Morphometric Inferences of the Euphrates River Islands and the Possibility of their Development through the Analysis of Remote Sensing Data and Geographic Information Systems

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DOI: https://doi.org/10.52939/ijg.v20i11.3687

Abstract
River islands are considered one of the most important components of the development of the river environment, due to their function as a ground appearance that hinders the speed of the flow of the river stream and the distribution of that flow over the seasons of the year, and these islands are important in creating environmental balance, as their components of sand have a role in reducing pollutants due to the mechanism of denitrogenization as a weakening element for aquatic organisms, and their cadastral development is of great importance in the possibilities of creating development opportunities for the surrounding areas, which are still the mechanism of investment of these islands is still limited to a very high degree, and therefore the aim of the study is to identify and compare the engineering characteristics of one of the most important islands of the Euphrates River by measuring its areas and height from the river and comparing its cadastral development in all its engineering dimensions using remote sensing data and processing it in the GIS environment, and the results showed that the area of the island has developed between 1973, which amounted to 289.07 m^2 to 2024 4,681.18 m^2 to reach the final length of the island 3,587 meters The results showed that the island takes a shape close to a rectangle with a strip extension, where the values according to the results of the aspect ratio reached (30.94), Its heights range between 32 - 58 meters above sea level, with a height difference of up to 2 meters from the riverbed. Its climatic effects are evident through the dense vegetation cover, which ranged according to NDVI between 1 - 0.92 in 1973 to 0.74-1 in 2024, and it has also become one of the most important lands that humans have begun to exploit for many purposes, including grazing. There is a need for further study on the development of river islands over time, and the importance of the impact of this study appears through alerting the community and farmers living in the region to the possibility of investing in these islands for many purposes, while being careful of the possibility of their exposure to sudden river floods.

Keywords: Development Possibilities, Island Development, Morphometric Inferences, River Islands Remote Sensing

1. Introduction

The phenomenon of river islands is one of the geomorphological forms affecting the course of the river, and the beginning of the formation of these islands is evidence that the river is in the stages of late maturity and early aging, and thus begins the process of sedimentation of materials carried by the river as a result of decreasing the speed of the water current and increasing the breadth of the course and decreasing its slope, as well as the variation in the water discharges of the river from one season to another [1]. as Carving and sedimentation operations are active during the increase in discharges at certain times of the seasons of the year and weaken in other seasons, which increases the chances of the island building process, and the phenomenon of river islands has emerged in recent years as a result of several reasons these include drought, increasing temperatures and lack of rainfall, reflected by climate change and its impact on the Middle East [2].

Comprehensiveness and accuracy in the study of ecosystems is one of the most important requirements for the implementation of the sustainable development goals [3]. Including river ecosystems, in which river islands stand out as one of the most important components of the development of the river's environment due to its function in creating an environment different from the previous change in flow speed, grass growth and twisting of the riverbed, and thus creating a new geomorphological unit for the river [4].

Morphometric properties are the mathematical measurement and analysis of the composition, shape and dimensions of the Earth's surfaces, including the measurement of linear, cadastral and topography properties [4]. It is important to understand the basic structure of any land form, when quantum methods was utilized in geomorphology and the riverbed system and is evaluated by comparing its morphometric parameters [5]. Remote sensing and GIS data highlight cost-effective tools for assessing hydrological impacts on spatial and temporal changes in land use and development [6]. It produces valuable information to facilitate proper planning and decision-making capacity, Multi-time satellite data provide valuable sources for analyzing land cover changes and GIS provides appropriate methods for mapping and evaluating these patterns.

The purpose of the present study is to investigate the morphometric characteristics of one of the most important river islands of the Euphrates River located near the city of Ramadi; it is an attempt to understand the nature of the formation and development of river islands in light of the change in climatic conditions and the extent of their reflection on river environment systems and use them as an important tool for future planning and development of the island with appropriate human uses in order to benefit from them [7]. By knowing the structural and engineering characteristics of those islands to outline the management of any geomorphological, environmental or landscape issue in line with contemporary developments. The objectives of this study were to obtain the continuous, long-term, spatio-temporal variation features of these river islands, including their areas and shapes [8]. Many previous studies have been presented in many rivers about the possibilities of developing river islands, including the study of the Middle Tagliamento River, which proved in its results the role of plants in the growth and expansion of the river island. The novelty of our study comes from the fact that previous studies of the region did not provide a developmental and investment aspect that exploits these river islands [9].

Many local studies have taken the initiative to study and explain river islands, some of which confirmed that the river, despite the large number of islands, did not reach the point of branching, as Munir Abbas confirmed the impact of climatic conditions and their role in the growth and development of river islands in the Euphrates River near the city of Babylon [10]. However, he did not address how to preserve and develop these islands. River islands were also studied in many rivers in the world, including the Neris River, which aimed to determine the spatial and morphometric characteristics of river islands along a distance of 234.5 km, which confirmed an increase in the number and area of river islands due to the decrease in water discharge quantities between the nineteenth century and the end of the twentieth century, which led to a decrease in floods in the river. River meanders also play a role in sedimentation of materials, as is the case in the study of the Yangtze River, and this is what we confirmed in our study [11].

In another study conducted on the Yangtze River, it was confirmed that the ratio of sediment separation to flow ratio ranges between 1 - 1.1 when the river is at its maximum flow, and it was also confirmed that the length of river islands is five times their width [12]. The effect of climate on the dynamics of river islands is also clear even in rivers of glacial regions, as is the case with the Lena River in Russia. It was proven that within fifty years the area of river islands changed by increasing their area, and other small islands appeared, which shows that climate change has global effects that are not limited to specific regions [13]. The factor of land slope may emerge as one of the most important factors in the development of river islands, as the relationship is inverse, the more the degree of land slope increases, the less the chances of forming and developing the area of the island, while the chances of forming river islands in flat plains are greater, as the sediment transport capacity is very weak [14]. As is the case in the Euphrates River alluvial plain area, which is characterized by its flatness and slight slope, which helped increase the amounts of sedimentation at the expense of transporting sediments to areas further towards the estuary in the Shatt al-Arab from the Arabian Gulf.

The study methodology revolves around the trend towards employing satellite data with ground survey by researchers through actual visits with the aim of examining, measuring and tracking one of the most important environmental components formed by rivers, namely river islands in one of the most important areas through which the Euphrates River passes in Anbar Governorate, and standing on the

development of these islands over time and how to benefit from them and what their environmental impacts are and then how the responsible authorities can manage and benefit from them, this study is the first of its kind to track the measurements of river islands in terms of measuring their heights using the digital elevation model (DEM) and to enhance and confirm this measurement by conducting field visits. This study is also the first to reflect the environmental and climatic effects of river islands on humans and the surrounding nature.

2.Data and Working Methods

2.1 Study Area

The Euphrates River originates in the Taurus Mountains in Turkey from two sources located between Lake Van, then extends towards Syria and then Iraq until it meets the Tigris River in the city of Basra, then flows into the Arabian Gulf with a total length from source to mouth of about 2940 km. It originates in mountainous areas, then heads towards the plateau region in Syria, then Iraq until west of the city of Ramadi, where it enters the flat alluvial plain region. The study area is represented by one of the river islands of the Euphrates River in west Iraq in Anbar Province, west of the Ramadi Dam, at a distance of 7.54 km along the river, while astronomically it is located between two latitudes 33º 28′37″N and 33º29′42″N and longitude 43º11′21″ E and 43º13′24″ E, and its area is 4,681.18 km^2 (Figure 1). After the island was connected to the river bank, it became difficult to identify it using Landsat data. Through a field visit to the island and the river, it was found that there is a water channel separating the island from the old river bank, used for irrigation purposes, which is dredged every year to get rid of sediments. Through this, as in the Figure 2 there is another characteristic that can be observed in the satellite data, which is the characteristic of vegetation cover, as vegetation cover appears regularly in the agricultural fields adjacent to the island, in contrast to the plants that cover the island, we were able to separate the borders of the island from the adjacent alluvial plain.

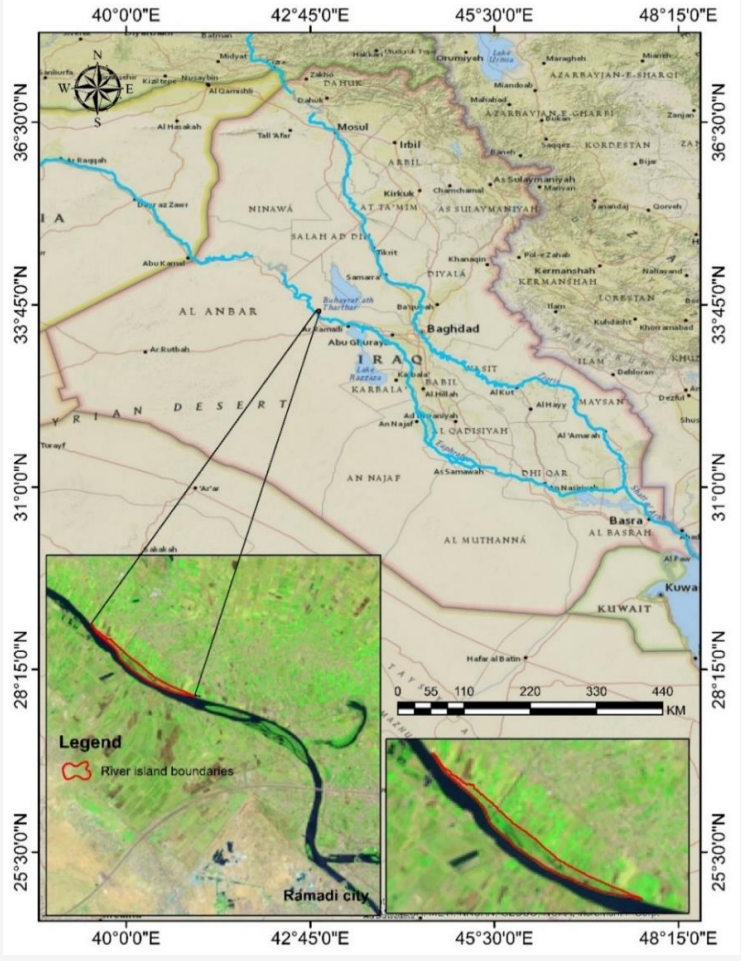

Figure 1: Location of the island from Iraq and Anbar province

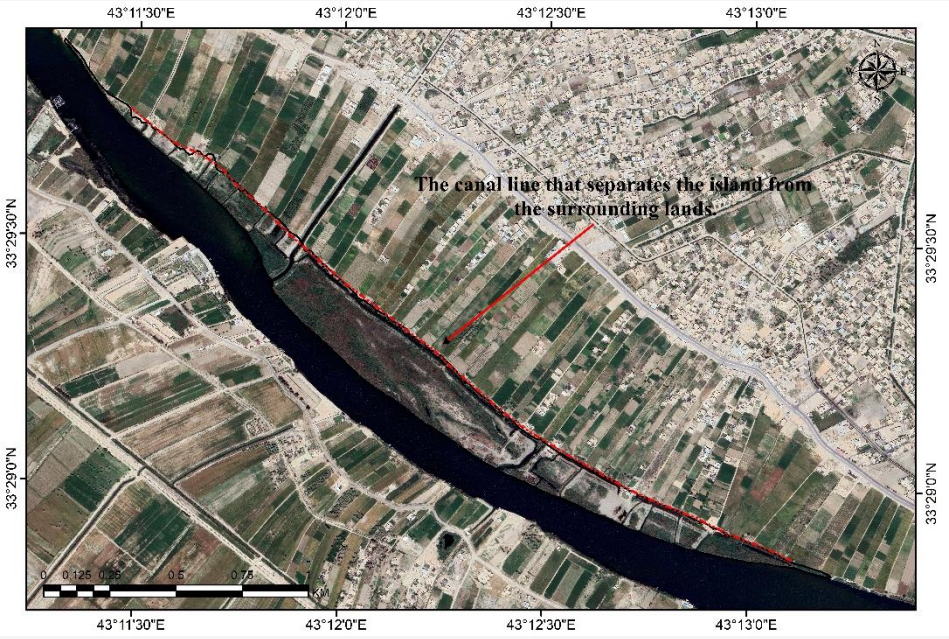

Figure 2: The line of the waterway on which the river island was determined

Table 1: Data description of satellite images from USGS Earth Explorer for various years

Years	Landsat series	Acquisition dates	Path / row	Bands	Resolution
1973	Landsat 1 MSS	2/05/1973	182 / 037	4, 5	60 m
1984	Landsat 5 TM	15/06/1984	169 / 037	1, 2, 3	30 m
1993	Landsat 5 TM	23/05/1993	169 / 037	1, 2, 3	30 m
2004	Landsat 5 TM	5/05/2004	169 / 037	1, 2, 3	30 m
2013	Landsat 8 OLI	15/06/2013	169 / 037	2, 3, 4	30 m
2024	Landsat 9 OLI	20/05/2024	169 / 037	2, 3, 4, 5	30 m

The geography of the region is characterized by being located in a flat plain area represented by the Euphrates River Basin, whose watercourse is in the middle of this wide plain that is defined by the plateau lands from the north and south. It is characterized by being lower in elevation and flatter, as its elevation in the areas surrounding the region ranges between 61 - 59 meters above sea level, and the slope of the land varies between 0° to 3°. The four-season is characterized by high temperatures that range in average between 20-30 degrees Celsius, with the emergence of the drought characteristic and seasonal rains that reach an average of about 110 mm annually with winds that are predominantly northwesterly. The soil is characterized by sandy and alluvial deposits that were brought by flood waters to the river over ancient times, which are characterized by their high fertility, making them ideal for agriculture. All of these characteristics make the region vital and easy to form river islands.

2.2 Data

In this study, we used satellite images from the United States Geological Survey (USGS). Table 1 shows these data starting from 1973 to 2024 and divided over a ten-year period. The data for the years 1973 consist of Landsat 1 images, which consist of two bands with a spatial resolution of 60 meters. The data for the years 1984, 1993, and 2004 consist of Landsat 5 images within bands 1, 2, and 3, with a resolution of 30 meters. The data for the year 2013 includes Landsat 8 and the data for the year 2024 includes Landsat 9. The Landsat images were projected to the UTM-WGS-84 coordinate system, Zoon 38 North. The path and row here is the line of motion of the satellite that it follows while orbiting the Earth from the North Pole to the South Pole in a certain period of time. The row intersects with it, forming a square of the area covered by the rays sent to photograph that spot, the row and track numbers are identical for all years of the study and for all Landsat data, they are 169 - 037 except for 1973, which is 182 - 037.

2.3 NDVI and FVC

Normalized Difference Vegetation Index (NDVI) is calculated using the visible and near-infrared bands of the Landsat satellite, as defined in Equation 1 [15]. The current amount of vegetation is an important component, and the normalized (NDVI) is used to determine the overall vegetation condition. Therefore, estimating the normalized vegetation index is of great importance [16]. The values of these indicators will be analyzed in Section 5.4.

$$NDVI = \frac{NIR - RED}{NIR + RED}$$

Equation 1

Where:

NDVI = Normalized Difference Vegetation Index

NIR and RED = represents the pixel values of Near Infrared bands and Red bands

To calculate partial vegetation (FVC) we need to measure the area covered by trees, branches and leaves which is fed back into the total vegetation area. FVC is derived in Equation 2, the maximum and minimum NDVI data are taken from the NDVI Raster image. The only input needed at this stage is the NDVI Raster dataset.

$$FVC = \left(\frac{NDVI - NDVI_{\min}}{NDVI_{\max} - NDVI_{\min}} \right)^2$$

Equation 2

Where:

FVC = Fractional Vegetation Cover

3. Morphological Characteristics of the Course of the River on the Island

The Euphrates River along its main course was subjected to morphological changes as a result of the variation in water discharges and the construction of dams for storage, which was reflected in the hydraulic situation, as it resulted in an increase in the amounts of sedimentation at the expense of sculpture and transportation, which constituted opportunities for the construction of many river islands and the development of others [17]. This pillar includes several aspects.

3.1 Breadth of Course of the River

The breadth of the course varies from one sector to another, and this is evidenced by the study of the cross-sections of the course using the program (ArcGIS 10.4) and the adoption of the digital elevation model (DEM), and the study of sectors is of great importance in knowing and monitoring the morphological changes of the river [18]. The development of the island and its area led to a difference in the width of the riverbed between 1973 - 2024, as is clearly shown in Figure 3. The width of the riverbed was measured in three sectors: A, B, and C. Sector A is the entrance to the island from the west, sector B is the middle, and C is at the exit of the island from the east. The width of the riverbed in 1973 was (318.73, 389.35, 294.37) meters for the three sectors, while in 2024 it was (256, 137, 253) meters. These differences show the extent of the change that occurred in the riverbed, as it became narrower than before.

3.2 Length of the Course of the River

The length of the course of the river in 1973 was recorded 3,681 meters, while the length of the course in 2024 varied by 3,697 meters, which is a period of approximately 50 years, which differed in this way as a result of a turn of the course towards the right of the river resulting from the construction and development of the island and the transformation of the hydraulic action of the river water to carve the right side of the river channel, Note that the length of the river course here is the distance formed by the river along the island from its beginning to its end.

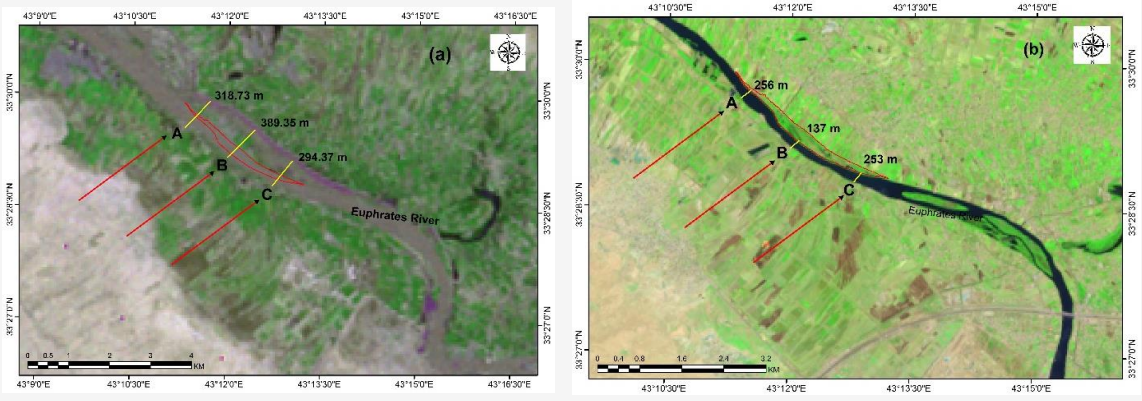

Figure 3: Changes in the riverbed width (a) 1973 (b) 2024

3.3 Depth of the Course of the River

The depth of the course of the river varies significantly from place to place and this is evident by studying the longitudinal sector of the course and the cross-section, and by relying on the digital elevation model (DEM) these variations can be found, It is possible to find the differences in elevations above sea level between one part of the island and the river, which depends in its entirety on analyzing the digital elevation model and using the Surfer program, where through the shapes it gives, which depend on entering the data of the digital elevation model, these differences in topography can be analyzed, as shown in Section 3.3.1 and Section 3.3.2.

3.3.1 Cross-sector analysis

In this section, three river sites were taken, A, B, and C, as shown in Figure 4 and all of them are located along the river in the distance opposite the river island. In site A, we notice that the river bank's heights range between 40 meters on the island side and 45 meters on the opposite side above sea level, while the height of the river bed or river channel is approximately 36 meters above sea level. In this case, the height of the plants covering the island must be excluded, which ranges between 1-2 meters. Through this difference, the depth of the river channel from the adjacent lands can be found, which in this section is approximately 2 meters after excluding the height of the plants from the surface of the island. As for section B, the heights appear close to section A, except for the shape of the river channel, while it is noted in section C that the shape of the channel differs, as well as the height of the river bank on the island side, as it appears to be wider, this shows that the sediments are more with the decrease in the depth of the channel by approximately one and a half meters instead of 2 meters.

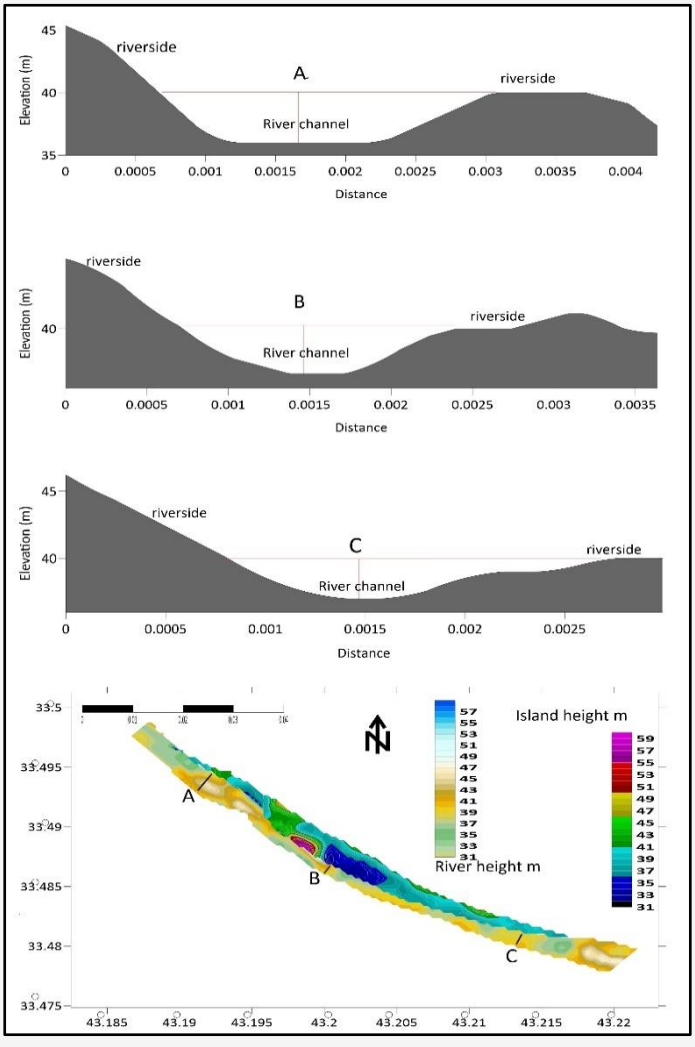

Figure 4: River cross-sections

3.3.2 Longitudinal sector analysis

The longitudinal sector consists of sequences of deep parts and shallow parts, where the deep parts are linked to the concave sides, while the shallow parts are linked to the convex sides, In some places, the shallow parts approach the water surface as a result of the accumulation of sediments until the depth of the water in them becomes about 67 cm, which was observed during the research team's visit to the island, which are the places that form the first nucleus for the appearance of river islands in Figure 5 which was derived as in the method of deriving Section 3.3.1, the general slope of the river course can be observed from point A to point C, where the difference in height between the two points ranges between 40 – 37 meters above sea level. Based on this, it can be said that the difference in height between the two is 3 meters. This shows that the slope of the river at this distance is not strong enough to transport sediments, and thus increase the amounts of silt deposition at the expense of its transport.

4. Morphometric Characteristics of the Island

In this section, the geometric dimensions of the island are studied in terms of length and width. By relying on Landsat satellite data, measurements of the island can be obtained after processing that data using the program (ArcGIS 10.4), through which the geometric dimensions of the island can be derived from that data.

4.1 Island Dimensions

River islands vary in dimensions according to varying morphological characteristics, some have a length greater than their width, and others have a width greater than their length [10]. The length of the island, as obtained from Landsat data and shown in Figure 6 was 3,587 meters. The width of the island was measured at three points, as the width varies from one place to another. Its width at point A was 48.3 meters, while at point B it was 245.9 meters, and at point C it was 53.7 meters. The average width of the island, which can be extracted by adding the width lengths of the three points A, B, and C and dividing them by their number, is equal to 115.9 meters. These dimensions in the measurement give the impression that the island is shaped like a riverboat.

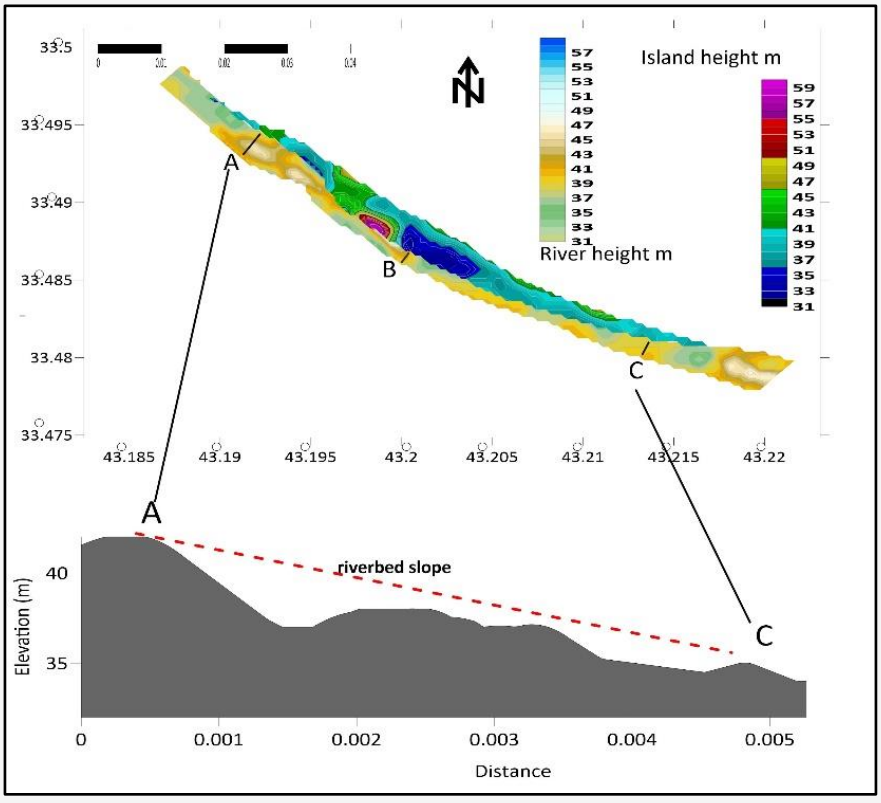

Figure 5: Profile of the river course of the island

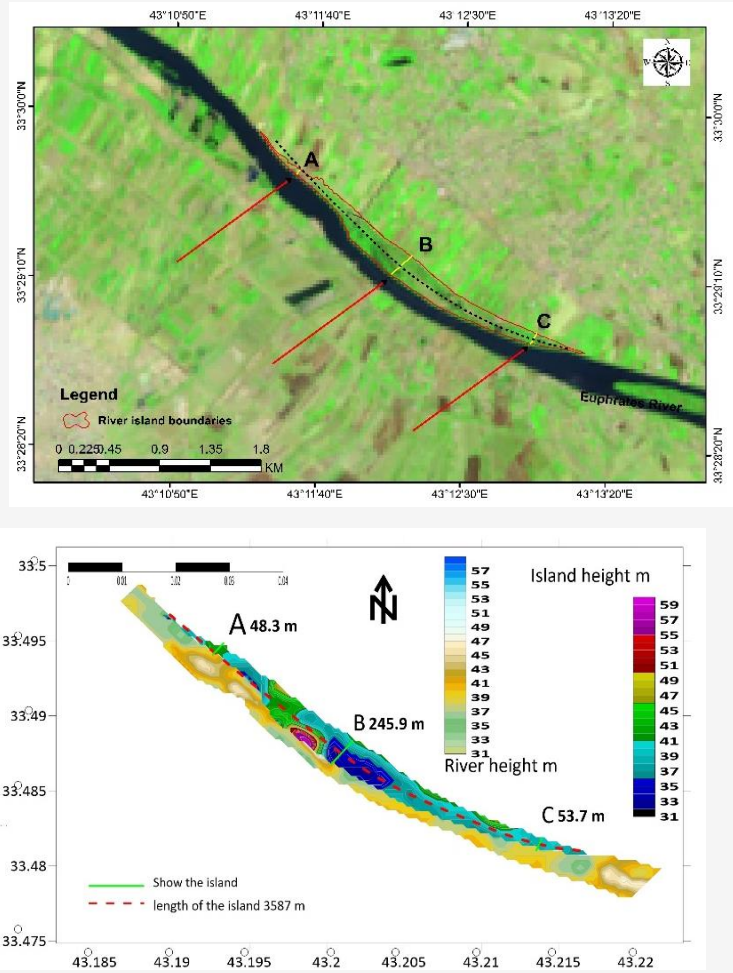

Figure 6: Dimension measurements of the island

4.2 Island Shape

River islands take different forms, including longitudinal, strip, and close to circular, regular and irregular, each according to its proximity to the riverbank and the nature of the riverbed [19]. The aspect ratio (A_r) of the island is defined in equation 3 [20].

$$A_r = \frac{LAL}{TAI}$$

Equation 3

Where:

A_r = Aspect ratio
LAL = Longitudinal axis length
TAI = Transverse axis length

The aspect ratio provides a measure of how elongated or stretched the body is. A ratio greater than 1, which equals 30.94, indicates that the long axis is longer than the short axis, indicating that the shape of the island is elongated or rectangular.

4.3 Horizontal Development of the Island

Since its inception to this day, the island has been subjected to stages of development in its area, the development in the area of the island can be observed by tracking the data of the Landsat satellite in addition to the field survey of the area. The island was identified by the presence of a water channel used for irrigation purposes, which is the course of the old river that is constantly dredged, so its features are clear on the Landsat data. By processing it using the ArcGIS10.4. program, it was possible to identify that island integrated with the river bank from 1973 - 2024, as shown in Figure 7. and over a period of nearly 50 years. Clear changes have occurred in the formation of the island since its inception until today, as it began with an area of 289.07 m^2 in the middle of the river, as shown in the Table 2. Then, after ten years, the situation changed, and there became a group of islands, three of which formed the current island under study, and their total area reached 947.12 m^2.

It is also noted that the river began to erode on both sides, and in 1993, sedimentation settled on the left side of the river and began to narrow, Here, the island appears to have begun to merge with the left bank of the river, taking a longitudinal shape with an area of 1,489.04 m^2, and in 2003 after thirty years, it took its current shape, except for some minor differences in it, and it became connected to the river banks, while the water current pushed in the other direction, and in 2013 it became more stable. At this stage, the current shape of the river was drawn. Its area in 2024, with a slight difference from the previous ten years, reached 4,681.18 m^2. This gradual development in the area of the island reflects the extent to which the river discharges are affected by climate changes and storage projects established in both Turkey and Syria.

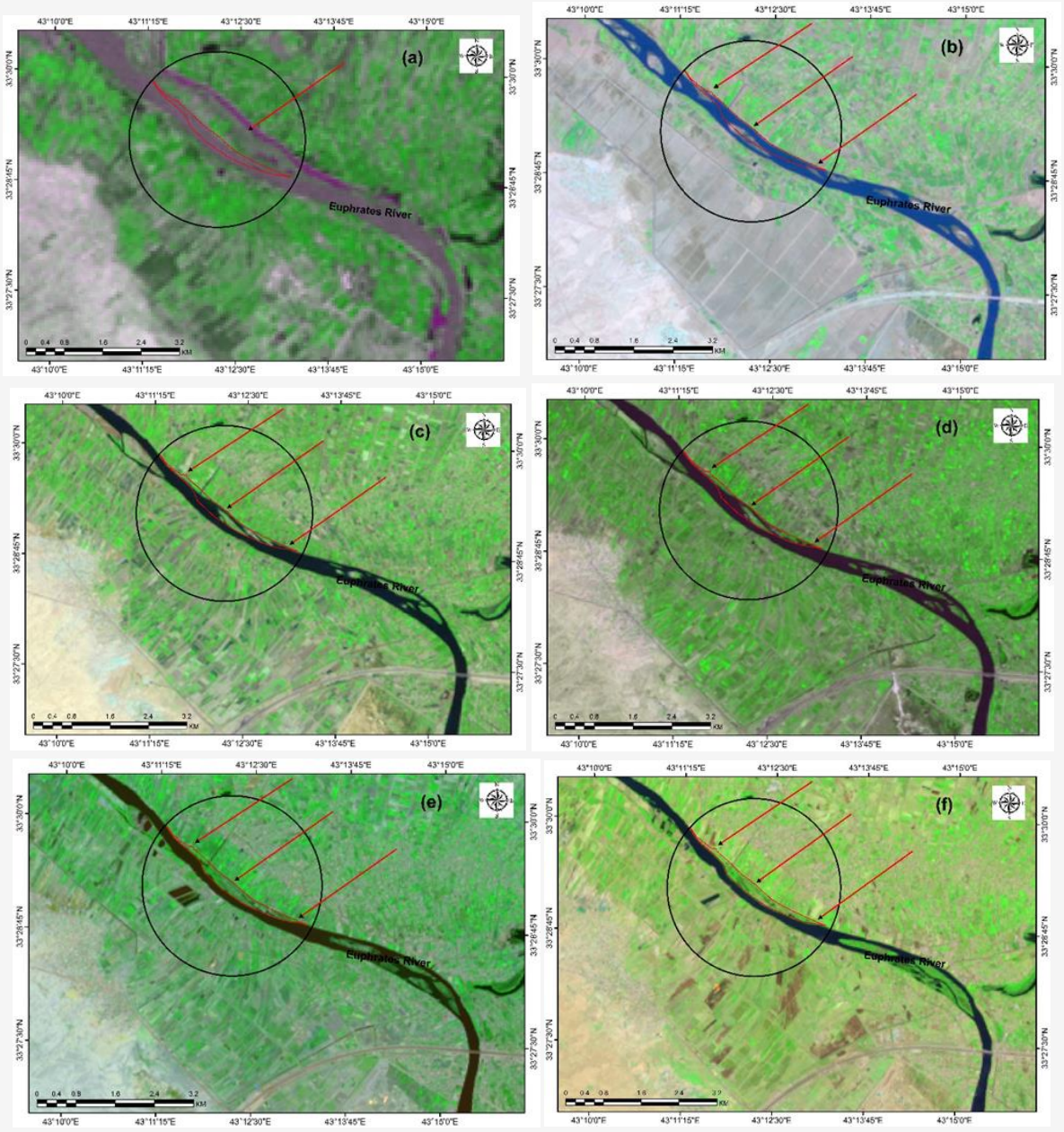

Figure 7: Variation in the island shape (a) 1973 (b) 1984 (c) 1993 (d) 2004 (e) 2013 (f) 2024

Table 2: The area of the Island from 1973 to 2024

Year	Area [m^2]
1973	289.07
1984	947.12
1993	1,489.04
2004	3,120.02
2013	4,544.65
2024	4,681.18

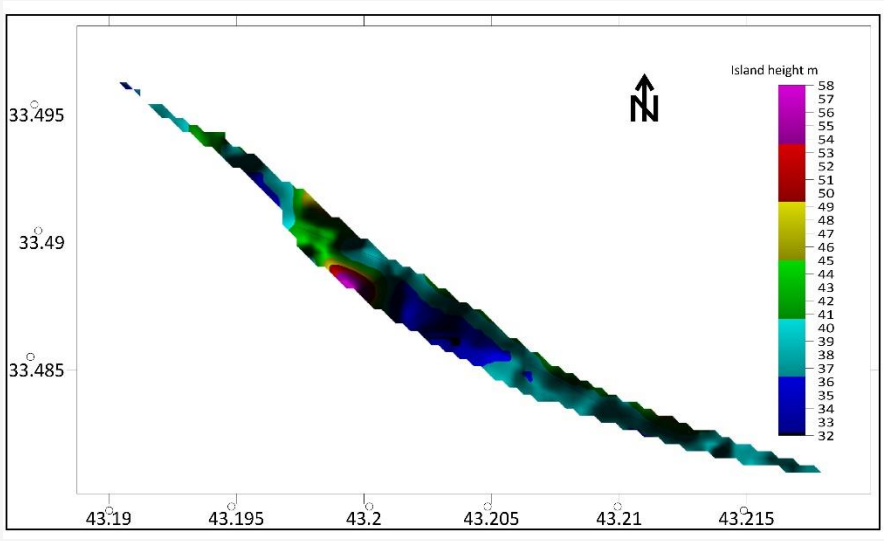

Figure 8: Elevation of the island

4.5 Terrain Sectors

The heights of the island vary from one place to another as shown in Figure 8. where the highest height of the island reached 58 meters above sea level located in the central western part of the island, while the lowest height reached 32 meters above sea level, these heights on the island show the extent of the height from the river waters, which range between 2.71 meters as shown in Figure 9. this gives the trench shape of the island and the river channel, which can be embodied in Figure 10. When comparing Figure 8 and Figure 9. we notice that the heights of the island start from 32 meters above sea level as the lowest point, while in Figure 9. it starts from 28 meters, which includes the heights of the river and the island together. This is the lowest point in the riverbed. When calculating the difference between the two points, we find it to be 4 meters at this point. We must remember that the height of the plants on the island ranges between 1-2 meters. If we take the 2-meter exception, the difference between the island and the river will be 2 meters, and thus it is the depth of the riverbed from the island.

5. Assessment of the Environmental Structure of the Island

Based on previous studies, human activities are one of the things that affect the stability of sand barriers and river islands [17]. There are too many sand barriers that have been inventoried but not included in the calculation because they have been affected by human activities, and river islands are essentially a concentration of sand deposits due to the reasons mentioned above that can be invested in one of the following activities [21].

5.1 Leisure Activity

The island is located in a position that qualifies it to exercise this role, where it is often taken by the people of the nearby area for the purpose of hiking in holidays and events and exploited for the purpose of hunting, including hunting wild birds and fishing in the river [22] and some places have been exploited in the construction of entertainment parks by the private sectors, although modestly, but it constitutes an entertainment outlet for many people see the Figure 11.

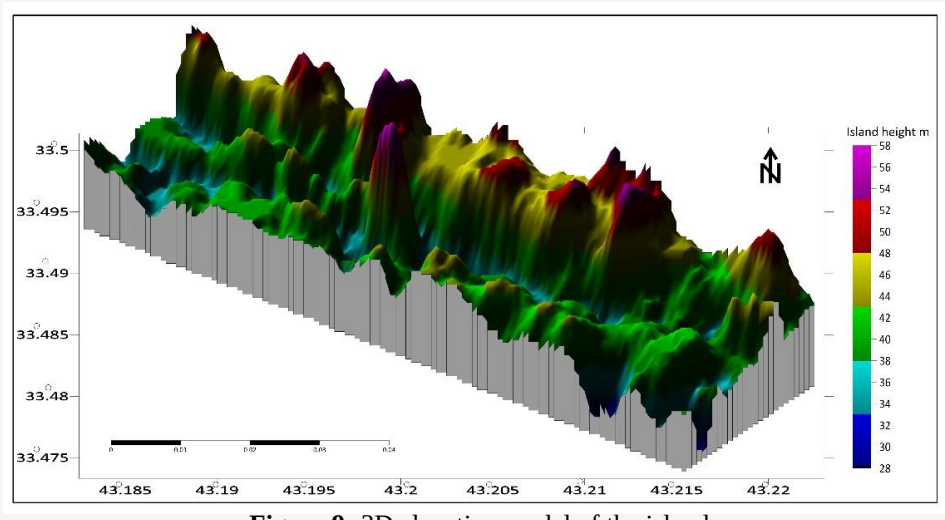

Figure 9: 3D elevation model of the island

Figure 10: The island as seen from the river

Figure 11: Entertainment places

Figure 12: Agricultural land

Figure 13: Cows pens on the island

5.2 Agricultural Activity

Agricultural activity is one of the prominent practices, as it formed a clear importance through the exploitation of large areas of land adjacent to the island in agriculture, and this investment was not limited to one side, but included the plant and animal side alike, and this is due to the linear pattern of population spread along the river course see Figure 12 and often the investment system varies from one region to another depending on the factors of location and geography, including the narrowness of the floodplain and the scarcity of agricultural land. This prompts residents to exploit all areas suitable for agriculture, including islands.

5.3 Grazing

The grazing profession is related to agricultural activity in the region and the exploitation of the island for grazing is one of the most important aspects of the main attraction of farms, and grazing cows is among the most important animals due to the amount of feed they need, and some places of the island have been exploited in building pens for those cows see Figure 13 and the availability of reed plants helped to spread that activity of grazing.

5.4 The Impact of River Islands on Climate Change

The effect of climate on the phenomenon of river islands is closely related to the association of river discharge with these changes. Rivers in general, including the Euphrates River, are characterized by many geomorphological phenomena that are clear features of river environments, including river islands. This section of the study is concerned with the factors affecting the emergence, development, numbers and area of river islands. River islands are considered important sedimentary phenomena in the areas of alluvial plains associated with rivers, especially in low-lying areas [23] where they have become the focus of attention of researchers in geography due to their environmental effect.

Rain is one of the most influential climatic elements on the formation of river islands, and rain is also considered a factor of weathering and erosion at the same time [24] as the torrents formed in the dry valleys connected to the river contribute to transporting abundant amounts of sediment annually to the river course, thus contributing to increasing the amount of river load and then becoming unable to bear the load of sediments resulting from their deposition in any area of the river channel, thus forming river islands or increasing their areas and heights [25]. Climate changes have indirectly affected the formation of river islands through changes in rainfall amounts and consequently a decrease in water discharge amounts, as the river discharge has changed. In January 1975, it recorded a rate of 598 m^3/s, then the amounts decreased in 2002 to 287 m^3/s, then the river discharge decreased again in 2023 to 256 m^3/s. This is due to the small share of water arriving from the upstream countries in Turkey and Syria, as well as the scarcity of rainfall amounts in the region, which averages 110 mm of total annual rainfall. All of these factors helped develop the areas of river islands.

The development of these islands has a clear impact on the surrounding climatic conditions due to the dense vegetation of reeds that grow in this environment here. Figure 14 shows the impact of climate change from the difference in NDVI values compared to 2024, as shown in Figure 15. where NDVI values ranged between 1 - 0.92, and we note that they have declined in 2024 between 1 - 0.74, The same is true for the FVC index, which also declined from 0.62 - 0.49 in 1973 to 0.58 - 0.37 in 2024. These differences show the extent of the impact of climate change on the region.

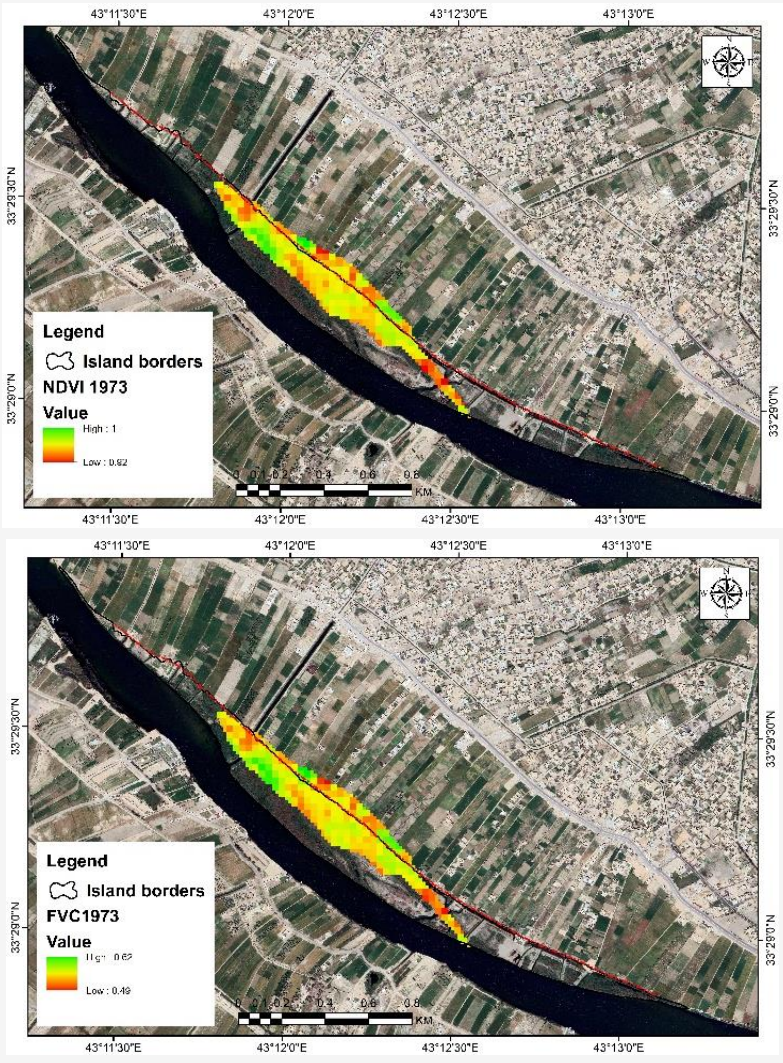

Figure 14: NDVI and FVC for 1973

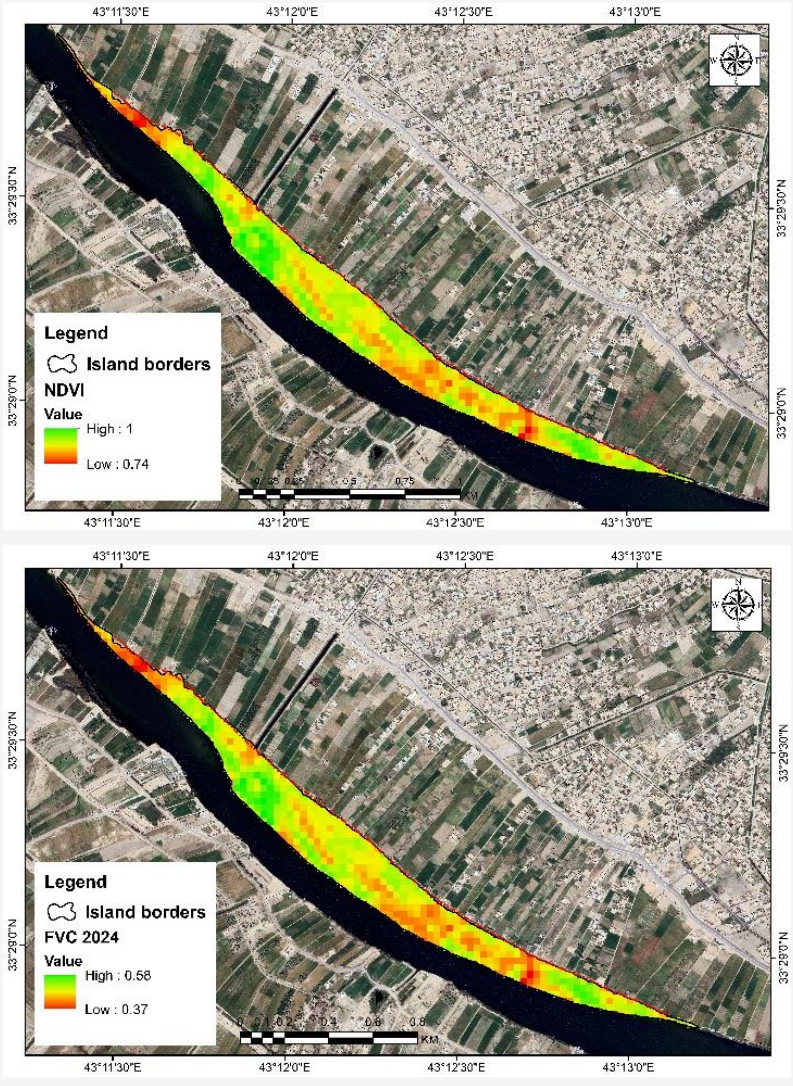

Figure 15: NDVI and FVC for 2024

6. Conclusion

Rivers are characterized by instability in terms of water and sediment flow, linked in one way or another to the state of climatic conditions and the extent of their fluctuation from time to time, especially the amounts of rain or melted snow in the source areas. River islands and the mechanism of their formation and formation are one of the most important morphological developments that the river is continuously exposed to and the multiple environmental repercussions it creates. The main goal of the authors was to identify one of the most important islands of the Euphrates River and monitor its development over fifty years using Landsat data from 1973 - 2024. This working paper includes a scenario for the development of the island in terms of area, extension, formation nuclei, and its height above the river, and then its environmental effects with the possibility of exploiting it for multiple purposes, during the study periods, which are 1973, 1984, 1993, 2004, 2013, 2024. Due to the impact of climate change and the decrease in water quantities in the river, the area and location of the island have developed significantly after it was a nucleus in the middle of the river and became a land connected to the river bank. The northern part has changed in area from 289.07 m^2 to 4,681.18 m^2, the difference it is of 4,392.11 m^2 as a result of the accumulated sediments of the river. The growth of the island to this size and its stability affected the river current and its extension in one way or another. The width of the river changed at three points A B C from 1973 (318.73, 389.35, 294.37) meters to (256, 137, 253) meters in 2024. Thus, it became narrower and curved towards the south.

The height of the island has developed by 2 meters more than the height of the river, and the shape of the island according to the law of the ratio of width to height has become close to the rectangular or ribbon shape with a longitudinal extension reaching 3,587 meters. The vegetation cover also contributes to the stability of the sandy soil of the island with its high density, which ranged according to the values of the natural vegetation index between 1 to 0.92 in 1973, while it ranged between 1 to 0.74 in 2024. This difference in values shows the extent of the impact of climate change on the region, and this is reinforced by the FVC index, which also shows the difference between the two periods, which ranged between 0.62 to 0.49 in 1973 and 0.58 to 0.37 in 2024. Therefore, we expect this island to be an important destination for investment, whether agricultural or recreational, in the future. In addition, the river sediments in their current state may increase the area of the island by half over the next forty years, as the river erodes more on the opposite side. This study will help planning authorities and decision-makers to consider this part of the river as well as similar areas and develop appropriate plans to exploit them or avoid their effects in the future.

Acknowledgements

This research has been supported by the College of Education for Humanities at the University of Anbar and one of the applied research in geospatial information we express our appreciation to everyone who contributed to supporting this study, the authors would also like to thank the referees for their valuable comments that enhance the quality of this article.

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