ISSN: 2458-8989

Natural and Engineering Sciences

NESciences, 2024, 9 (2): 347-358 doi: 10.28978/nesciences.1574446

Geomorphological Changes of the Terrestrial Features of the Euphrates River between the Cities of Al-Kifl and Al-Mishkhab Using Geographic Information Systems (GIS)

Kamil Hamza Fleifel Al-Assadi [1*], Aqeel A. Al Kaabi [2]

[1*] Faculty of Arts, University of Kufa, Najaf, Iraq. E-mail: kamil.alasadi@uokufa.edu.iq

[2] Faculty of Arts, University of Kufa, Najaf, Iraq. E-mail: aqee.alkabi@uokufa.edu.iq

Abstract

The study area occupies part of the southwestern part of the sedimentary plain from the city of Al-Kifl and Najaf to the city of Al-Mashkhab, which is predominantly characterized by extraversion, which made the study area a low topographical variation. However, this variation contributed significantly to determining the geomorphological forms of the Euphrates River course as well as the direction of the course, which was consistent with the direction of the surface slope from the northwest towards the southeast. Thus, the natural characteristics of the study area vary from geological structure, surface, climate, soil and natural vegetation. When taking into account the true longitudinal extension of the Euphrates River course of (59) km, we find that these characteristics have a prominent impact in causing geomorphological changes in the study area.

Keywords

Euphrates river, geomorphological changes, terrestrial features, Geographic Information Systems (GIS), Al-Kifl to Al-Mishkhab.

Article history:

Received: 11/06/2024, Revised: 06/08/2024, Accepted: 09/09/2024, Available online: 30/10/2024

Introduction

Rivers have been of great importance in geomorphological studies as one of the important elements that have contributed and contribute significantly to the formation of the features of the Earth's surface**,** and that understanding this change can only be done using maps and remote sensing data (space visuals) for different periods of time for comparison, and since the river course located within the flood plain and its various land manifestations, represented by river islands of all kinds, river banks and other land forms, is the scene of geomorphological operations between demolition and construction, where the study area is part of the

*Corresponding Author: Kamil Hamza Fleifel Al-Assadi, E-mail: kamil.alasadi@uokufa.edu.iq

Euphrates River (Nidhi et al., 2024; Čomić & Hrustić, 2021; Lemenkova, 2020; Al-Shalash, 1981; Binnie 1956).

1. **The Problem of the Study: -** The problem of the study is summarized as ((What is the change in the land manifestations of the Euphrates River between the cities of Kifl and Mishkhab))?
2. **The Hypothesis of the Study: -** By identifying the problem of the study, the answer can be reached to the question of the problem of the study, which is the extent to which the land forms in the river change within the study area through satellite visualizations for the years (1976-2000-2021) according to the quantities of rain and river discharge**.**
3. **The Objective of the Study: -** The main objective of the study is to detect the change in the terrestrial manifestations of the years (1976-2000-2021) and to identify the geomorphological processes that control the formation of the terrestrial manifestations of the Euphrates River.
4. **The Limits of the Study: -** The study area is located within the sedimentary plain in the central part of Iraq on the main course of the Euphrates River, which is (Shatt Al-Kufa) from the city of Al-Kifl in Babil Governorate to the city of Mishkab in Najaf Governorate. The study area is located within the astronomical site between the Dadaiyat ("50′13° 32N - ″45′21° 44e) north and ("52′45° 31N - ″35′30° 44e) south as in Figure 1.

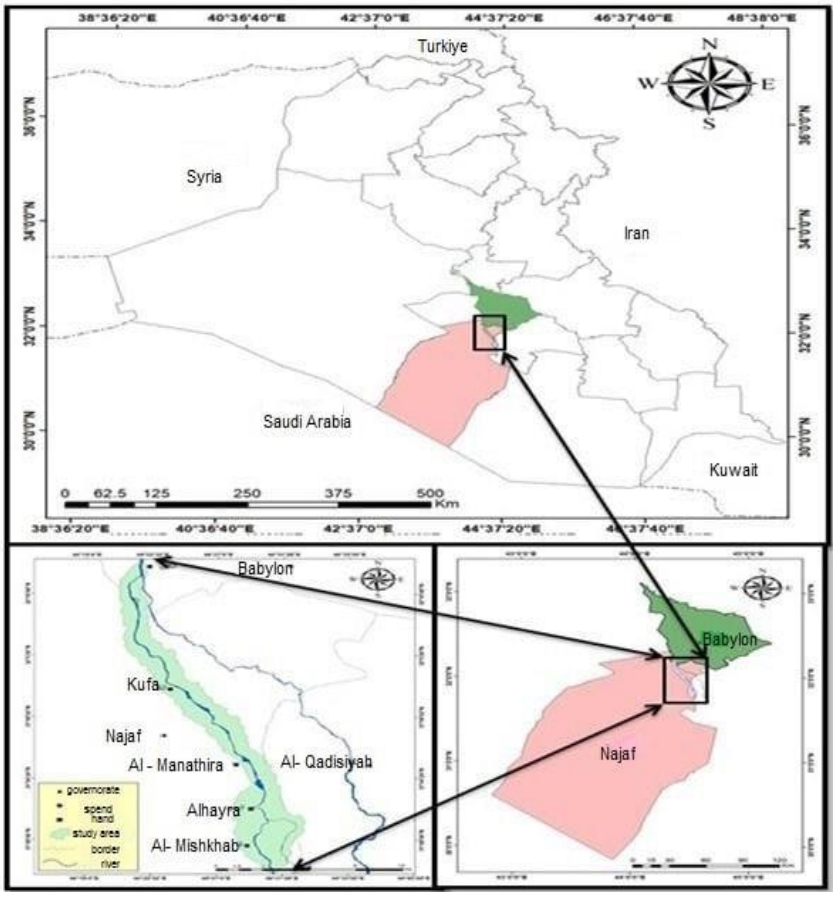

Figure 1. Study Area

Natural Factors Affecting the Ground Manifestations of the Euphrates River within the Study Area

The natural characteristics of the study area vary from geological structure, surface, climate, soil and natural vegetation, and when taking into account the true longitudinal extension of the Euphrates River course of (58) km², the factors are:

1. Geological Structure

Quaternary time deposits cover most of the study period, which is represented in river deposits, and deposits belonging to human activities, which are represented in (gypsum deposits (the Pleistocene – the Holocene) and- deposits filling depressions or sediments (Holocene) and deposits of the flood plain (Holocene).

2. Surface

The study area is part of the sedimentary plain region, which consists of areas of shoulders, basins, marshes and swamps and slopes from north to south, which are formed as a result of river sedimentation operations of the Euphrates River (1), and the nature of the surface that this part of the region is characterized by general extensiveness, it turns out that the study area consists of three slopes, the first slope is graduated from the north (27°) to the northwest (30°) of the study area and the rate of slope is equal to (0.15 m), while the second slope is from the west of the study area (30°) to the east of the study area (24°) and the rate of slope is (0.6 m), while the third slope is east of the study area (24°) and south of the study area (21°) and the rate of slope is (0.1 m).

3. Climate

Climate is one of the factors that have a direct impact on geomorphological processes such as weathering and erosion processes. Sediments covered the surface of the research area during the times preceding the time of Pleistocene. When the Earth's climate entered the time of Pleistocene, climatic conditions changed (Falah & Nora, 2022). Among the climatic elements studied within the research area, solar radiation is the amount of actual solar radiation during the winter, in which the hours of actual solar brightness reach (6) hours per day, so temperatures decrease, while the opposite occurs in the winter season. Summer, as the hours of actual solar brightness increase to reach more than (12) hours on some days, and this leads to raising temperatures and results in an increase in water losses by evaporation from riverbeds, and the temperature is that the high temperature and fluctuating humidity that the banks are exposed to due to the movement of river water leads to the exposure of iron oxides to the process of iron oxides during high temperatures during the day, so iron oxides turn into water-soluble iron hydroxide, and this material is present in the mud that forms the banks of the river, and the wind works directly through its mechanical work where it works On the erosion of the banks of the rivers when they fall strongly and continuously, but their work in an indirect way, where they create high waves that lead to their collision with the banks, and rain, where the increase in rainfall and its impact on the increase of drainage as well as the ability of the river on the process of erosion, transportation and sedimentation, and relative humidity. The lower the humidity, the greater the evaporation process continues due to the length of solar radiation rates, but in the event of high relative humidity, the evaporation process decreases, even if the radiation is hot (20), and evaporation, the lower the evaporation rates for rainfall becomes surplus with running water, and vice versa, when the evaporation rates are higher than the rates of precipitation, there is a water deficit in the dry season without rain (earthexplorer).

4. Soil

Soils are the crumbling surface layer of the earth's crust, which ranges in thickness from several centimeters to several meters (Sousse & Euphrates, 1945). Soils vary in their natural, chemical and life characteristics clearly (Kadhim et al., 2023). This variation is important in the conduct of geomorphological processes affecting the surface of the earth. This is done by knowing the sizes of soil particles, their texture and organic matter, and knowing the amount of their impact on the top of the soil (Sousse & Euphrates, 1945). Soil varieties found in the study area can be studied according to the Bjornk study of the soil of Iraq, which is the soil of

river shoulders, the soil of river basins and the soil of river basins submerged in silt (Almudhafar, 2020; Alattabi et al., 2023).

5. Vegetation Cover

It is a real product of the environmental conditions prevailing in the study area on the riverbed (Almudhafar, 2018; Sousse, 1983; Safaa Majeed, 2017; Almudhafar & Alattabi, 2019), and the vegetation cover in the study area is represented in the natural plant and agricultural plant, the area of agricultural fields and natural plant is about (64 km²), representing about (17%) of the area of the study area, and the areas without vegetation cover occupy an area estimated at (247 km²) equivalent to about (69%) of the study area represented by wild bats and aquatic plants (Veerasamy & Fredrik, 2023; Radhika & Masood, 2022).

Phases of the Euphrates River

The Euphrates River passed through five phases, which changed its course from one place to another within the sedimentary plain area, where geological, geological and archaeological studies in the Middle and Lower Euphrates indicated that the river had passed through five phases. The river was in its first phase, which is located between (5000 – 4000 years BC) in the far east of Babylon Governorate, which is the ancient eastern stream known as the Kothi stream, which runs along the Tigris River (Al-Dulaimi, 2017), and that stream was changing from one location to another in the area between Fallujah and Al-Masib for the river The Euphrates, of which the Shatt al-Hilla is one of its branches, and the second phase, which is between 4000 years BC and the sixth century AD, the course of the Euphrates River shifted towards the city of Babylon after the level of the Kothi River rose due to an increase in sedimentation. This was in the second Babylonian era, which was characterized by irrigation projects that developed, which is one of the greatest in Iraq's long history (Safaa Majeed, 2013; Abu, 2007) and the river remained in its course for up to two thousand years, and this period is one of its longest and most organized phases in terms of irrigation (Hrebid & Al-Zamily, 2022), and the third phase extends during the Arab era Between the seventh century AD and the thirteenth century AD, as the course of the river shifted from the Babylonian direction to the direction of its other ancient branch (Balakopas), which was mentioned in the Babylonian texts as (Nar Balukat), and this branch was a drain of excess water in the flood season when the Euphrates River was running in the course of Babylon southeast towards the city of Kufa. Currently, the Euphrates River returns in the fourth phase to the course of the city of Babylon, while the fifth and last phase (Fleifel & Hamid, 2023; Almudhafar & Abboud, 2018).

Geomorphological Changes of the Ground Forms of the Euphrates River in the Study Area for the Years (1976 – 2000 – 2021)

1. Changing the Course of the River

Through the analysis of the satellite visuals Land sat 1-5 for the sensor Mcc C2 L1 for the year (1976) for the study area and the outputs of the Arc Gis 10.8 program, it is clear that the length of the course of the Euphrates River extending within the study area for the year 1976 (55 km), and for the year (2000) and the analysis of the satellite visualization Land sat 5 for the sensor Tm C2 L1, and the satellite visualization Land sat 8 for the sensor Oli/Tips C2 L2 for the year (2021), where the length of the course of the Euphrates River within the study area (59 km), and by taking (10) sections of the river appears as shown in Table 1.

Table 1. Changes in length and cross-section of the riverbed for the years (1976-2000-2021)

S/N	Cross-Section	Coordinate	True Length 1976 km	Cross section of the river 1976 AD	True Length 2000km	Cross section of the river 2000 m	True Length 2021km	Cross section of the river 2021 m
1	Al-Kifl, Abu Gharb village	44° 21' 44" E 32° 12' 43" N	55	267	59	256	59	195
2	The right bank of the river, Albu Hidari area The left bank of the river Al-Hawatim area	44° 20' 58" E 32° 11' 41" N		178		154		177
3		44° 21' 31" E 32° 9' 23" N		106		103		143
4		44° 21' 20" E 32° 6' 51" N		141		134		120
5		44° 23' 24" E 32° 4' 18" N		157		140		53
6	Al-Manathira District and Al-Hira sub-district	44° 24' 48" E 32° 2' 10" N		130		127		100
7		44° 27' 11" E 31° 59' 2" N		197		209		78
8	Mishkab District	44° 28' 6" E 31° 57' 5" N		173		117		81
9		44° 29' 32" E 31° 54' 58" N		104		101		110
10		44° 29' 51" E 31° 52' 3" N		84		107		95
& Modified				153.7		144.8		115.2

Source/Researcher's work based on Land Sat satellite visualization 1976-2000-2021 using Arc Gis 10.8

2. Changes of River Twists and Turns

The river course is the place where river operations take place from erosion to sediment from time to time. Rivers change constantly due to the dynamic movement of water, represented by the impact of the dynamic force of water on the banks and bottom of the river. River bends and twists are subject to change due to erosion and sedimentation (Fleifel & Hamid, 2023). The bend is most often the result of the development of river twisting and may later develop into crescent lakes. Twists and turns are measured by a number of morphometric laws, including measuring the length of the course in the bend and the length of the turning wave, the ratio of zigzagging, and the range. Therefore, the Euphrates River included within the study area on (8) twists and (2) twists in (1976). Changes have occurred in these turns due to the incision of the neck of the bendium and the establishment of the Kufa on it and its transformation into a crescent island. As shown in (2000), the number

of twists are (16), (2) twists, (14), (4) and (2021). Through this, the characteristics have changed during the years (2000-2021), and as shown in the Figure 2.

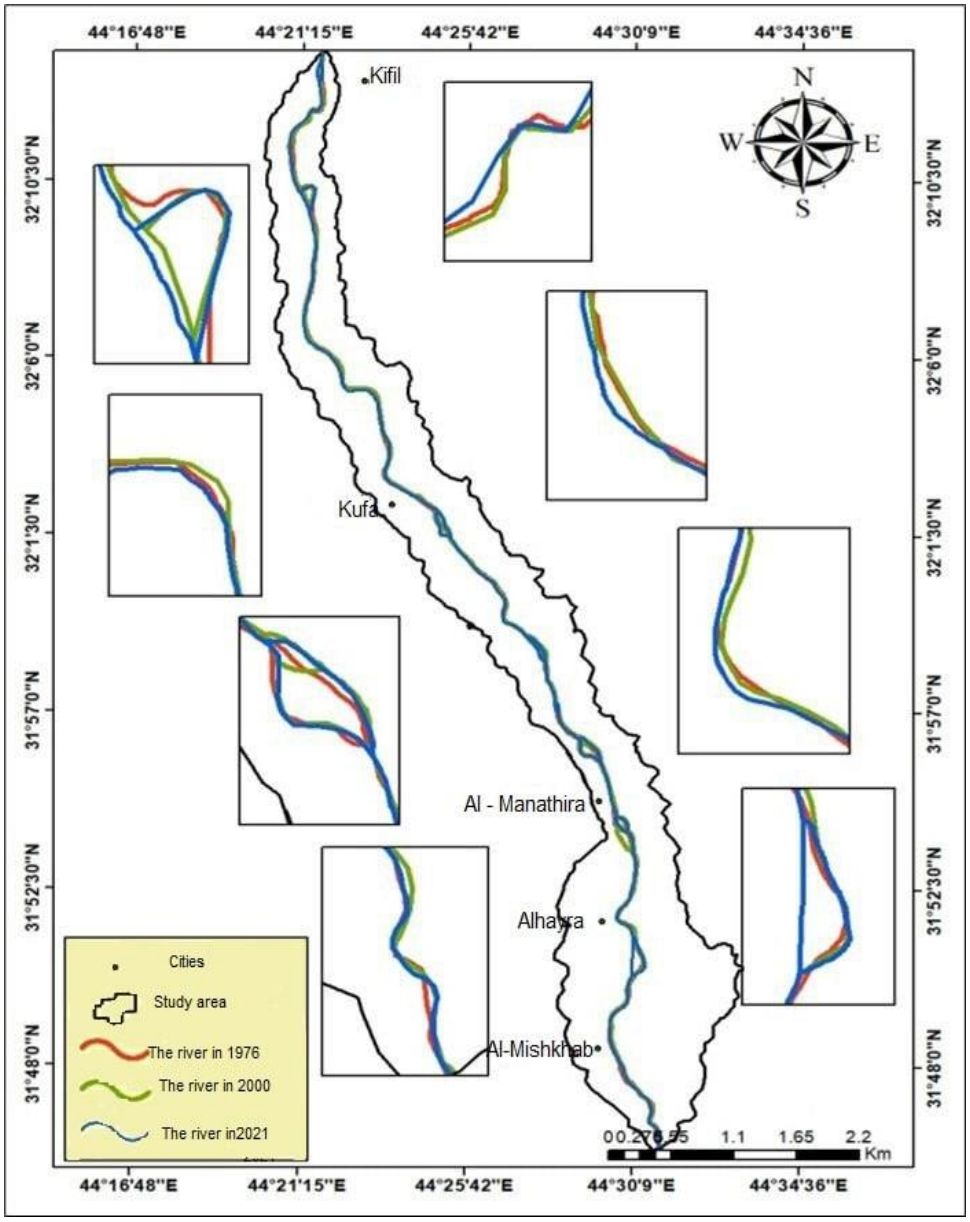

Figure 2. Changes of twists and turns of the euphrates river in the study area in (1976-2000-2021)

Source/Researcher's work based on satellite visualizations (1976) Land Sat 1-5 Mcc C2 L1, (2000) Land Sat 5 Tm C2 L1, (2021) Land Sat 8 Oli/Tips C2 L2 and Arc Gis 10.8 outputs.

3. River Island Changes

The course of the Euphrates River in the study area witnessed significant changes, due to the activity of the sedimentation process that appeared clearly in the river course, and the river islands are one of the geomorphological forms that witnessed a change in the study area, and that this change clearly appears from what it was in (1976). Some old islands merged with the nearest banks and some continued to exist so far. Due to the continuous sedimentation process to which the river is exposed, the study area witnessed the emergence of new islands, especially during the period between (2000-2021), due to the low water level in the Euphrates

River, as well as due to the lack of rainfall. The number of river islands increased from (15) river islands in (1976) to about (23) river islands in the year (2021), which led to a change in the morphometric characteristics of the Euphrates River, and by tracking the phenomenon of the development of the islands on satellite visualizations, it is clear that the lengths of the islands for the year (2000 to 2021) increased from what they were in the year (1976), due to the low water level and quantities of sediments at the beginning of the islands, and an increase in sedimentation at the end, and it is clearly shown in the high-resolution satellite visualization. It is also noted that the development of the islands through clay sediments and sandy, and the center of the carrot shows the plant densely, and this indicates the presence of wide-area islands since previous periods of time (Figure 3 and Tables 2-4).

Table 2. Measurements and dimensions of river islands in the study area for 1976

Carrot number	Zone name	Al-Jazeera coordinates	Island Length (m)	Island area (m^2)	Island Width (m)	Island perimeter (m)	Nearest Bank
1	The right bank of the river, Albu Hidari area The left bank of the river Al-Hawatim area	E 44° 21' 40" N32° 13' 20"	346	14391	50	856	Center
2		E 44° 21' 47" N32° 12' 46"	1205	48209	52	2419	left
3		E 44° 21' 31" N32° 12' 20"	343	11680	35	781	left
4		E 44° 21' 31" N 32° 9' 38"	657	23295	42	1343	Right
5		E 44° 21' 10" N32° 11' 59"	569	31001	88	1204	left
6		E 44° 22' 11" N 32° 5' 43"	1315	110403	124	2709	left
7		E 44° 22' 31" N 32° 5' 17"	696	30660	84	1435	Right
8		E 44° 23' 8" N32° 5' 3"	644	40026	99	1327	left
9	Al-Munathirah District and Al-Hira sub-district	E 44° 23' 32" N32° 4' 3"	1269	66416	79	2652	Right
10		E 44° 23' 35" N32° 2' 57"	734	39377	93	1487	Right
11		E 44° 24' 59" N32° 1' 47"	1246	206240	212	2684	left
12		E 44° 27' 39" N 31° 58' 30"	745	80666	164	1562	left
13	Mishkab District	E 44° 28' 55 " N 31° 56' 4 "	1344	332693	499	2999	Center
14		E 44° 29' 54" N 31° 53' 57"	1696	451823	389	3666	Center
15		E 44° 30' 10 " N 31° 47' 28"	6 61	49052	83	1380	left

Source/Researcher's work based on satellite visualizations (1976) Land Sat 1-5 Mcc C2 L1 using Arc Gis 10.8 software.

Table 3. Measurement and dimensions of river islands in the study area for the year 2000

Carrot number	Zone name	Al-Jazeera coordinates	Island Length (m)	Island area (m^2)	Island Width (m)	Island perimeter (m)	Nearest Bank
1	The right bank of the river, Albu Hidari area The left bank of the river Al-Hawatim area	E 44° 21' 40" N32° 13' 20"	730	44910	87	1499	Center
2		E 44° 21' 28" N32° 12' 18"	437	25134	57	953	left
3		E 44° 20' 57" N32° 11' 23"	1438	82703	91	2914	Right
4		E 44° 21' 29" N 32° 9' 40"	762	45103	84	1566	Right
5		E 44° 21' 10" N32° 11' 59"	620	42298	111	1276	Right
6		E 44° 21' 20" N32° 7' 3"	635	39410	107	1358	left
7		E 44° 22' 10" N 32° 5' 50"	670	29339	79	1362	Right
8		E 44° 23' 33" N32° 3' 34"	810	32880	66	1630	left
9		E 44° 24' 59" N32° 1' 47"	1235	231768	329	2691	left
10	Al-Munathirah District and Al-Hira sub-district	E 44° 27' 39" N 31° 58' 30"	698	39377	172	1487	left
11		E 44° 28' 55" N 31° 58' 29"	1382	350331	527	3300	Center
12		E 44° 28' 55 " N 31° 56' 4 "	672	28635	59	1365	Right
13		E 44° 29' 33" N 31° 55' 5"	672	134604	282	1575	Center
14	Mishkab District	E 44° 29' 54" N 31° 53' 57"	1221	327537	399	2664	left
15		E 44° 29' 56" N31° 53' 48" N	299	8232	40	681	left
16		E 44° 29' 31" N 31° 48' 59"	631	29037	78	1284	left

Source/Researcher's Work on Satellite Visualization (2000) Land Sat 5 Tm C2 L1 Using Arc Gis 10.8.

Table 4. Measurements and dimensions of river islands in the study area for the year 2021

Island Number	Zone name	The coordinate	Carrot Length (m)	Carrot Area (m²)	Carrot Width (m)	Carrot Perimeter (m)	Nearest Bank
1	The right bank of the river, Albu Hidari area The left bank of the river Al-Hawatim area	E 44° 21' 42" N32° 13' 0"	1022	145109	121	3821	Center
2		E 44° 21' 22" N32° 12' 6"	406	19433	74	796	left
3		E 44° 20' 57" N32° 11' 31"	868	50417	77	1783	Right
4		E 44° 21' 34" N32° 8' 55"	825	47576	72	1746	left
5		E 44° 21' 32" N32° 8' 15"	681	32289	56	1383	Right
6		E 44° 21' 22" N32° 7' 33"	1035	55727	75	2111	left
7		E 44° 21' 21" N32° 6' 55"	1501	96037	95	3064	Right
8		E 44° 22' 12" N 32° 5' 50"	1023	50718	93	2128	left
9		E 44° 22' 31" N32° 5' 16"	854	46164	114	1742	Right
10		E 44° 28' 5" N 31° 57' 7"	600	29771	80	1238	left
11		E 44° 23' 25" N32° 4' 18"	1424	80986	78	2877	Right
12		E 44° 24' 59" N32° 1' 47"	1242	235592	183	2702	Center
13		E 44° 26' 41" N 31° 59' 41"	438	14852	46	896	Right
14		E 44° 27' 39" N 31° 58' 30"	1444	163482	107	2968	Center
15		E 44° 27' 59" N 31° 57' 33"	455	9121	35	919	Right
16	Al-Munathirah District and Al-Hira sub-district	E 44° 28' 55 " N 31° 56' 4 "	1308	365424	528	3022	Center
17		E 44° 29' 35" N31° 54' 46"	790	60056	119	1680	left
18		E 44° 29' 51" N 31° 54' 13"	735	145861	284	1671	Right
19		E 44° 29' 54" N 31° 53' 57"	1167	342112	395	2710	left
20	Mishkab District	E 44° 30' 2" N 31° 52' 18"	764	|||UNTRANSLATED_CONTENT_START|||41441|||UNTRANSLATED_CONTENT_END|||	40	2029	Right
21		E 44° 29' 33" N 31° 48' 45"	597	25971	58	1209	left
22		E 44° 28' 13" N 31° 56' 47"	190	4435	38	398	Right
23		E 44° 21' 38" N32° 12' 21"	380	16749	60	796	left

Source/Researcher work based on Land Sat 8 sensor Oli/Tips C_2L_2 using Arc Gis 10.8.

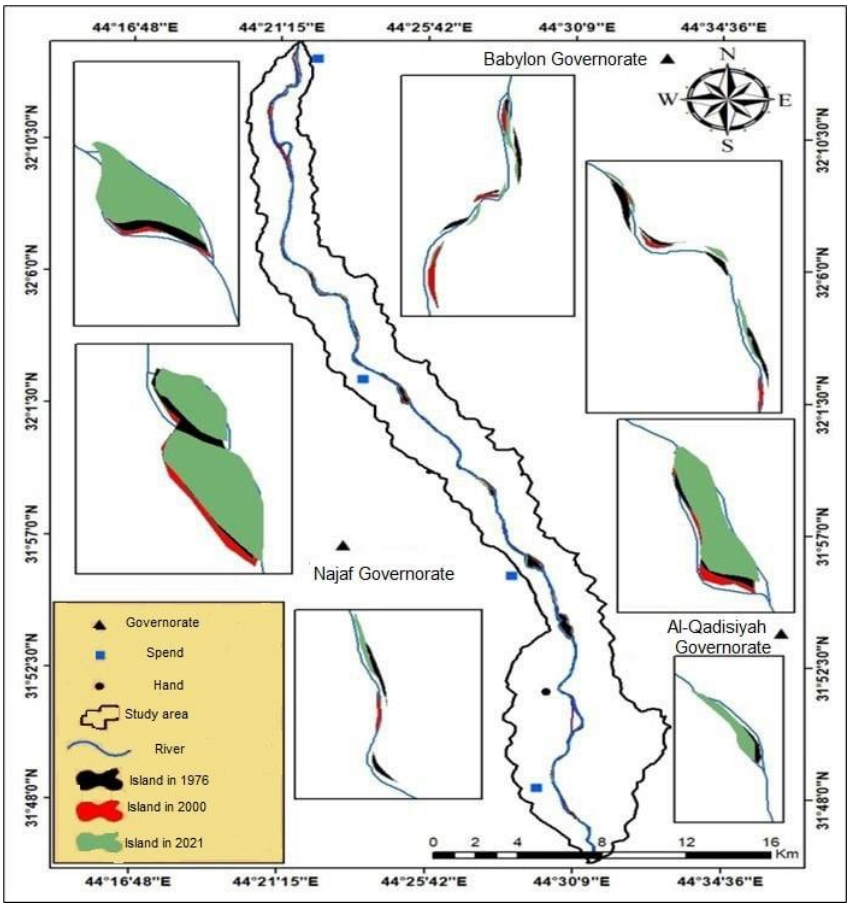

Figure 3. Variation of river islands in the study area for the years (1976- 2000- 2021)

Source/Researcher's work based on satellite visualizations (1976) Land Sat 1-5 Mcc C2 L1, (2000) Land Sat 5 Tm C2 L1, (2021) Land Sat 8 Oli/Tips C2 L2 and Arc Gis 10.8 outputs.

Conclusions

1. The study revealed a change in the length of the main course of the Euphrates River within the study area between the true length of (4 km²) and the ideal length of (1 km²).
2. The study revealed an increase in the number of river islands and in their forms between the years of study, where the number of river islands in (1976) was (15), while the year (2000) became (16) and in (2021) (23) river islands.
3. The study revealed changes in the dimensions of river twists and turns during the study years represented by their morphological characteristics such as the ratio of zigzag, wavelength, range, wavelength of the turn, length and width of the stream in the twist and turn, and that they are caused by natural and human factors.

Author Contributions

All Authors contributed equally.

Conflict of Interest

The authors declared that no conflict of interest.

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