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Spatiotemporal Assessment of Accelerated Anthropogenic Shoreline and LU/LC Change: The Case of the East Coast of Qatar 1986- 2015

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Abstract

The study area along the eastern coast of Qatar has experienced a rapid change to its natural and built environments in response to the accelerated economic, urban development, and population growth over the past few decades. This study investigates the anthropogenic-induced spatiotemporal dynamics changes to the shoreline and the land use/land cover in response to this development. Remote sensing and GIS techniques were used to examine the impacts on the coastal environment. Results showed high total accuracy averaging 95.6%. The area witnessed an increase of 104% in built-up areas and 78% in urban greenery during the study period of 19862015-. Most of these changes took place between 2005 and 2015 as a result of unprecedented economic and population growth (annual average of 15% for GDP and 10% for population). A substantial change to the shoreline was reported through land reclamation of 2671 hectares by 2015 to cater to ever-growing cities and urban centers.

Keywords: Qatar, Land use, Land cover change, Shoreline detection, Coastal environment, Anthropogenic change, Remote Sensing, GIS.

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1. Introduction

The shoreline is defined as the line between the land and the water body[1] . Across the world, coastal areas are of paramount importance to human life. The UN Atlas on the Oceans (2019)[2] states that a great proportion of the world›s population (more than 40%) has settled within a certain proximity to the coast and that 80% of most populous cities are located on the coast. This bond between humans and the coast is explained by the fact that the coast has been providing humans with means of sustenance, economic prosperity, transportation, and other ecological benefits. Coastal areas are unique places for seagrass beds, mangroves, coral reefs, coastal vegetation, and other ecosystems that interact with, and affect, different forms of human activities[3]. This concentration of the population in coastal areas leads to significant damage to the delicate and ever-changing coastal ecosystems and the marine environments, giving rise to other challenges and stress on local communities[4]. Coastal areas are naturally highly dynamic and are subject to constant change due to anthropogenic and natural processes. Due to this dynamic nature, accurate monitoring and demarcation of shoreline is essential for understanding different coastal processes[5].

Remote sensing (RS) satellite imagery is commonly used to detect shoreline changes due to their potential of providing extensive information about the shoreline in an efficient and timely manner. Such imagery is capable of providing information about large areas repeatedly and, therefore, are very useful in the detection of shoreline[6]. In recent years, RS has become an established technology for global climate understanding, environmental monitoring, and planning, as well as accurate detection of land use and land cover (LU/LC) changes[7]. The integration of RS and Geographic Information Systems (GIS) plays a vital role in obtaining accurate and up-to-date spatial information regarding LU/LC[8]. Land cover (LC) defines the landscape of a region with its different constituents such as forest, wetlands, desert, water body and so on, while land use (LU) refers to the way this landscape is used by people such as urban development, conservation and so on(8.1). The change in LC due to anthropogenic activities has been described as the most significant environmental disturbance. Information about LU/LC is essential for planning the appropriate use and management of water, land, and vegetation resources[9].

Shoreline changes play a crucial role in coastal management and understanding the dynamics of coastal environments. Over the years, numerous studies have been conducted to investigate and analyze shoreline changes using various data sources and analytical techniques[10][11][12]. One of these studies was conducted along the coast in south India and used Digital Shoreline Analysis System (DSAS) to measure the shoreline changes after the 2004 Tsunami. This study relied on GIS and RS to understand the anthropogenic and natural processes in shoreline erosion, confirming the suitability of geospatial technology in shoreline change studie[13][14][15]. Another study[16] investigated the changes in accreted and eroded areas along the coast of the Nile Delta in Egypt using Landsat satellite images. They applied the Supported Vector Machine (SVM) classification and rectification approach that revealed a significant erosion in parts of the Delta and accretion on the southeast side. A different study[17] also analyzed historical shoreline using Landsat imagery and applying techniques such as the Modified Normalized Difference Water Index (MNDWI) and Normalized Difference Water Index (NDWI). In this study, they successfully utilized the Digital Shoreline Analysis System (DSAS) and found that the average shoreline change was 2.7 m/year.

This study aims to develop a better understanding of the coastal environment in east coast shoreline in Qatar, as well as the extent and magnitude of anthropogenic-induced LU/LC change during the study period between 1986 and 2015. The study also aims to investigate the scale of change to the shoreline as a result of land reclamation due to unprecedented economic and population growth during the specified period. Due to the scarcity of readily available data and research findings of this nature in Qatar, this study is important because it may constitute the basis for further related studies, as well as raise awareness about the current coastal urban structure and its challenges among planners and decision-makers in the country. This study does not address the effects of environmental and climatic factors such as climate change and sea level rise because they are beyond the scope of this study.

2. Study Area

Qatar is a peninsula located in the Arabian Gulf region, covering an area of 11,437 sq. km. The terrain of Qatar is mostly characterized by a flat desert, with a dry climate that is mild in winter and hot and humid in summer, receiving an average annual rainfall of 77 mm. Over the past few decades, Qatar has witnessed accelerated economic and urban development[(18)]. This was propelled by a large oil and natural gas industry where Qatar has the third-largest natural gas field and is the largest exporter of liquefied natural gas in the world. The rapid development has led to very high population growth due to the influx of expatriates who make up around 85% of the population[(19)], and has caused a large-scale migration of Qatari citizens from small towns and villages dotted the country to the major cities, primarily to the Capital City of Doha. Between 1970 (first census) and 2020 (estimated), the population jumped from 111,133 to 2,794,148[(20)], a massive increase of 2515% over a period of 50 years, with an average annual population growth of 6.66%. During the period 20042015-, the average annual growth rate of GDP in Qatar stood at 15%, while the average annual population growth for the same period was around 10%[(21)].

The study area is situated along the eastern coast of Qatar (Figure 1) and it stretches from the newly built modern cities of Lusail and the Pearl-Qatar in the north, through the capital city of Doha, then southward to the historical city of Al–Wakrah. This area experienced a large-scale change in response to the aforementioned developments. The new Hamad International Airport (opened in 2013) is also within this area. As such, the study area has a significant economic value, and it is imperative to understand the anthropogenic changes in shoreline and in LU/LC that may help decision-makers to assess the potential impact of these changes on the environment, society, economy, and infrastructure.

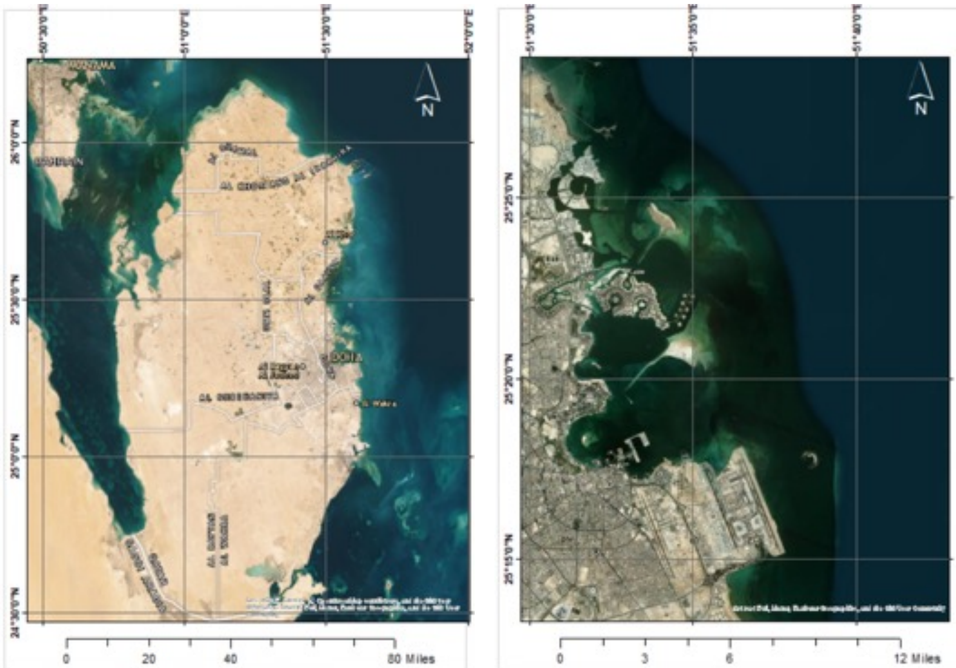


Figure 1: Study area: left, the State of Qatar. Right, the study area on the Eastern Coast of Qatar (source: ESRI Basemap).

2.1. Drivers of Urban Expansion along the East shoreline of Qatar

Qatar has undergone massive urban growth in the past few decades. New urban communities along the shoreline and in reclaimed lands from shallow water areas were constructed. Examples of such constructions include The Pearl-Qatar, Katara Cultural Village, high-rise towers at Al-Dafna, the City of Lusail, and the massive aviation structure of the Hamad International Airport (HIA). The capital city of Doha and other major urban centers are already situated by the coast, and planning policies and strategies are mainly targeting these cities as they are home to more than 95% of Qatar›s population. To aid the economy by increasing tourism activities, many economically valuable infrastructures are built on the coast of Doha. Another primary driver of urban growth along the shoreline in Qatar is hosting mega-sports events. While such events are short

and held within a specific and limited timeframe, organizing these events attract tourists and entails significant economic investments[33]. Such events lead to long-term effects on the host city›s infrastructure and economy, receiving global media attention[34].

Qatar created massive urban constructions back in 2006 to host the 15th Asian Games. However, the millstone increase in its urban areas, infrastructure, and transportation plans began after 2010 in preparation to host the 2022 FIFA world cup event which left a legacy of sustainability to the nation and the region. Besides its focus on the sports industry to enhance its economy, Qatar has been investing in the leisure industry, building hotels, attractions, museums, and amusements. The leisure industry and urbanization are intertwined, driving the demand for leisure services and the leisure industry contributing to urban areas› livability and economic growth. Effective urban planning is necessary to accommodate the needs and aspirations of urban residents while preserving natural and recreational spaces.

3. Materials and Methods

This study utilizes RS techniques and GIS data integration. The application of visual interpretation and digital image processing methods enables the extraction of LU/LC and shoreline information from remotely sensed imagery. On-screen visual interpretation, combined with ground-truth data collection, mapping, accuracy assessment, and data integration within a GIS environment is implemented in this study. Fieldwork involved the use of GPS, while software tools such as ArcGIS 10.x, Digital Shoreline Analysis System (DSAS) V 5, and TerrSet Geospatial Monitoring and Modeling Software are employed for image processing and data integration. Satellite images from Landsat and ASTER sensors are utilized in this study.

3.1. Data Sources and Data Collection

Most of the variables in this study are dynamic in nature and were derived from satellite imagery, freely available data as well as data accessible through the Center for GIS (CGIS) in Qatar. We used Landsat TM and Landsat 8 multispectral satellite imagery from the USGS›s EarthExplorer. We also used ASTER multispectral satellite imagery

downloaded from NASA›s EarthData archive. The dates of selected scenes span across a period of almost 30 years from 1986 to 2015, with intermediary dates in 1997 and 2005 which would help to understand the trends and evolution of shoreline and LU/LC changes in the area. The data sets used for this study are presented in Table 1.

In this study, fieldwork was carried out for verifying some ambiguous ground-truth information collected from Google Earth and for organizing image interpretation key used for the accuracy assessment of the output maps. Extra care and attention were exercised to record multiple observations of LU/LC types for each of the classes identified in the image classification scheme.

Table 1: List of data sets used in the Study.

Variable	Data Used	Resolution	Period
LU/LC	Scenes from Landsat TM	30 m	1986,1997
	Scenes from ASTER	15 m	2005
	Scenes from Landsat 8 (OLI)	30 m	2015
	historical aerial photographs (for map accuracy assessment)	variable	1986, 1997
Shoreline change	Scenes from Landsat TM	30 m	1986,1997
	Scenes from ASTER	15 m	2005
	Scenes from Landsat 8 (OLI)	30 m	2015
Population	Planning & Stat. Authority	N/A	1970 - 2020

Change analysis of LU/LC is often carried out to assess coastal vulnerability(22). The protection of an area becomes particularly important if it is of high economic, social, environmental, and cultural value(23). Therefore, understanding and assessing LU/LC change is essential for a country such as Qatar where major cities, including the capital city of Doha, are located on the coast. The RS scenes for the years 1986 and 1997 were obtained from Landsat Thematic Mapper (TM), whereas ASTER was used for the 2005 scenes due to lack of usable Landsat data for the study area during that year. As for the scenes of 2015, scenes were acquired from the Landsat 8 satellite. The Study area was categorized into six LU/LC classes described in table (2). Using ESRI›s ArcGIS software, False Color Composite images were created from satellite images of the years 1986, 1997, 2005, and 2015. Training samples were constructed and supervised classifications were performed using Maximum Likelihood Classification.

Table 2: List of LU/LC classes in the study area.

LULC class	Description
Open/Barren Land	Describes areas that are void of any type of construction, greenery, or any other land feature but includes undeveloped lands
Built-up Area	Designates constructed areas that include commercial buildings, roads, and housing developments
Saltmarsh/Wetland	Describes wetland ecosystems such as mangrove forests
Open Water	Represents deeper water body which is spectrally distinctive from shallow water
Shallow Water	Designates water body near the shoreline which is spectrally distinctive from deep/open water
Vegetation	constitutes grass, trees, or any type of plantation

The accuracy of each LU/LC map was assessed using random ground truth points[24] which were given LU/LC values using ArcToolbox function "Extract Value to Points",. Each of these points in the LU/LC maps was crosschecked against the real-world LU/LC type as interpreted from historical aerial photographs (especially for 1986 and 1997) and from Google Earth (using the Historical Imagery feature). A confusion matrix was created and the KAPPA coefficient was calculated, and areas covered by each class were calculated using sensors resolution and number of pixels covered by each LU/LC class. Figure (2) shows the flowchart which summarizes the method used to create LU/LC maps in this study.

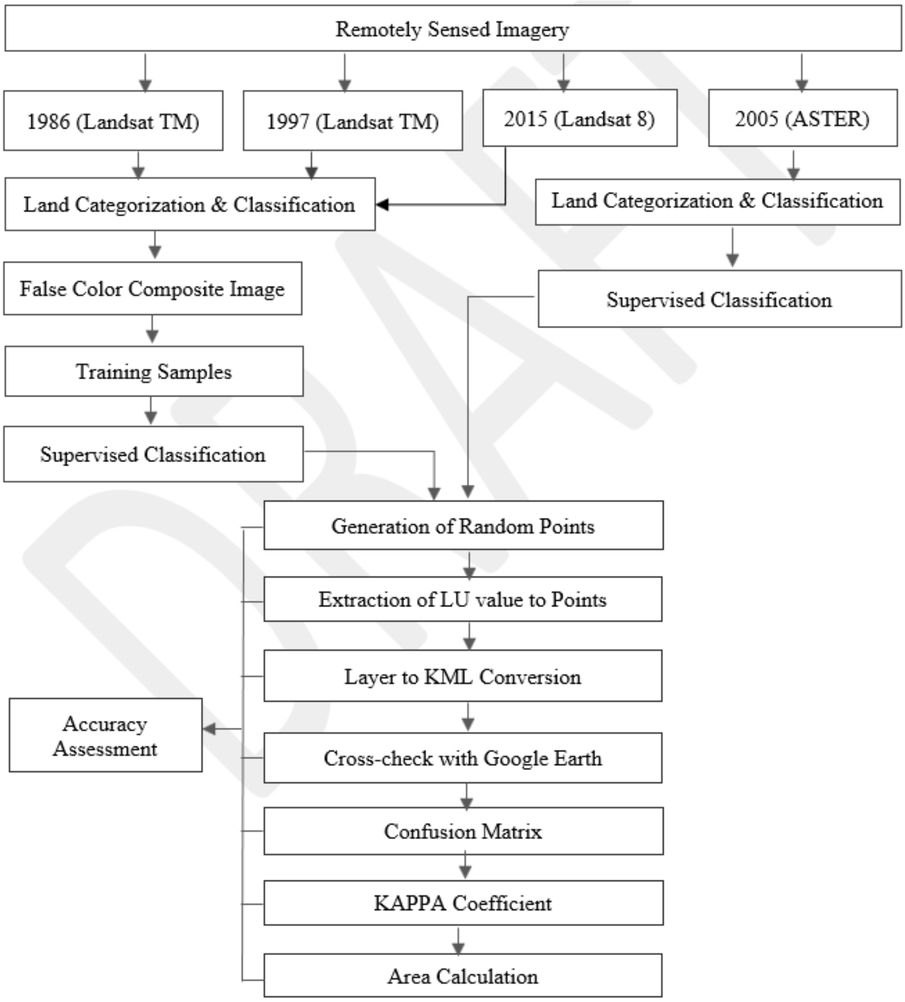


Figure 2: Flowchart of the method used to create LU/LC maps.

3.3. Shoreline Detection and Land Reclamation

DSAS V5 (Digital Shoreline Analysis System) tool was used to calculate the shoreline change rate using the mathematical model[27]:

$$V_c = \left(\frac{L_{ae}}{\sum N_{ae}}\right).Y^{-1}$$

where:

Vc = the mean rate of change forward / backward (m/year)

Lae = the overall length of a single transect on shoreline grids (meter) according to the entity accretion (+) and erosion (-)

∑Nae = the number of transects on each shoreline grid

Y = Time range for the extracted shoreline future set 1986 and 2015 (29 years)

This method was used to detect the shoreline of the study area for the years 1986, 1997, 2005, and 2015. The first step in this approach is Land-Water separation using the spectral band-ratio approach. The NDWI is then used to represent open-water features using the following equation:

$$NDWI = \left(\frac{Green - NIR}{Green + NIR}\right)$$

The values of the NDWI index are then converted into a binary format where the value [1] represents the land surface and the value [0] represents the water body, and then the shoreline is depicted(29). After the formation of the continuous edges which represent the shoreline, the polygon file was converted to a polyline and, consequently, the shoreline was acquired.

To assess the risks of loss to infrastructure and other economically valuable resources due to land reclamation, reclaimed lands were calculated using the shoreline of 1986 as a baseline. The area of reclaimed lands was extracted from LU/LC maps of 1997, 2005, and 2015.

4. Results and Discussion

4.1. LU/LC Change Detection and Assessment:

Figure (3-a) exhibits the 1986 LU/LC map where the most dominant classes are the open/barren and built-up areas, and the presence of a considerable amount of saltmarsh areas. Concentrated built-up areas are evident in the capital city of Doha, and then become scattered as we move outwards. Areas of Lusail and West Bay appear to be rich in saltmarshes, and this is also the case in the south towards an area where Hamad International Airport is located at

present. The 1997 LU/LC map of the study area (Figure 3-b) shows an increase in built-up area and in land areas dedicated to Doha Port and for the planned Hamad International Airport at that time (airport is operational now). The map also shows a green patch (Doha Golf Club) towards the Lusail area and an artificial lagoon to the south of it.

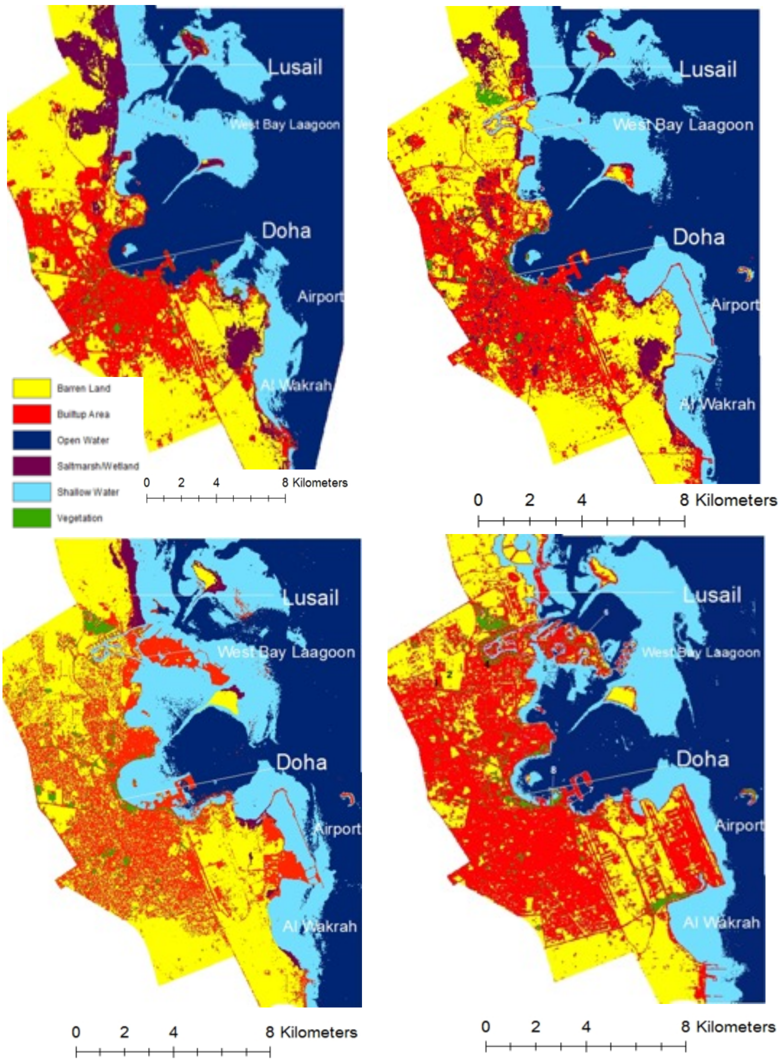


Figure 3: LU/LC maps of the following: a) year 1986; b) year 1997; c) year 2005; and d) year 2015.

The 2005 LU/LC map depicted in Figure (3-c), derived from ASTER satellite imagery, presents the initial stages of The Pearl artificial island. Contrasting with the other images utilized in this study, this map illustrates several notable changes. These include a considerable expansion of the land area occupied by the new airport, a reduction in the extent of salt marshes, and a notable increase in the built-up area. This highlights the accelerated anthropogenic effect on the ecosystems in the study area where wetlands are replaced by urban developments. Additionally, a visible increase in vegetation is observed along the coast, while the majority of natural saltmarsh areas can be detected along the coast of the City of Lusail.

For the 2015 LU/LC map (Figure 3-d), results show that the most prominent changes represent the completion of the new Hamad International Airport and The Pearl artificial island. The map also reveals a noticeable increase in the built-up area and in urban vegetation around the lagoon area, while a visible decrease in the open area is detected. Saltmarshes have apparently disappeared where these areas are turned into either open spaces or built-up areas. Figure (4) shows photographs taken during fieldwork in 2015 that represent the main LU/LC classes in the study area.

The confusion matrix and the KAPPA coefficient for accuracy assessment were calculated for the four LU/LC maps using 250 points. Table (3) for the 1986 map shows that the most accurately classified classes were open water and saltmarsh. However, some saltmarsh points were classified as shallow water due to the high tide when marshlands are partially submerged under water and their spectral reflectance becomes similar to shallow water reflectance. The overall accuracy and the KAPPA coefficient are regarded very satisfactory. Table (4) for the 1997 map indicates a lower accuracy for the Saltmarsh along the shoreline that were partially confused with built-up area and vegetation. This is because the grey-brown marshy soil gives off a spectral reflectance similar to that of concrete grey-brown built-up area.

Table 3: Confusion Matrix of LU/LC Map for Year 1986.

Class	(O/BL)	(BUA)	(OW)	(SM/WL)	(SW)	(V)	Total	Commission error (%)
Open/ Barren Land (O/BL)	**80**	5	0	0	0	0	85	5.9
Built-up Area (BUA)	0	**35**	0	0	0	1	36	2.8
Open Water (OW)	0	0	**83**	0	1	0	84	1.2
Saltmarsh/ Wetland (SM/WL)	1	0	0	**10**	1	0	12	16.7
Shallow Water (SW)	0	0	0	0	**31**	0	31	0
Vegetation (V)	0	0	0	0	0	**2**	2	0
Total	81	40	83	10	33	3	**250**	
Omission error (%)	1.2	12.5	0	0	6.1	33.3		96.4
KAPPA coefficient								0.951

Table 4: Confusion Matrix of LU/LC Map for Year 1997.

Class	(O/BL)	(BUA)	(OW)	(SM/WL)	(SW)	(V)	Total	Commission error (%)
Open/ Barren Land (O/BL)	**98**	4	0	0	0	0	102	96.1%
Built-up Area (BUA)	1	**37**	0	1	0	1	40	92.5%
Open Water (OW)	0	0	**70**	0	3	0	73	95.9%
Saltmarsh/ Wetland (SM/WL)	0	0	0	**8**	0	0	8	100.0%
Shallow Water (SW)	0	1	0	0	**19**	0	20	95.0%
Vegetation (V)	0	1	0	1	0	**3**	5	60.0%
Total	99	43	70	10	22	4	**248**	
Omission error (%)	1	4	0	20	13.6	25		94.8
KAPPA coefficient								0.927

Table (5) for the 2005 map reveals lower classification accuracy for saltmarsh where some points were misclassified as built-up areas. Vegetation, shallow water, and open water were accurately classified. Table (6) for 2015 map confirms an overall high classification accuracy, especially for vegetation and built-up areas, with an overall accuracy of 96.4% and a KAPPA coefficient of 0.952.

Table 5: Confusion Matrix of LU/LC Map for Year 2005.

Class	(O/BL)	(BUA)	(OW)	(SM/WL)	(SW)	(V)	Total	Commission error (%)
Open/ Barren Land (O/BL)	**120**	0	0	0	0	0	120	0
Built-up Area (BUA)	5	**26**	0	1	0	0	32	18.7
Open Water (OW)	0	0	**67**	0	0	0	67	0
Saltmarsh/ Wetland (SM/WL)	0	3	0	**6**	0	0	9	33.3
Shallow Water (SW)	0	0	0	0	**20**	0	20	0
Vegetation (V)	0	0	0	0	0	**4**	4	0
Total	125	29	67	7	20	4	**252**	
Omission error (%)	4	10.3	0	14.3	0	0		96.43
KAPPA coefficient								0.947

Table 6: Confusion Matrix of LU/LC Map for Year 2015.

Class	(O/BL)	(BUA)	(OW)	(IL/SW)	(V)	Total	Commission error (%)
Open/ Barren Land (O/BL)	**72**	5	0	0	0	77	6.5
Built-up Area (BUA)	1	**56**	0	0	0	57	1.8
Open Water (OW)	0	0	**71**	2	0	73	2.7
Inland/ Shallow Water (IL/SW)	0	0	1	**38**	0	39	2.6
Vegetation (V)	0	0	0	0	**4**	4	0
Total	73	61	72	40	4	**250**	
Omission error (%)	1.4	8.2	1.4	5	0		96.40
KAPPA coefficient							0.952

Spatiotemporal dynamics of LU/LC classes over the study period have been analyzed based on maps shown in Figure (3). Table 7 summarizes the area coverage of each of these LU/LC classes within the limits of the study area. Open water class was excluded because it is beyond the scope of this study. The table reveals significant growth in built-up areas from 57.69 km2 in 1986 to 117.74 km2 in 2015, which amounts to an increase of 104% over this period. A large portion of this increase took place between 20052015- (an increase of 72%) due to the accelerated development and rapid urbanization in this economically significant area.

On the other hand, the area of open/barren land has decreased by 15% between 1986 and 2015, but an opposite trend was observed between 19972005- in this class where an increase of 5.5% is attributed to the draining of some saltmarshes/wetlands in preparation for large development projects. By 2015, the Saltmarsh/Wetland area had totally disappeared from the study area. As for the vegetation area, it has increased by 78% during the study period which was a direct consequence of the introduction of progressive planning policies aimed at gradually increasing urban green spaces and improving the quality of urban life. Most of the expansion of vegetation area (37.3%) took place during 20052015- when the urban master plan started to take shape across the country, and more specifically within the study area.

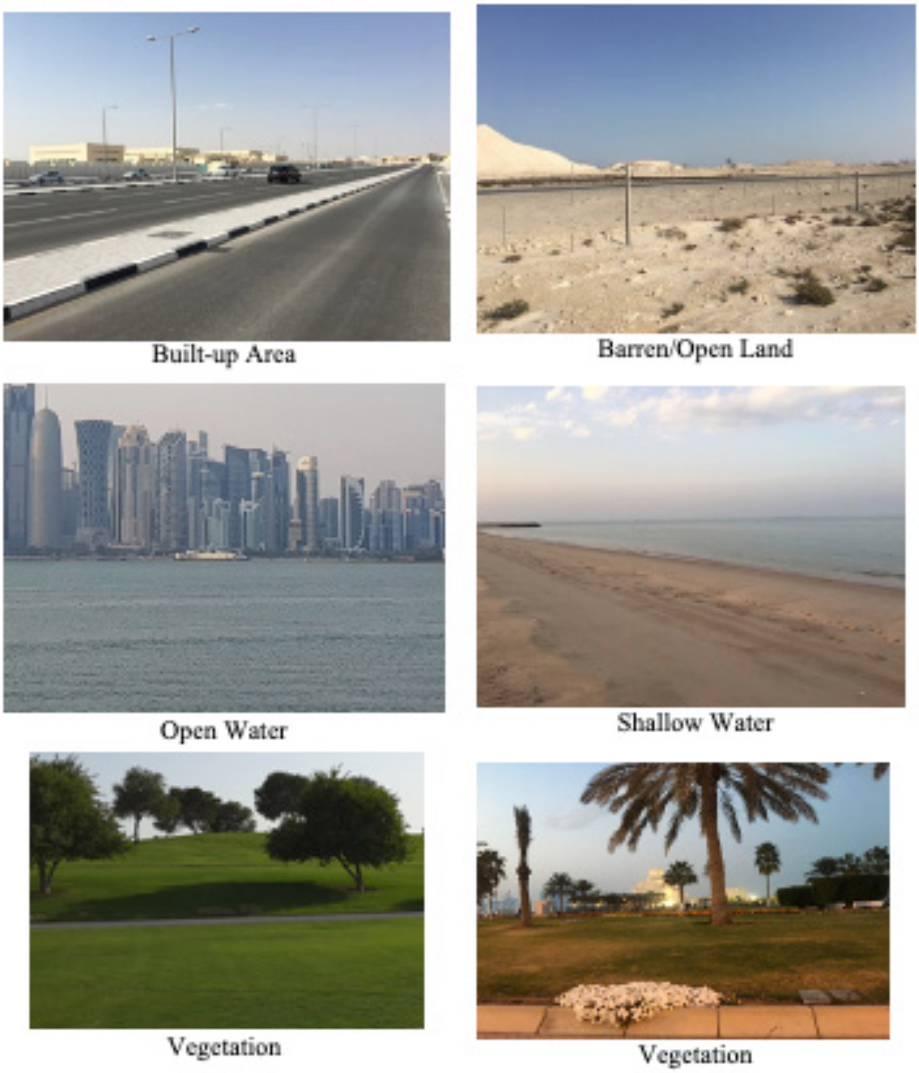


Figure 4: Photographs taken in 2015 showing the main LU/LC classes in the study area (source: authors)

Table 7: Percent area covered by each LULC class for the period 1986–2015.

LULC class	Area (in km2)			
	1986	1997	2005	2015
Open/Barren Land	100.95	99.65	105.11	85.82
Built-up Area	57.69	66.60	76.19	117.74
Saltmarsh/Wetland	25.92	22.48	5.15	0.00
Shallow Water	68.56	68.56	65.00	60.19
Vegetation	4.66	4.31	6.03	8.28

These results of LU/LC Change show that the natural coastal areas and the built environment in the study area have undergone a substantial change over the past few decades. This rapid change has been driven by accelerated economic growth, mainly fueled by a massive oil and gas industry, which attracted a large-scale labor migration into the country and caused an unprecedented population growth of 2500% between 1970 and 2020(30). The findings of this study confirm that rapid economic development and population growth have impacted the natural environment where, for example, the saltmarshes and wetlands have totally disappeared from the study area during the period of investigation between 19862015-. This kind of impact has also been documented and reported by other studies from different parts of the world(31,32) where the impact of human actions on the environment is very strong.

4.2. Spatiotemporal Dynamics of Shoreline and Land Reclamation

As explained in section (3.3), DSAS V5 model was implemented to extract the shoreline of 1986, 1997, 2005, and 2015. The study area was divided into four zones. Zone 1 covers the Lusail area, Zone 2 comprises The Pearl and the West Bay Lagoon, zone 3 consists of the coastal area of Doha City, and Zone 4 includes Hamad International Airport and Ras Abu-Abboud (Figure 5). Keeping 1986 as the baseline, the extent of land reclamation was investigated in the study area using the LU/LC maps of 1997, 2005, and 2015. The 1986 shoreline was used to clip the LU/LC maps so that only the LU/LC beyond the shoreline and towards the sea would be delineated. LU/LC areas were calculated in hectares (table 8). While the open/barren land in the reclaimed areas did not change much from 1997 to 2005, it witnessed a substantial increase of 355% between 2005 and 2015.

The built-up area has greatly expanded by 316% between 1997 and 2005, adding a substantial area of 943 hectares. The expansion then slowed down during 2005- 2015, adding 54% (669 hectares). The vegetation area also increased by 128.6% between 1997 and 2005 (adding 9 hectares of urban greenery) and then massively increased again up to 2015 by 700%, adding 112 hectares. Figure 6 shows the maps of land reclamation in 1997, 2005, and 2015 against a background of the 1986 map.

Table 8: Dominant LU/LC in the reclaimed land area.

LU/LC Class	Reclaimed Area in Hectare (HA) in each date, with 1986 used as a baseline		
	1997	2005	2015
Open/Barren Land	142	139	633
Built-up Area	298	1241	1910
Vegetation	7	16	128

This study shows that, in general, the shoreline in this area has not been receding over the entirety of the study period. The exception to this trend was observed in the 2015 map (Figure 5) where the shoreline has receded in zone 1 which was caused by the restructuring of the coast of the new Lusail City, and this can also be seen in the LU/LC map of 2015 (Figure 3).

Major changes in the shoreline were observed due to coastal projects and land reclamation to construct the new Hamad International Airport and The Pearl-Qatar. This trend in shoreline change, development, and land reclamation is common in most of the GCC (Gulf Cooperation Council) countries(35,36). Land reclamation and environmental implications of coastal wetland loss in Qatar's coastal wetlands, including marshes, mangroves, and estuaries, are particularly vulnerable to the impacts of urbanization due to their proximity to coastal areas, where urban development tends to concentrate.

Wetlands serve as vital habitats for various plant and animal species, including many endangered or threatened species. They provide grounds of abundance for commercially important resources such fish and shellfish, contribute to water filtration and purification, and act as buffers against coastal erosion and storm surges. Wetlands also play a crucial role in carbon sequestration and climate regulation, helping mitigate the impacts of climate change(37,38,39).

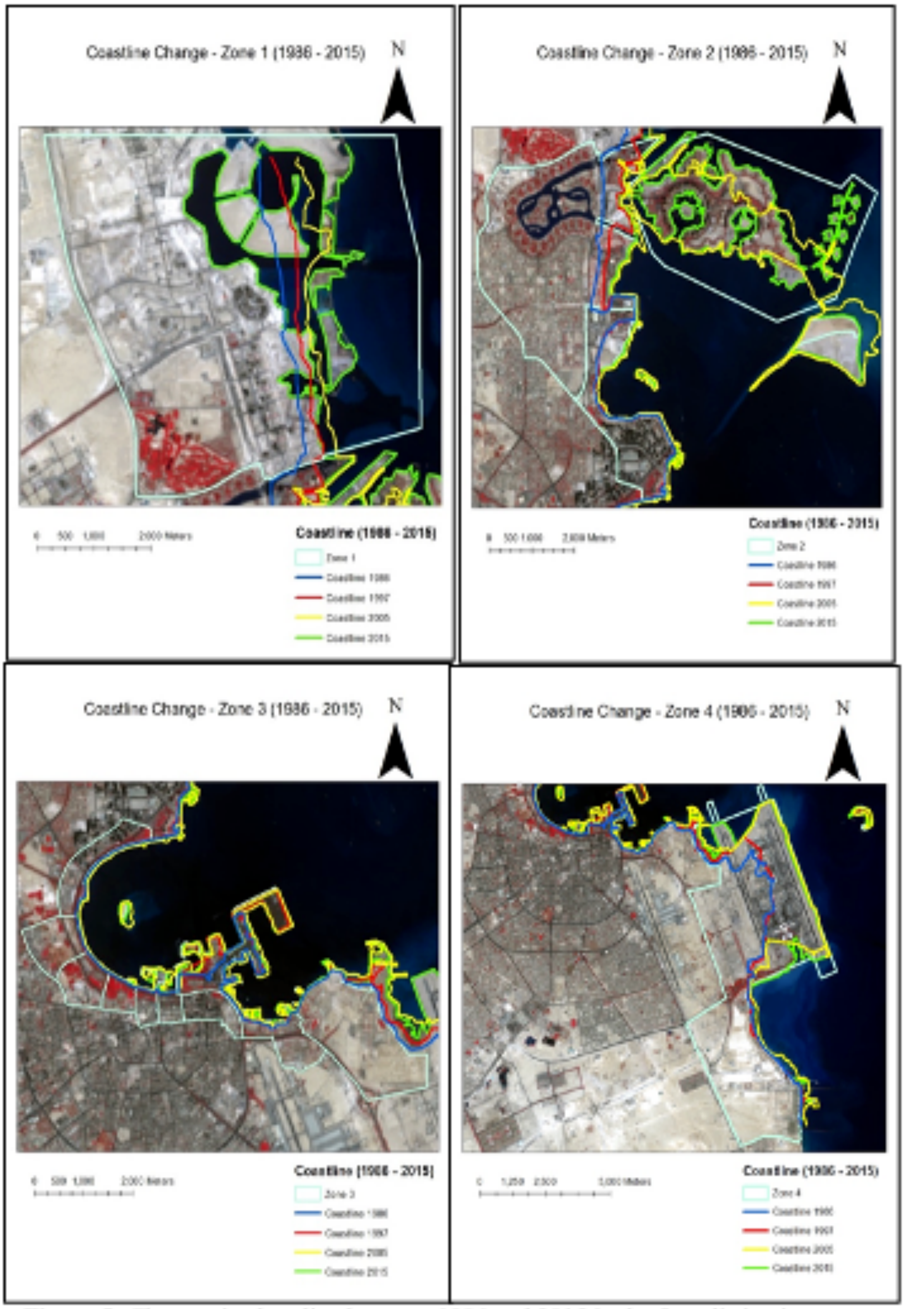
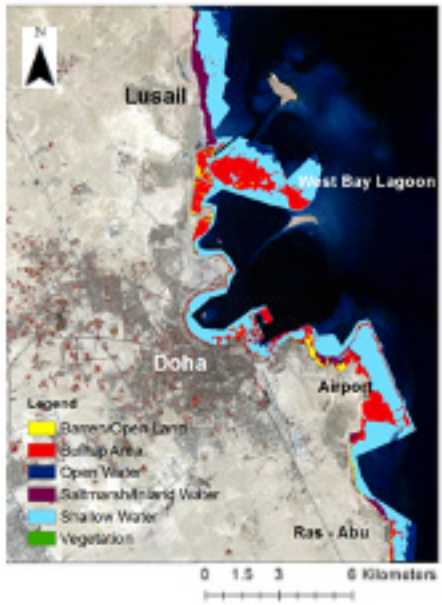


Figure 5: Changes in shoreline between 1986 and 2015 in the four distinctive zones.

Land reclamation in 1997 against 1986 background



Land reclamation in 2005 against 1986 background

Land reclamation in 2015 against 1986 background

Figure 6: Land reclaimed in 1997, 2005, and 2015 against a background of 1986 image.

5. Conclusion

This study managed to shed a light on the significant changes to the east shoreline of Qatar which has lost substantial areas of its marshlands. This loss was due to land reclamation projects and conversion to built-up areas and the associated urban greenery to enhance the quality of urban life. To the best of our knowledge, this study is the first of its kind in this vital socio-economic region of Qatar, and it may constitute a solid baseline for further investigations and monitoring of this coastal region and other similarly vital areas in the country. The study has demonstrated that in a country undergoing rapid economic growth such as Qatar, human actions, in the form of urban and infrastructure development, leave visible imprints on the natural environment in the form of changes to the land use/land cover and to the shoreline of the coastal areas.

The study also demonstrated the power of using well-established GIS and RS techniques to gain an in-depth understanding of the multi-decadal changes in shoreline and LU/LC caused mainly by anthropogenic factors. The availability of robust GIS & RS solutions and techniques facilitates a powerful monitoring and modeling system which can be regular, reliable, and in need of a minimum amount of fieldwork which cuts cost and produce faster monitoring results. This is particularly important for policymakers in the State of Qatar, which has been going through unprecedented economic, demographic, and social changes that have a profound impact on the natural environment and on the ecosystems of the country.

Nadeem Hashem
and Perumal Balakrishnan

التقييم المكانيّ – الزمانيّ للتغيّر المتسارع في خطّ الساحل وفي استخدامات الأرض نتيجة النشاط البشريّ: حالة الساحل الشرقيّ لقطر ما بين ١٩٨٦-٢٠١٥

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ملخّص

تعرّضت البيئة الطبيعية وكذلك البنية التحتية في منطقة الدراسة على الساحل الشرقي لدولة قطر لتغير سريع، وذلك استجابةً للتطور الاقتصادي والحضري المتسارع والنمو السكان الكبير على مدى العقود القليلة الماضية. تهدف هذه الدراسة إلى فهم الديناميات المكانية والزمانية والتغيرات الناتجة عن النشاط البشري على الخط الساحلي وكذلك على استخدامات الأراضي نتيجة هذا التطور. استخدمت هذه الدراسة تقنيات الاستشعار عن بعد ونظم المعلومات الجغرافية لدراسة تأثير الأنشطة البشرية على البيئة الساحلية وكانت النتائج ذات دقة عالية بمتوسط 95.6 ٪. أظهرت النتائج أن المناطق العمرانية قد ازدادت بنسبة 104 ٪ وارتفعت مساحة المسطحات الخضراء بنسبة 78 ٪ خلال فترة الدراسة من عام 1986 إلى عام 2015، علماً أن معظم هذه التغيرات قد حصلت بين عامي 2005 و2015 نتيجة للنمو الاقتصادي والسكاني غير المسبوق (بمتوسط نمو سنوي 15 ٪ للناتج المحلي الإجمالي و10 ٪ للسكان) خلال هذه الفترة. أظهرت الدراسة وجود تغيّر كبير في شكل خط الساحل بسبب الاستخدام الواسع للدفان في المياه الضحلة وإضافة مساحة 2671 هكتارًا من اليابسة بين 1986 و2015 من أجل تلبية الاحتياجات المتزايدة للمدن والمراكز الحضرية في منطقة الدراسة.

الكلمات المفتاحية: قطر، استخدام الأراضي، تغير الغطاء الأرضي، الكشف عن السواحل، البيئة الساحلية، التغير البشري، الاستشعار عن بعد، نظم المعلومات الجغرافية.

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