Geographical Analysis of the Impacts of Shoreline Changes Using Remote Sensing and GIS Techniques. Case Study: Rosetta Nile Branch Promontory, Egypt

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Abstract:

Rosetta Nile branch promontory; the western headland of the Nile Delta retreated dramatically during the last century. Such a retreatment was accelerated since 1960s after the construction of the High Dam, which reduced the sediment load discharged at the Nile promontory. Moreover, these dramatic changes of the shoreline had a number of significant adverse impacts, which need to be assessed and analyzed. Such an assessment and analysis may assist decision and policy makers in mitigating the adverse impacts of shoreline changes.

The main objective of this paper is to assess and analyze various impacts of shoreline changes in the vicinity of Rosetta Nile branch promontory during the period from 1972 to 2005 through remote sensing and GIS techniques.

For that purpose, the paper applied two different methodologies in order to delineate shoreline from MSS, TM and ETM+ images for the study area in 1972, 1984, 1990 and 2005. For MSS image of 1972, the band ratio of [(Band3 + Band4) / Band1] was applied. Meanwhile, for TM images of 1984 and 1990 as well as ETM+ image of 2005 a combination of histogram threshold of band 5 and two band ratios (band 2/band 5 and band 2/Band 4) was employed. Moreover, a geodatabase for the study area was developed to map and quantify shoreline changes. Also, the developed geodatabase was employed to analyze these changes spatially and assess their impacts

The study found that the maximum retreatment of the shoreline in Rosetta Nile branch promontory was about 3010 meter between 1972 and 2005 with an average retreatment rate of 91.21 m/year. Such dramatic changes of shoreline during the period 1972 – 2005 had a significant impact on the territory, infrastructure and land use pattern of the study area. For example, the study area has lost about 11.6 km^2 of its territory during the period between 1972– 2005. Also, about 7.6 km of roads were lost. Moreover, retreating shoreline contributed to the development of wetlands, which in turn, affected land use pattern in the study area.

Keywords: Rosetta, band ratio, histogram threshold, shoreline changes.

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1. Introduction:

Nile Delta is one of the most distinct features and populated area in Egypt. Currently, the shoreline of the Nile Delta is subjected to extensive changes due to a wide number of factors. Rosetta Nile branch promontory, which represents the western headland of the Nile Delta retreated dramatically during the last century. This trend has been accelerated since 1960s after the construction of the High Dam, which reduced the sediment load discharged at the Nile promontory. These dramatic changes had a wide range of significant adverse impacts, which need to be assessed and analyzed regularly. It is thought that such an assessment and analysis may assist decision and policy makers in mitigating the adverse impacts of shoreline changes, and attaining sustainable development of coastal zone.

Shoreline changes in Rosetta promontory have been repeatedly considered. Most of the previous studies were concerned with monitoring shoreline changes of the Nile Delta including Rosetta promontory. For example, Frihy and Komar (1993) assessed the changes in shoreline of the Nile Delta. The study carried out a field survey for beach profile at 65 positions along the coastline of the Nile Delta. The results evaluated the average annual rate of shoreline retreatment along the Rosetta promontory to be as much as 106 meter/year between 1971 and 1990 (Frihy and Komar, 1993). Similarly, White and El Asmar (1999) detected the changes in Nile Delta coastline during the period between 1984 ad 1991 from three TM images using region growing image segmentation algorithm technique. The results revealed that Rosetta promontory experienced rapid rate of change during the period 1984-1991, which was estimated to be as much as 113.8 meter annually during this period (White & El Asmar, 1999).

Other studies investigated various factors undelrlying shoreline changes in Rosetta promontery. For example, Frihy & Dewidar (2003) argued that the shoreline in the Rosetta promontory retreated dramatically during the past few decades and accelerated since the 1960’s after the construction of Aswan Dam, which reduced the sediments load discharged at the Nile promontory (Frihy & Dewidar, 2003). The reduction in sediments supply and the continued action of waves and currents induced coastal erosion leading to significant changes in the shoreline (Frihy, et. al, 2003). Similarly, Akl (2004) concluded that the shoreline has eroded and retreated since the 1960's as a result of a wide range of factors such as waves action, sea level rise, land subsidence and low sediment supply due to establishment of High Dam. The study suggested a number of protection measures to deal with the shoreline retreatment (Akl, 2004).

As a remedial action a wide range of protective measures were undertaken. For example, two seawalls were built during late 1980's and early 1990's on both sides of Rosetta Nile branch promontory.

A number of studies evaluated the impacts of protective engineering works on the erosion and accretion pattern in Rosetta promontery. For instance, Sholla (2000) based on cartographic analysis for the available maps in addition to a field survey studied the geomorphologic changes in the western side of Rosetta Nile branch promontory. The study highlighted some secondary impacts of protective engineering works that were constructed in early 1990's. The rsults argued that despite the protective engineering works assist in reducing the annual erosion rate, the western side of rosetta promontory has been suffring from sea water intrusion and development of salt water pools behind the erected dolos as a result of distorsion of seawall itself (Sholla, 2000). Also, Frihy et. al. (2003) analyzed the erosion and acrretion patterns and consequent changes in shoreline along the Nile Delta coastline before and after protective engineering works implemented in early 1990's. The study, which based on convetional field survey, concluded that erosion at Rosetta promontory was shifted and reduced considerably due to the protective measures that were constructed between 1989 and 1991 on both sides of Rosetta Nile branch promontory (Frihy, et. al., 2003).

Elsayed et. al. (2005) who evaluated the effects of the protection works on Rosetta promontory, argued that the shoreline along Rosetta promontory is still unstable and the protection works have not been efficient enough to stop erosion (Elsayed, et. al., 2005). Moreover, Hareher (2011) employed post classification technique (supervised classification) of remotely sensed data to detect changes of shoreline in Rosetta Nile branch promontory and estimate the quantity of land loss due to coastal erosion. The study concluded that although coastal protection structures have considerably reduced coastal erosion, such structures promoted down drift erosion (Hareher, 2011).

Generally, it is noted that most of previous studies, agreed on the historical dramatic changes of the shoreline in the Rosetta Nile branch promontery. The results of these studies revealed high rate of erosin and shoreline retreatment before 1990, which reduced considerably after constructing the potective engineering works implemented during early 1990s. Also, most of the previous studies did not consider inland impacts of these dramatic changes in shoreline.

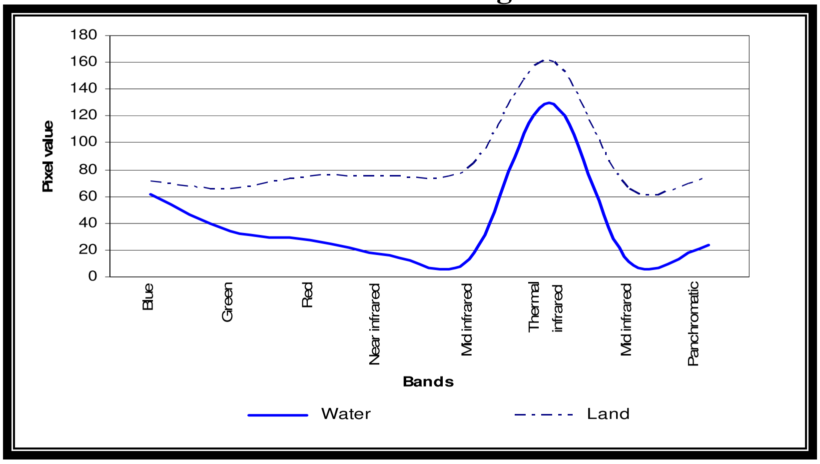
The paper in hand is intended to assess and analyze various impacts of shoreline changes in the vicinity of Rosetta Nile branch promontory during the period from 1972 to 2005 through remote sensing and GIS techniques.

2. Shoreline Delineation from Remotely Sensed Data:

Delineating shoreline is a prerequisite for detecting shoreline changes and assessing their impacts. In addition to traditional techniques such as conventional field survey, modern altimetry technology, and aerial photography, remote sensing techniques provide an effective approach to delineate and detect changes in shoreline. Actually, remote sensing techniques have a wide range of advantages compared to other traditional approaches. For example, contrary to other traditional methods, remote sensing techniques save time, efforts, and funds. Additionally, remotely sensed data provide large ground coverage monitoring (Van & Binh, 2008).

Shoreline delineation through remote sensing techniques relies on the varied spectral behavior or spectral response of water and other land surfaces at different wavelengths. Generally, water bodies absorb most of radiation in Near-infrared (NIR) and Mid-infrared (MIR) regions of the spectrum. Thus the reflectance of water is almost equal zero in these wavelengths. Meanwhile, the reflectance of various land covers in NIR and MIR is relatively high and greater than water (Figure 1).

Figure (1): Varied spectral behavior of water and land surfaces in different wavelengths.

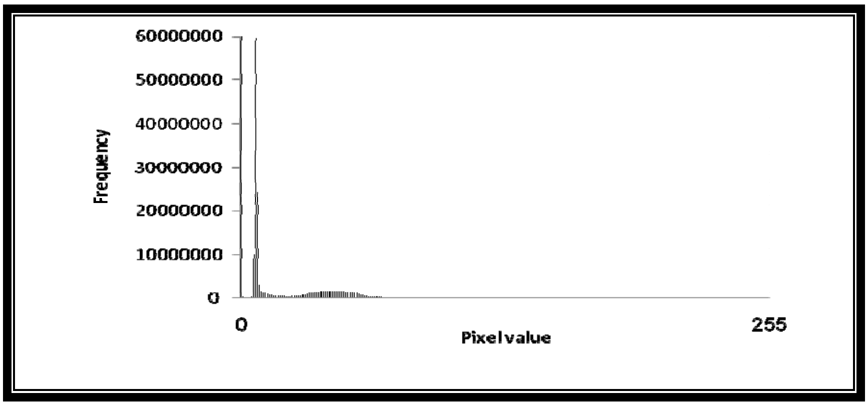


Based on this notion, shoreline can be delineated from satellite imagery through a number of techniques such as on-screen digitizing, image segmentation algorithm, post classification, histogram thresholding and band ratios, According to histogram thresholding technique, water bodies can be separated from other land covers and shoreline is consequently delineated from band 5 (Mid-infrared) in TM and ETM+ images. The histogram of band 5 illustrates usually a curve with two peaks and the transition zone between water and land i.e. the shoreline is located between the two peaks (Figure 2). However, such a method individually is not quite accurate in determining the shoreline as the threshold value separating land and water could be any value at this transition zone and consequently is not easily identified from the histogram (Alesheikh, et. al., 2007).

Meanwhile, band ratios technique can provide unique information and subtle spectral reflectence differences between varuious surfaces that are often difficult to detect in a standarad images. Therefore, band ratios used widely for distinguishing bwteeen water and land surfaces and delineating the shoreline.

For MSS images, band ratio of [(Band3 + Band4)/ Band1] can be employed to delineate the shoreline. For instance, this band ratio was applied to detect changes in the shoreline of Phan Thiert coastal area, Vietnam (Thao, et. al., 2008).

Figure (2): The histogram of band 5 note the two peaks and the transition zone between water and land.



To attain high levels of accuracy in delineating shoreline from TM and ETM+ images, a combination of band ratios and histogram thresholding was suggested. For instance, Alesheikh, et. al. (2007) suggested two band ratios (band 2/band 4) and (band 2/band 5) to be used accompanied with histogram thresholding of band 5 for separating water and land directly and determining the shoreline in TM and ETM+ images, This method revealed great potentials when applied to detect shoreline changes in Urmia lake in Iran between 1989 and 2001 (Alesheikh, et. al., 2007) and in Cuu Long estuary in Vietnam between 1989 to 2004 (Van & Binh 2008).

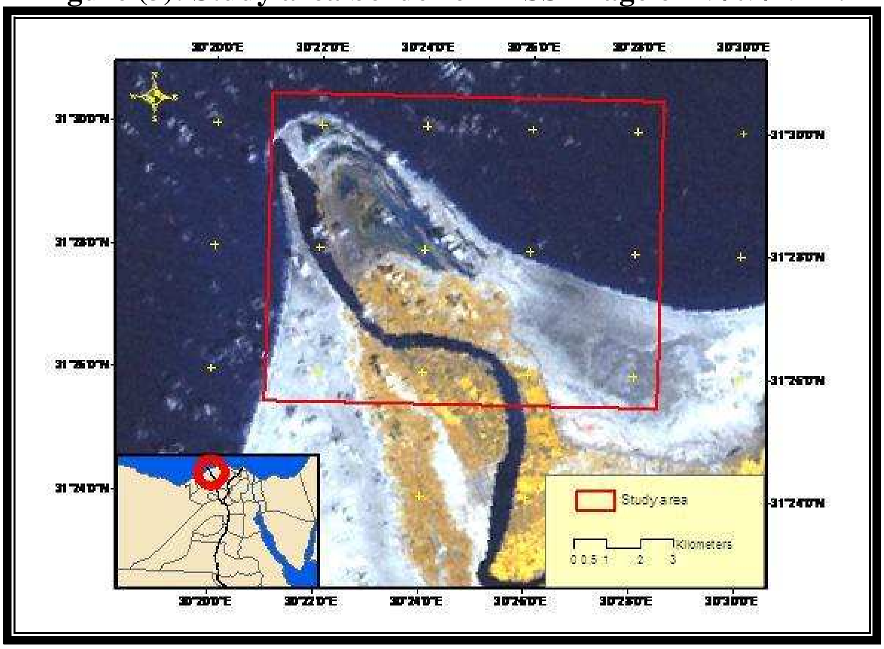
Alternatively, Thao et al. (2008), proposed a combination of histogram threshold of band 7 with band ratio [(band 5+band 7) / band 2] to delineate the shoreline from TM and ETM+ images. This methodology was apllied to detect the changes in shoreline in Phan Thiert coastal area, Vietnam (Thao, et. al., 2008).

3. Study Area:

Rosetta Nile branch promontory, which represents the western headland of Nile Delta extends from 31° 25' 30" to 31° 30' 30" Latitude, and from 30° 21' 00" to 30° 28' 30" Longitude (Figure 3).

The area is subdivided administratively into three localities; namely Al Jazirah Al Khadra, Borg Megheizl and Borg Rashid. The first two localities are located at the eastern side of Rosetta Nile branch promontory in Kafr El Sheikh Governorate, while the third locality is located in the western side of Rosetta Nile branch promontory in Behaira Governorate (Figure 4). The three localities, which are rural localities, cover a total area of about 40.86 km^2.

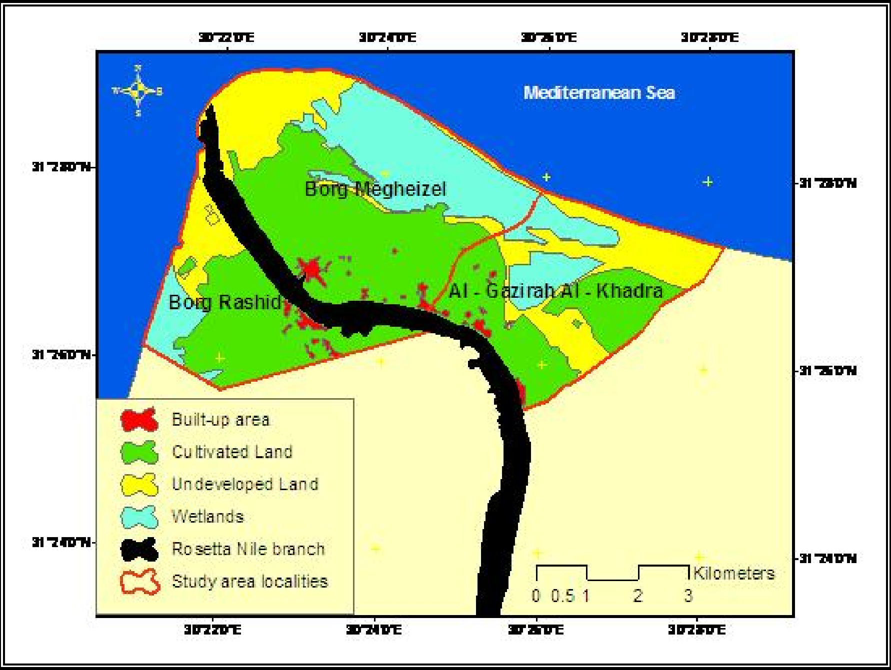
Figure (3): Study area border on MSS image of 19/09/1972.



The land use pattern of the study area is characterized by the dominance of cultivated lands, which cover 20.14 km^2 representing about 49.28% of the total study area. Also, undeveloped land and wetlands cover considerable parts of the study area representing about 24.04% and 24.87% of the total study area, respectively. Meanwhile, built-up area represents about 1.80% of the total study area (Figure 4).

It is worth mentioning that coastal strip is prevailed by heavy concentrated black sands, which deposited from the Nile stream, during flood seasons, in a thin layer ranging between 0.5 to 40 meter near and parallel to the shoreline. These black sands contain a number of valuable economic minerals such as ilmenite, hematite, magnetite, zircon, and monazite (Abdel Zahir and Abdel Aziz, 2011).

Figure (4): Land use/land cover and administrative subdivision of the study area.



4. Data and Methodology:

Assessing the impacts of shoreline changes on land use pattren entails developing a geodatabase for the study area and delineating shoreline at different point of time. A geodatabse for the study area was built based on a topographic map for the study area scale 1:50,000 sheet No. NH36-M1d (Rashid). Using ArcGIS 9. The topographic map was firstly georeferenced and rectified to a common UTM (Universal Transverse Mercator) coordinate system. Thereaftre, various ground features were digitized from the rectified map. To delineate shoreline in the study area over time four satellite images in different dates were used (Table 1).

Table (1): Characteristics of satellite images used for shoreline extraction

Acquired date	Sensor	Path / Row	Coordinate system	Datum/Ellipsoid	Zone
19/09/1972	MSS	191 / 38	UTM	WGS 84	35 N
11/09/1984	TM	177 / 38	UTM	WGS 84	36 N
03/08/1990	TM	177 / 38	UTM	WGS84	36N
05/03/2005	ETM+	177 / 38	UTM	WGS 84	36 N

Using ERDAS Imagine 9.1, each one of the four satellite images was manipulated. For MSS image of 1972, the band ratio of [(Band3 + Band4) / Band1] was used. As water bodies reflect high in band1 and absobe the radiation in Infrared, while land surfaces reflect high in Infrared, this ratio will be less than one for water and greater than one for land. As a result of this band ratio a binary image was produced, in which the pixels with ratio higher than "1", are classified as land and given "1" value while the pixels with ratio less than "1" are classified as water and given "0" value.

To delineate shoreline from TM images of 1984, 1990 and ETM image of 2005, a combination of histogram threshold of band 5 and two band ratios (band 2/band 5 and band 2/Band 4) was employed. According to this method three main steps should be carried out to delineate shoreline (Figure 5).

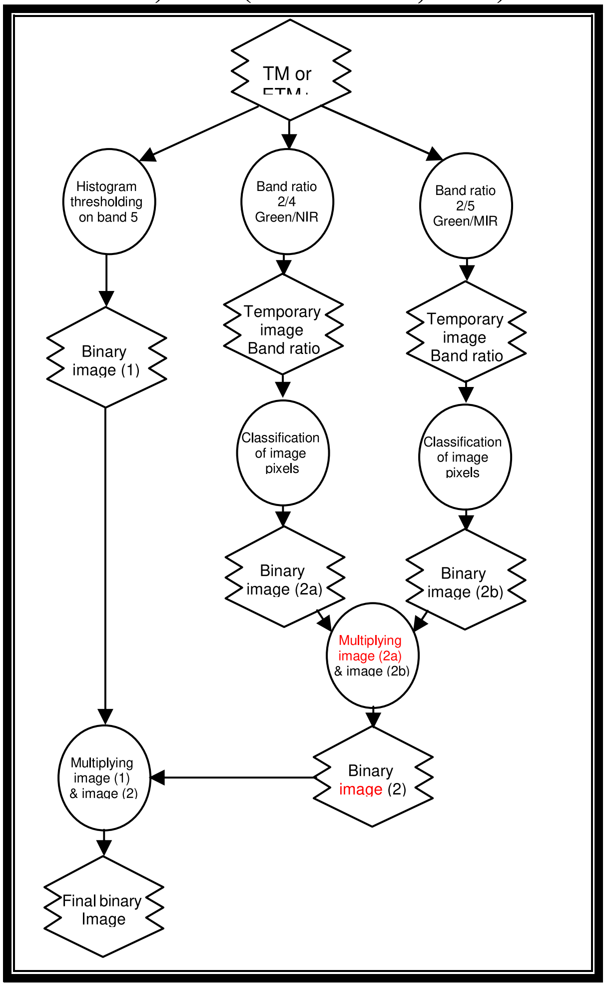
The first step is histogram thresholding of band 5 (MIR) to classify all image pixels into two categories; water and land. This can be done by a threshold value which should be determined on band 5 histogram. To select an approperiate threshold value separating between water and land, sample pixel brightness values was examined using inquire cursor in different parts of the image. Thereafter, all the image pexils were classified, where the pexils with DN value less than the threshold value were classified as water and given "1" and those with DN values larger than the threshold value were classified as land and given “0”. As a result of this step a binary image is produced in which water pixels are given “1” value while land pixels are given “0” value.

The second step is to calculate tow band ratios, Green/Mid-infrared ratio (band 2/band 5) to separate vegetation land cover from water, and Green/Near-infrared ratio (Band 2/band 4) to separate non vegetation land covers from water. Due to the low reflectance of water and high reflectance of land in near-infrared (band 4) and Mid-infrared (band 5) and the relatively lower reflectance of water in band 2 compared to other land covers, these ratios will be greater than one for water and less than one for land. Next, the pixels of the two images produced from two band ratios were classified, where pixels that have ratio larger than “1” are classified as water and given “1” value and those having ratio less than “1” are classified as land and given “0” value. To eliminate mistakes and generate a new composite binary image, the two produced binary images resulted earlier from the two band ratios were thereafter multiplied to each other.

The third and final step is to produce a final binary image through multiplying the two binary images produced from the first and second steps. In the resulted final binary image, the pixels with “1” value represent water bodies, while the pixels with “0” value represent land covers. Thereafter, for the purposes of spatial analysis, the resulted binary images were manipulated using ArcGIS 9.3. Firstly, each resulted binary image for a certain point of time was converted into vector layer (Feature class) with two main polygon features; water and land. Secondly, the created polygon layers were masked by study area border to have the same spatial extent required for comparison purposes. Accordingly, four vector polygon feature classes representing shoreline in 1972, 1984, 1990, and 2005 were created.

To quantify shoreline changes in the study area in each period of time, each two polygon layers representing the distribution of sea and land in two subsequent points of time were overlaid using (Symmetrical Difference Tool). Consequently, three layers were created, each of them represents erosion and accretion areas within the study area in each period time; 1972 – 1984, 1984 – 1990 and 1990 – 2005. Moreover, the wetland areas developed behind the shoreline in 1984 and 2005 were delineated in two polygon feature classes representing the spatial extent of wetlands in these two points of time.

Figure (5): Model for extracting shorelline form TM and ETM+ satellite images Source: Adopted from (Alesheikh, et. Al., 2007) and (Van & Binh, 2008).



To assess the impacts of shoreline changes, a number of spatial analysis operations was carried out using the produced feature classes together with other feature classes representing various ground features in the study area such as land use/land cover, roads, and administrative borders…etc.

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5. Results and Discussion:

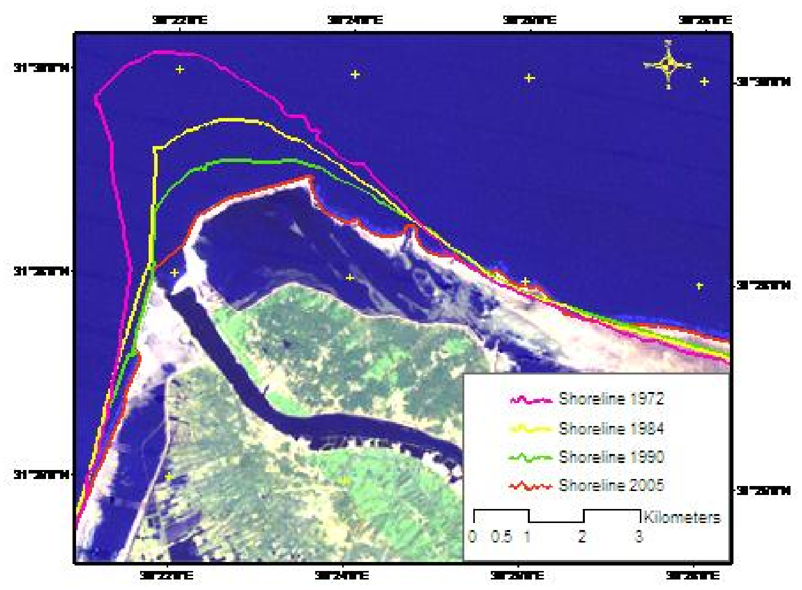
The comparison of shoreline in different points of time showed that the shoreline in the study area has retreated considerably between 1972 and 2005 due to erosion process (Figure 6). The maximum retreatment rate alongside Rosetta Nile branch promontory was measured from the resulted feature classes. The measurements indicated that the shoreline retreated about 1550 meter during the period 1972 – 1984 with an average annual retreatment rate of 129.17 (Table 2). Meanwhile, the shoreline retreaded about 710 meter during the period 1984 – 1990 with an annual retreatment rate of 118.33 meter on average.

The retreatment rate of shoreline reduced considerably during the subsequent period (1990-2005). During this period the shoreline retreated about 750 meters, which means an average annual retreatment rate of 50 meter. Also, it was noted that the retreatment pace decreased steadily with going to the east and the west along the shoreline away from Rosetta Nile branch promontory (Figure 6).

Table (2) : Maximum retreatment of shoreline in Rosetta Nile branch promontory between 1972 and 2005.

Period	Maximum retreatment (m)	Annual rate (m/year)
1972 - 1984	1550	**129.17**
1984 – 1990	710	**118.33**
1990 - 2005	750	**50.00**
Total	3010	**91.21**

Figure (6): Shoreline changes in Rosetta promontory between 1972 and 2005.



In order to assess the accuracy of the adopted methodology to extract shoreline from satellite images, the results of current study were compared to those of previous work carried out in the study area using different methodologies and techniques (Table 3).

The comparison revealed some sort of similarity between the results of the current study and those of previous studies despite different employed techniques and methodologies. For instance, the difference between average annual retreatment rate of shoreline estimated in current study for the period 1972 – 1984 and those of previous studies conducted by Sholla (2000) and Hareher (2005) for a relatively same time period ranged between + 4.43 and - 0.33 meter (Table 3). Moreover, the result of current study for the period 1990 – 2005 was close to the results of Hareher study (2011) with a difference of about 5 meter for similar period of time extending from 1990 to 2008. This, generally, reveals certain levels of reliability of the adopted methodology, which based on a combination of histogram thresholding and band ratio.

Table (3): Comparison of the results of current study and previous studies using different methodologies

The study	Time period	Annual retreatment rate (m/year)	Adopted methodology
Sholla, 2000	1971 – 1988	124.74 (*)	Cartographic analysis
Frihy & Komar, 1993	1971 – 1990	106.00	Field survey
White & El Asmar, 1999	1984 – 1990	113.80	Image segmentation algorithm
Hareher, 2011	1973 - 1984	129.5 (**)	Post classification
	1984 – 1990	99.00	
	1990 - 2008	55.00 (***)	
Current study	1972 - 1984	129.17	Band ratio and histogram thresholding
	1984 – 1990	118.33	
	1990 – 2005	50.00	

(*) This an average retreatment rate in both sides of the Rosetta Nile branch promontory during two time periods; 1971 – 1982 and 1982 – 1988.

(**) This an average retreatment rate of the Rosetta Nile branch promontory during two time periods; 1973 – 1978 and 1978 – 1984.

(***) This an average retreatment rate of the Rosetta Nile branch promontory during two time periods; 1990 – 1999 and 1999 – 2008.

As a result of shoreline retreatment, considerable areas of coastal zone in the study area were eroded. In this respect, the total area eroded during the period 1972 – 2005 was found to be as much as

12.7 km^2 (Table 4), which means an annual erosion rate of 0.4 km^2 on average.

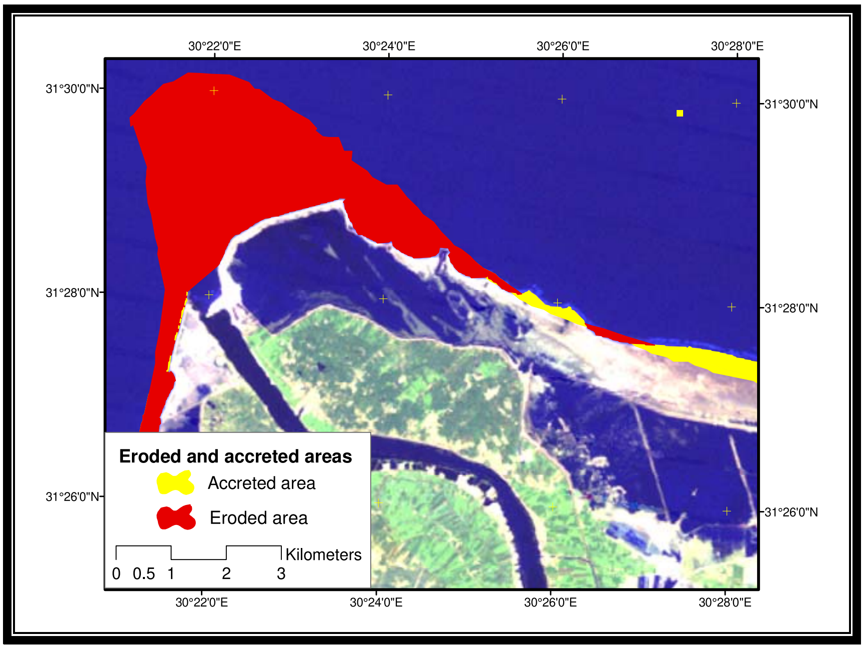
Spatially, the erosion process varied between eastern and western sides of Rosetta Nile branch promontory. Generally, the eroded area in the eastern side was found to be as much as 10.5 km^2, which is considerably larger than the eroded area in the western side of the promontory (2.2 km^2).

Table (4) : Accreted and eroded areas in both sides of Rosetta Nile branch promontory between 1972 and 2005.

Period	**Area (km^2)**	
	Accretion	**Erosion**
Eastern side		
1972 – 1984	0.4	4.7
1984 - 1990	0.2	2.3
1990 – 2005	0.4	3.5
Subtotal	1.0	10.5
Western side		
1972 – 1984	0.1	1.3
1984 – 1990	0.0	0.4
1990 – 2005	0.0	0.5
Subtotal	0.1	2.2
Both eastern and western sides		
1972 – 1984	0.5	6.0
1984 – 1990	0.2	2.8
1990 – 2005	0.4	4.0
Total	1.1	12.7

Meanwhile, a noticeable accretion process was revealed in the eastern side of Rosetta Nile branch promontory between 1972 –2005 (Figure 7). As a result of such accretion process, the shoreline in the eastern part study area stepped forward about 230 meter on average during the period 1972 – 1984. In the next two periods 1984 – 1990 and 1990 - 2005 the shoreline stepped forward about 45 and 65 meter, respectively. Due to such noticeable accretion process and step forward movement of shoreline, a total area of 1.1 km^2 was added to the coastal zone in the study area (Table 4). These accreted areas were mostly concentrated in the easternmost part of the study area (Figure 7).

Figure (7): Eroded and accreted areas in Rosetta promontory between 1972 and 2005.



Temporally, the erosion process reduced during the period 1990–2005 compared to the first two periods 1972 – 1984 and 1984 – 1990. It is worth mentioning here that the noticeable reduced speed of shoreline retreatment and erosion during the period 1990 – 2005 can be attributed to the protective engineering works such as dolos, groins and sea wall which were erected in early 1990s and led, in turn, to decrease the erosion process in Rosetta promontory area later on.

Such changes of shoreline during the period between 1972 and 2005 have significant impacts on the study area. One of the most noticeable impacts is represented in the considerable changes in territories of the three localities of the study area. In this respect, it was found that the area of the most eastern localities, where the accretion process was prevailed, has grown. For instance, the area of Al Jazirah Al Khadra locality grew about 5% of its original area in

1990s. On contrast, Borg Megheizl and Borg Rashid localities, which represent the headland of Rosetta Nile branch, have lost about 47.4% and 22.2% respectively of their original areas in 1990s during the period of 1972 – 2005 (Table 5).

Table (5): Accreted and eroded areas in each locality of Rosetta Nile branch promontory between 1972 and 2005.

Locality	Area (km^2)		Net change	% of locality territory in 1990s
	Accretion	Erosion		
Al - Gazirah Al – Khadra	0.8	0.1	0.7	5.0
Borg Megheizel	0.3	10.3	-10.1	- 47.4
Borg Rashid	0.1	2.2	- 2.2	- 22.2
Total	1.1	12.7	-11.6	-

As most of eroded parts are sandy beaches, which are dominant by black sands, the erosion of these sandy beaches means, consequently, loss of a valuable resource due to the high economic value of black sands.

Moreover, shoreline retreatment has significant impacts on the infrastructure in the study area. In this context, the retreating shoreline led to loss of about 7.6 km of roads in the study area between 1972 and 2005. It was found that 77.6% of the lost roads were paved roads, while the remaining proportion was unpaved roads. Meanwhile, 47.4% of the lost roads were located in Borg Megheizel locality and 52.6% were located in Borg Rashid locality.

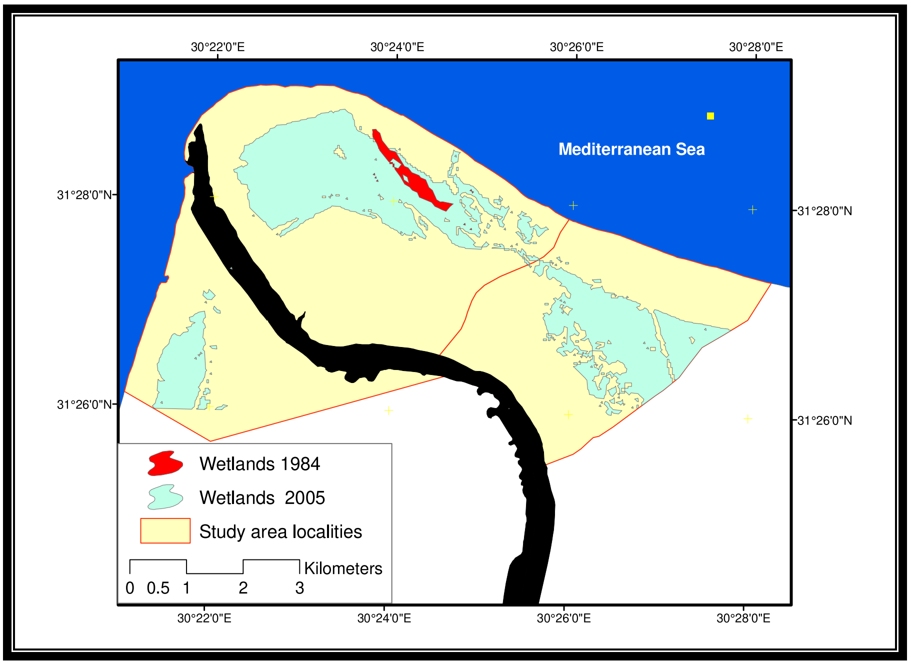
Also, it was noted that a wide areas of wetlands were formed behind the shoreline. The comparison between the two polygon feature classes, representing the spatial extent of wetlands in 1984 and 2005, indicated that wetlands have expanded notably from 0.34 km^2 in 1984 to 10.64 km^2 in 2005 (Table 6 and Figure 8).

Such wetlands formation could be attributed to sea water intrusion due to instability of sea wall, which led to formation of wetlands in low laying parts of the study area. With retreating shoreline, these wetlands became closer to the sea and were additionally fed by sea water as a result of high waves during winter storms.

Table (6): Wetland areas formed behind the coast line in each locality of Rosetta Nile Branch in 1984 and 2005.

Locality	Area of wetlands (Km^2)	
	1984	2005
Al - Gazirah Al – Khadra	0.00	3.50
Borg Megheizel	0.33	6.00
Borg Rashid	0.01	1.14
Total	0.34	10.64

Figure (8): Wetlands formed behind the shoreline in 1984 and 2005.



However, the development of wetlands has significant impacts on land use patterns in the study area. To assess various land uses that are affected by created wetlands, the feature classes of wetlands in

2005 and that of land use pattern of the study area were overlaid (intersect overlay). It was found that about 4.4 km^2 of cultivated land were converted into wetlands during the period between 1984 and 2005. This means that about 21.9% of the total cultivated land in the study area was lost due to shoreline changes and consequent development of wetlands (Table 7 and Figure 9).

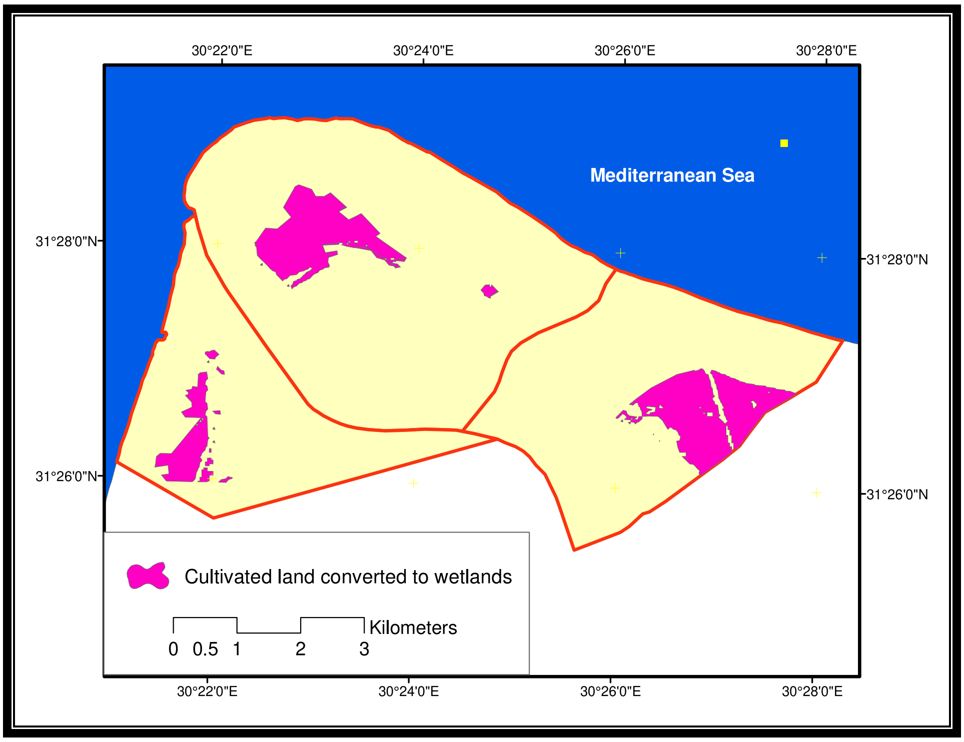
Table (7): Area of cultivated land converted into wetlands in various localities of the study area.

Locality	**Cultivated land converted into wetlands**	
	Area (Km^2)	**% of total cultivated land in the locality**
Al - Gazirah Al – Khadra	2	34.8
Borg Megheizel	1.7	18.9
Borg Rashid	0.7	13.0
Total	4.4	21.9

Furthermore, the development of these wetlands, indicating raising levels of groundwater table, can adversely affect agricultural activities in adjacent cultivated land impeding agricultural activities and lead to declining crops productivity. Also, such wetlands and high levels of groundwater table may have adverse impacts on real estate in nearby human settlements. It should be noted that with the projected sea level rise during coming decades and consequent high levels of groundwater, more parts of the study area are expected to be adversely affected. However, as an adaptation option to deal with this issue, these wetlands can be used by the local residents in aquaculture activities,

The application of band ratio and histogram thresholding methodology revealed that the shoreline in Rosetta promontory was retreated considerably during the period 1972 – 2005. The maximum shoreline retreatment in the study area was noticed in the area adjacent to Rosetta Nile branch promontory, where the shoreline retreated as much as 3010 meter between 1972 and 2005 with an average retreatment rate of 91.21 m/year.

Figure (9): Cultivated land converted into wetlands between 1984 and 2005.



6. Conclusion:

Despite different methodology applied in previous studies, the comparison of annual retreatment rate of shoreline in the study area estimated in this study with those estimated in previous studies revealed some sort of similarity. This, consequently, reflects certain level of reliability of the adopted methodology in the current study. It should be noted that the successful application of the band ratio and histogram thresholding methodology relies on the availability of data (satellite images) with reasonable spatial resolution and in proper time interval.

The dramatic changes of shoreline during the period 1972 – 2005 have significant impacts on the territory, infrastructure and land use pattern of the study area. In this respect, it was found that the territories of the three localities of the study area changed considerably during the period 1972–2005. For instance, the area of Borg Megheizl and Borg Rashid localities, which represent the headland of Rosetta Nile Branch have lost about 47.4% and 22.2% respectively of their original areas in 1990s. Also, it was found that the shoreline retreatment led to loss of 7.6 km of roads in the study area. Moreover, retreating shoreline contributed to loss of about 21.9% of fertile cultivated land in the study area, which converted into wetlands.

References:

- Abouzeid, A. M., and Khaled, A. M., (2011), "Mineral industry in Egypt-part I: Metallic Mineral Commodities", **Journal of Natural Resources**, Vol. 2, pp. 35-53.
- Akl, M. Tohamy, (2004), "Geomorphologic Development of Rosetta Promontory Area During 20th Century", **Bulletin of Faculty of Arts**, University of Alexandria, Vol. 53, pp. 301-385.
- Alesheikh, A. A., " A Ghorbanali and N Nouri, (2007), Coastline Change Detection Using Remote Sensing", **International Journal of Environmental Science Technology**, Vol. 4, pp. 61-66.
- Elsayed, Mohamed A. K., Younan, N. A., Fanos A. M., and Baghdady K. H., (2005), "Accretion and Erosion Patterns along Rosetta Promontory, Nile Delta Coast", **Journal of Coastal Research**, Vol. 21, Issue 3, pp. 412-420.
- Frihy, Omran E. and Komar, P.D., (1993), "Long-term Shoreline Changes and the Concentration of Heavy Minerals in Beach Sands of the Nile Delta, Egypt", **Marine Geology**, Vol. 115, pp. 253-261
- Frihy, Omran E., Debes, E. A, and El Sayed, W. R, (2003), "Processes of Reshaping the Nile Delta Promontories of Egypt: pre- and post-Protection", **Geomorphology**, Vol 53, pp. 263-279.
- Frihy, Omran E., and Dewidar, K. M., (2003), "Patterns of Erosion/Sedimentation, Heavy Mineral Concentration and Grain size to Interpret Boudaries of Litoral Sub-cells of the Nile Delta, Egypt"**,** **Marine Geology**, Vol. 199, pp. 27-43.
- Hareher, M. E., (2011), **Mapping Coastal Erosion at the Nile Delta Western Promontory Using Landsat Imagery**, Environmental Earth Science, London.
- Sholla, M. M., (2000), "The Geomorphologic Changes in the Western Side of Rosetta Promontory, Al Ensaniat", **Bulletin of Faculty of Arts in Damanhour**, University of Alexandria, Vol. 1, pp. 171 -221.

- Thao, Pham Thi Phuong, Ho Dinh Duan, and Dang Van To, (2008), "Integrated Remote Sensing and GIS for Calculating Shoreline Change in Phan-Thiet Coastal Area**", International Symposium on Geoinformatics for Spatial Infrastructure Development in Earth and Allied Sciences**, Hanoi, 4-6 December 2008.
- Van, Trane Thi and Trinh Thi Binh, (2008), "Shoreline Change Detection to Serve Sustainable Management of Coastal Zone in Cuu Long Estuary", **International Symposium on Geoinformatics for Spatial Infrastructure Development in Earth and Allied Sciences**, Hanoi, 4-6 December 2008.
- White , K., and El Asmar, H. M., (1999)," Monitoring Changing Position of Coastline Using Thematic Mapper Imagery, an Example from the Nile Delta", **Geomorphology**, Vol. 29, pp. 91-195

التحليل الجغرافي للآثار الناجمة عن التغيرات في خط الساحل باستخدام تقنيات الاستشعار عن بعد ونظم المعلومات الجغرافية : دراسة حالة : منطقة مصب فرع رشيد لنهر النيل، مصر

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الملخص العربي:

تُعد دلتا النيل أحد أهم الملامح الرئيسية بمصر وأكثر المناطق كثافةً بالسكان، ويتعرض خط الساحل لدلتا النيل في الوقت الراهن لتغيرات حادة نتيجة لعوامل عديدة، حيث تراجع مصب فرع رشيد، الذي يمثل الرأس الغربي لدلتا النيل، بشكل كبير خلال القرن الماضي. وقد ازداد هذا الاتجاه نحو التراجع منذ الستينيات من القرن العشرين بعد بناء السد العالي وهو ما أدي إلى تقليل كمية الرواسب التي كانت تصل إلى مصب النيل. مثل هذه التغيرات الكبيرة كان لها عدد من الآثار السلبية البالغة والتي يجب تقييمها. ويمكن أن يساعد هذا التقييم متخذي القرار وصانعي السياسات في التقليل من حدة تلك الآثار السلبية والإدارة المستدامة للنطاق الساحلي بمنطقة الدراسة.

ويهدف هذا البحث إلى تقييم وتحليل الآثار الناجمة عن التغيرات في خط الساحل بمنطقة مصب فرع رشيد خلال الفترة ما بين عامي ١٩٧٢ و ٢٠٠٥م باستخدام تقنيات الاستشعار عن بعد ونظم المعلومات الجغرافية. ولتحقيق هذا الهدف فقد طبق البحث أسلوبي النسبة الطيفية وتقسيم الهيستوجرام لتحديد ورسم خط الساحل من مرئيات فضائية لمنطقة الدراسة في أعوام ١٩٧٢، ١٩٨٤، ١٩٩٠، و٢٠٠٥م. فبالنسبة للمرئية الفضائية من نوع (MSS) لعام ١٩٧٢م فقد تم تطبيق النسبة الطيفية التالية (النطاق الطيفي الثالث+النطاق الطيفي الرابع/النطاق الطيفي الأول). أما فيما يختص بالمرئيتين الفضائيتين من نوع (TM) لعامي ١٩٨٤ و١٩٩٠م، وكذلك المرئية الفضائية من نوع (+ETM) لعام ٢٠٠٥م فقد تم تطبيق أسلوب يعتمد على المزج ما بين النسبة الطيفية وتقسيم الهيستوجرام، حيث تم تطبيق النسب الطيفية (النطاق الطيفي الثاني/ النطاق الطيفي الخامس، والنطاق الطيفي الثاني/ النطاق الطيفي الرابع)، وتقسيم الهيستوجرام للنطاق الطيفي الخامس. كذلك تم بناء قاعدة بيانات جغرافية لمنطقة الدراسة وذلك لاستخدامها في تقييم التغيرات في خط الساحل وتحليل تلك التغيرات مكانياً وتقييم آثارها.

وقد أوضحت الدراسة أن أقصى تراجع لخط الساحل بمنطقة الدراسة قد بلغ ٣٠١٠ مترا (٣,٣كم٢) خلال الفترة من ١٩٧٢ إلى ٢٠٠٥م بمعدل تراجع سنوي حوالي ٩١,٢١ مترا. هذا التراجع لخط الساحل كان له أكبر الأثر على مساحة منطقة الدراسة، والبنية الأساسية، ونمط استخدامات الأرض بها. فعلى سبيل المثال، فقد فقدت الوحدات المحلية بمنطقة الدراسة حوالي ١١,٦ كم² من مساحتها نتيجة لتراجع خط الساحل خلال الفترة ما بين ١٩٧٢، ٢٠٠٥م. كذلك تم تدمير عدد من الطرق بمنطقة الدراسة بلغ مجموع أطوالها حوالي ٧,٦ كم. هذا بالإضافة إلى تكون مساحات من المستنقعات والبرك التي كان لها تأثير على نمط استخدامات الأرض بالمنطقة.

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