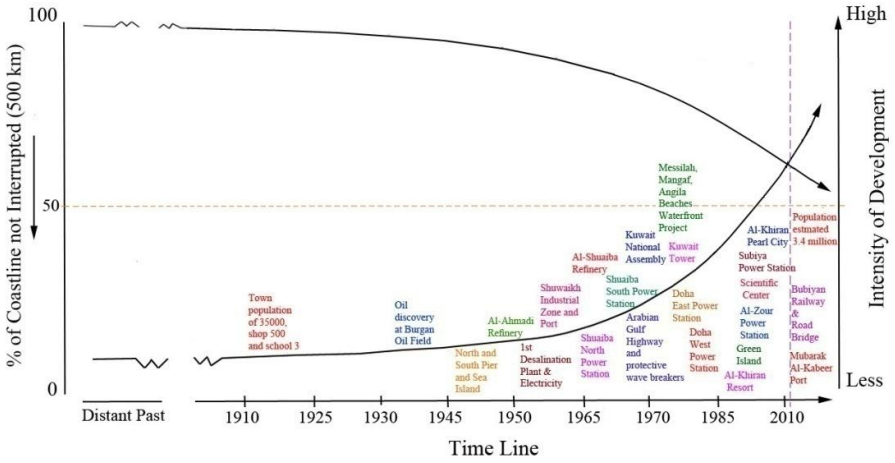

Figure 7. Idealized representation of the intensity of coastal landscape development in relation to coastline interrupted.

The coast of Kuwait is categorized into two main parts. One extending along the Arabian Gulf and the other around the Kuwait Bay and Khor Subiya Creek. Most of the former area is characterised by sandy beaches because it is exposed to sea currents and waves, while the latter, 70 km in length, is characterised by mudflats, especially in the shallow northern area of the Bay of Kuwait which faces Kuwait city.The trend in coastal land use activites shows that the one extending along the Arabian Gulf is occupied more by coastal land use activites rather than one around Kuwait Bay and Khor Creek which have undergone major changes from natural process or induced impacts.

Major coastal developmental projects upcoming in future listed below and shown in Figure 8.8 and 8.9 would be decisive in defining and characterizing the evolution of coastal morphological landscape in the State of Kuwait.

1) *Bubiyan road and railway bridges*
2) *Development of Bubiyan Island*
3) *Development of Failaka Island*
4) *Mubarak Al-Kabir Port*
5) *Sheikh Jaber Al-Ahmed Al-Sabah Cause Way: Doha link and Main link*
6) *Artificial Island and impact on coastal morphology*
7) *Future township at Doha, Sabriyah and Subiya*
8) *Al-Khiran lagoon, real estate and township*

Fig. 8 shows 11 main locations where the above developments will change the coastal landscape. It could be understood that development and impact along the shores of Kuwait Bay and Khor Creek would be greater than what would be in the Southern coast of Arabian Gulf because of natural morphological landscape setup conditions. Future new settlement plan for Subiya (1.0 million), Metropolitan area towards Kuwait Bay (2.8 million) and Al-Khiran (0.75 million); information obtained from anonymous source would be of great significance to the impact on changing and evolving coastal morphology of these area and beyond.

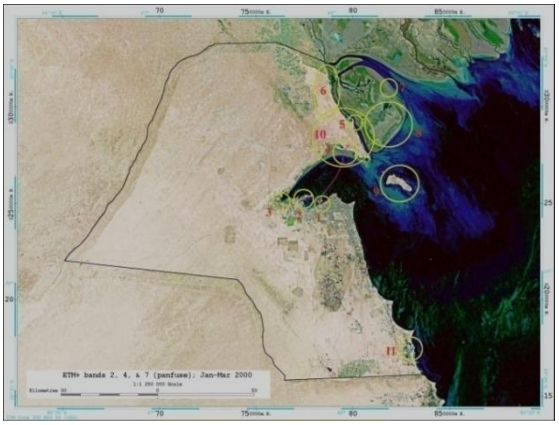

Figure 8. Location for major development

Any activities interacting with coastal landscape of Kuwait Bay and Khor Creek (Fig. 9) would be more ecologically magnified due to high sensitive landscape ecosystem as compared to what would happen along the Southern coast. These developments will pose uncertain complex impact along the ecologically important

landscape habitat from landscape alteration directly. Additionally from indirectly from induced or changed hydrodynamic condition along the coastal area of Kuwait Bay. The future developments have strong possibility to pose geomorphological threat to areas which could extend and expand beyond areas out of control. Bay Island South (29.7 ha) and Bay Island North (30 ha) are the two new islands that will be built along the route of the main bridge from Shuwaikh and Subiya. Doha Link is 12.43 km and Main Link is 36.14 km.

Figure 9. Major developmental projects in and around Kuwait bay and khor creek

(Source: Baby, 2003)[27].

End Note:

As understood from the results obtained from research studies, in highly dynamic coastal ecosystems with high demographic momentum towards coast of Kuwait either for residential or commercial or trade or recreational or petroleum related economic activities, adequate and timely responses are critical to current levels of environmental stress on coastal resources. One of the primary problems with coastal evolution directed by urbanization and industrialization is that human institutions of governance and cultural proclivities have never had to evolve under such time lines. As said by Baird (1996)[28] 'Institutional' performances is a conceptualized measure of the adequacy of societal response to environmental challenges and conflicts. Performance is determined by a complex set of interactions among the numerous entities that collectively determine society's response trajectory towards safeguard of the environment and limited and non-renewable natural landscape heritage. This includes governance/legal systems, jurisdictions, research institutions, educational systems, public sector and awareness.

IV. Conclusions & Recommendations

The research on coastal evolution has provided authentic and sufficient information to understand current and historical shoreline trends and characteristics. The erosion and deposition pattern of the coastline have helped in identifying stable / unstable, coast helping coastal managers, shorefront landowners, and potential property buyers to take appropriate decision. Since the master planning activities along several areas of the coast of Kuwait is in the pipeline, the outcome of coastal geomorphologic evolution studies will provide an important message to rethink / prepare / modify / revise master plans to sort out discrepancies in the plan.

Land reclamation and dredging are major problems and have affected coastal morpho-ecological landscape; moreover the habitat is increasingly becoming un-isolated. One principal hypothesis mentioned in (PAP/RAC, 1996)[29], is that morphology has a major impact on the ecological functioning. Any alteration in morphology would imbalance the ecosystem and carrying capacity. Concepts and the outcome of a carrying capacity study for CML would facilitate in carrying out a similar type of study in future for additional ecological components with sampling, analysis and measurement for physical, chemical, and biological parameters supported by modeling studies. One of the highlights of the work is the importance of manmade impact on the evolution of the coast and stressing the priority of coastal management and sustainable development of the coast through coastal zoning, buffering and set-back.

Studies reveal that there is lack of effective legislations that would shield the natural coastal morphological landscape. Moreover, the available legislations focus broadly on the coastal habitat, ecology and pollution aspects and not explicitly on coastal physiographic or landscape. The research provides scientific and technical information of CML changes that would give support to decision makers for ICZM planning for the existing or future engineering/ developmental activities and put forward strategies to initiate in developing policies, laws, regulations and standards to preserve coastal resources and natural landscape habitat.

This research work and study would positively assist in further and future extensive and intensive studies on coastal suitability, coastal zoning and categorizing land resources, creating more appropriate buffering, establishing set-back from coastline and considering alternatives and options including no-go-option before developmental activities are carried out. Ultimately developing a National Coastal Index Map (NCIM) on GIS platform is an encouragement from this study.

V. Recommendations

The antidote based on the research findings intended for sustainable development of coasts and coastline has been recommended to preserve the integrity of the coastal morphological landscape environment from deterioration, degradation and depletion. Fourteen (14) imperative recommendations are listed below with adequate explanation.

1) Urge –Greater Role of 'Kuwait Government' and 'Policy Makers'

2) Considering an Environmentally Preferred Alternative

3) Multi-Sectoral Approaches Towards Integrated Coastal Management (ICM)

4) Involvement of Stakeholders for Policy Making

5) Zoning of Coastal Areas

6) Considering Socio-Economic Factors

7) Design Guidelines for Protecting the Coastal Edges

8) Consideration of Setback Distance

9) Evade Coastal Visual Intrusion

10) Shoreline Management Plan (SMP)

11) Apply Smart Growth Principles and Approaches

12) Beach Management Practice

13) Crucial Policy Aims

14) Utilizing the Mandate that KEPA Holds to Protect and Conserve the Coastal Ecosystem

VI. The Way Forward

Future research should expand widely on carrying capacity of different aspects of the coast apart from the studies undergone hereby i.e. on coastal morphological landscape which could optimize the setback distance with more extensive research, and based on that, categorize the coast into zones for land use, and the modeling of coastline integration with physical survey, hydrodynamics process, coastal ecology, remote sensing and GIS covering the entire range of the coastline (including the islands) and predict future changes and risk. Future research should be enhanced with high resolution sensor data, digital aerial photograph and fractal analysis that can achieve higher accuracy and a new level of outcomes for shoreline geometry and coastal land use land cover pattern.

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