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Assessment of the Geomorphological Effects of Human Activity in Russeifa District, Jordan

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Abstract

The results of the study showed that the population growth rate in Ruseifa ranged between 13.5% to 8.35% for the period from 1952-1994, due to the displacement of refugees from Palestine and the Gulf due to wars, in addition to the industrial expansion of the area and the decline in land prices. That urban expansion and multiplicity of human activities in the Russeifa district resulted in a change in the features of the region, both topographically and geomorphologically, as the altitudes ranging from 690 to 720 widened from what they were previously, and reached 25%, while altitudes ranging from 600-630 decreased to 3% from the study area, and it witnessed a change in all elevation categories, and the nature of the slopes changed from flat and medium gradients to medium and light gradients, but the northeastern direction of the slope is still the predominant, and it reaches 15.36% in the study area, as the study showed a change in the characteristics of the stream. Over a period of 51 years from 1967 to 2017, when the length of the stream each decreased by approximately, 110 meters, and its area decreased by 10,000 square meters. The river meander rate decreased by 0.02%, and there was a clear decrease in the number of meanders from 19 to 16 meanders. This indicates the progression of the erosion phase, the narrowing of the stream, and the speed of water reaching the downstream.

Keywords: Geomorphological effects; meander; downstream.

تقييم الآثار الجيومورفولوجية للنشاط البشري في لواء الرصيفة

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ملخّص

بينت نتائج الدراسة ان معدل نمو السكان في الرصيفة تراوح بين 13.5% إلى 8.35% للفترة من 1952-1994، ويعود ذلك الى نزوح اللاجئين من فلسطين والخليج بسبب الحروب، إضافةً إلى توسّع المنطقة صناعيًا وتدني أسعار الأراضي. أنَّ التوسع العمراني وتعدد الأنشطة البشرية نتج عنه تغير ملامح المنطقة طبوغرافيًا وجيومورفولوجيا، حيث اتسعت رقعة الارتفاعات التي تتراوح من 720 -690، عما كانت عليه سابقا، وقد بلغت نسبتها 25% في حين تراجعت الارتفاعات التي تتراوح 600-630 إلى 3%من مساحة المنطقة، وشهدت تغير في جميع فئات الارتفاعات، وتغيرت طبيعة الانحدارات من درجات الانحدار المستوية و المتوسطة إلى الانحدارات المتوسطة والخفيفة إلا أنَّهُ مازال الاتجاه الشمالي الشرقي للانحدار هو الغالب، ويصل إلى 15.36%في منطقة الدراسة، كما بيّنت الدراسة تغير في خصائص المجرى المائي على مدار 51عامًا من الفترة 1967 إلى 2017، حيثُ تراجع كلّ من طول المجرى المائي بمقدار 110م تقريبًا، وانخفضت مساحته بمقدار 10000م^2، كما انخفضت نسبة تعرج مجرى النهر بمقدار 0.02%، وظهر تناقصًا واضحًا في عدد الالتواءات من 19 إلى 16التواء. وهذا يؤشر إلى تقدم المرحلة الحتية، وضيق المجرى المائي، وسرعة وصول المياه إلى المصب.

الكلمات الدالة: التأثيرات الجيومورفولوجية، تعرج مجرى النهر، المصب

Introduction

Human beings alter many features of the Earth's surface through mining, building homes and paving roads, in addition to industrial facilities. These changes are not limited to any place but rather include the entire planet. This inflation in the numbers and sizes of cities reflects a rapid increase in the total population around the world, which increases the impact of human activity and its strength on the earth, and this increase is able through its activities and overlapping to change the features of the surface of the earth more than natural geomorphological processes. The study of the geomorphological impact of human activity is of utmost importance, where it helps in understanding the response of the geomorphological processes to human activity and determining the human role in achieving balance and disturbance in the geomorphological system (Salama, 1980). For this reason, this study evaluated the geomorphological impact of human activity, highlighting the importance of the human role in shaping the features of the earth's surface, and identifying changes of the natural landscape that occurred in the region.

Objectives of the study:

This study attempts to achieve the following objectives:

1. Study the geographical distribution of human activities in the Ruseifa district.
2. Evaluating the size of the geomorphological effects of human activities in the Rusaifa District.
3. Tracking stream changes in the Ruseifa district.

Study methodology:

The methodology of the study was based on previous studies, books and published research related to the subject of the study through the contents of libraries and the Internet and the collection of information related to the study area from unpublished reports, statistical publications and climatic data in addition to topographic, geological and aerial maps issued by ministries, departments and official bodies such as the Ministry of Energy and Mineral Resources., Royal Geographical Center, General Statistics, Department of Meteorology, and United States Geological Survey. The historical method was also used in determining the stages of development of the study area, relying on office and field data to trace the emergence of the Rusaifa District. While the descriptive analytical approach was followed to show the evolution of population and spatial growth resulting from urban expansion and its impact on the geomorphological features of the study area, the description process was based on the results of automated analysis based on the employment of geographic information systems, the ArcGIS.10.5 program and its following applications (Arc catalog, Arc Map, Arc tool box,) up to the digital elevation model, and field work that included field and exploratory visits to know the impact of human activity on the geomorphology of the area, recording observations on the places of human activity spread in the study area, and confirming the results of the analysis of maps and aerial and space images.

Previous studies:

It turns out that there is poverty in the Arab Library in general, and in Jordan in particular, in the geomorphological studies that study the geomorphological impact of human activity with its multiple types, although we desperately need these studies, due to the distinctive geomorphology of Jordan and the multiplicity of human activities in it. Many foreign and Arab studies have dealt with the subject of the geomorphological impact of human activity, such as the study of Al-Ananzeh (Al-Ananzeh, 2019) also studied the geomorphological changes of urban expansion in the city of Karak, and the study showed that urban expansion has a serious geomorphological impact, as it causes floods and collapses in the study area, and the study indicates that the main reason for the occurrence of urban expansion is the increase in population and what followed it. Rock layers to create buildings and roads. It also explains the union of the natural side with the human being and its role in the occurrence of change and the evolution of geomorphological processes and the change of water drainage and the resulting collapses and floods. Hassan (Hassan, 2016) also dealt with human activities and their monitoring in the coasts of Kuwait, and the study showed that several activities are classified as being responsible for geomorphological change, namely population settlement, ports, oil, and industrial facilities. These activities have also resulted in a role in hindering the sustainable development of the region and causing a change in its geomorphology from medium to severe, represented by digging and changing its topographical appearance. However, Dean (2014), dealt with the spatial elements and the activity responsible for bringing about the change in the shape of the earth and its topography and proved that human processes create many types of terrain, and remain a distinct imprint on the topographical landscape, and the basis of these changes is mostly due to mining operations, as it is considered the main responsible for changing geomorphology. In addition to the role of road construction dependent on urban development, dams and sanitation sites, and the resulting geomorphological changes. Al-Qaralah (Al-Qaralah, 2013) explained the geomorphological effect of urban expansion in the Aqaba region, especially the study period after 2012, the study showed the effect of urban expansion on the water of the drainage basins of wadis and the expansion's ability to change the morphology of the area. Tomczyk and Ewertowski (2010) studied the effect of human activity on changing landscapes and took the Bellefjorden polar region as a case study, and the results showed that there are three types of activities, divided according to their impact from the major impact such as mines, mining activity, and medium-term activity such as associated activities. With tourism, scientific research, and a small-scale activity such as camps, industrial activity was found to be recent and its beginning in 1927, which is the reason for the intensity of human activity.

Whereas SURTAN (2006) dealt with human activity (mining and construction of dams) and its impact on the morphology of aqueducts in northern Italy, and the results showed that mining and building dams resulted in an increase in the depth of the riverbed up to three to four meters and a decrease in the width of the canal in addition to due to a change in the stream of the canal and a decrease in the number and migration of springs.

Allam's study (Allam, 2004) indicated the geomorphological effects of human activities related to quarries, and Cairo was the case for the study. The results showed a group of negative effects of the quarrying activity, the most prominent of which was a change in the shape of the slopes, the roughness of the ridge, and the occurrence of a group of collapses and slips on both sides of the slopes. The study of Al Mughayer (Al Mughayer 1999) highlighted the role of the location of the sidewalk in the way it spans, interpreting and tracking the growth of the city and its directions, and identifying the characteristics of the extension at each stage the study found that the flood plain has a great impact on the expansion and extension of the area, as the expansion was characterized by the longitudinal shape of a certain stage, and in the stage after 1970 phosphate mines became the largest role in the expansion, as the expansion became far from the flood plain, as the study showed that the most widespread terrestrial forms are The slopes between the valleys.

Study area location:

The Rusaifa district is located in the southwestern part of the Zarqa Governorate, where it is bordered from the north and east by the Zarqa Kasbah Brigade and from the south and west the capital Amman, where it is located (15 km) to the northeast from the center of the capital Amman and 10 km to the southwest of the center Zarqa Governorate Figure (1), and thus the road connecting the cities of Amman and Zarqa, in addition to what distinguishes the study area with a river passage (Zarqa River) that divides it into two parts, north and south.

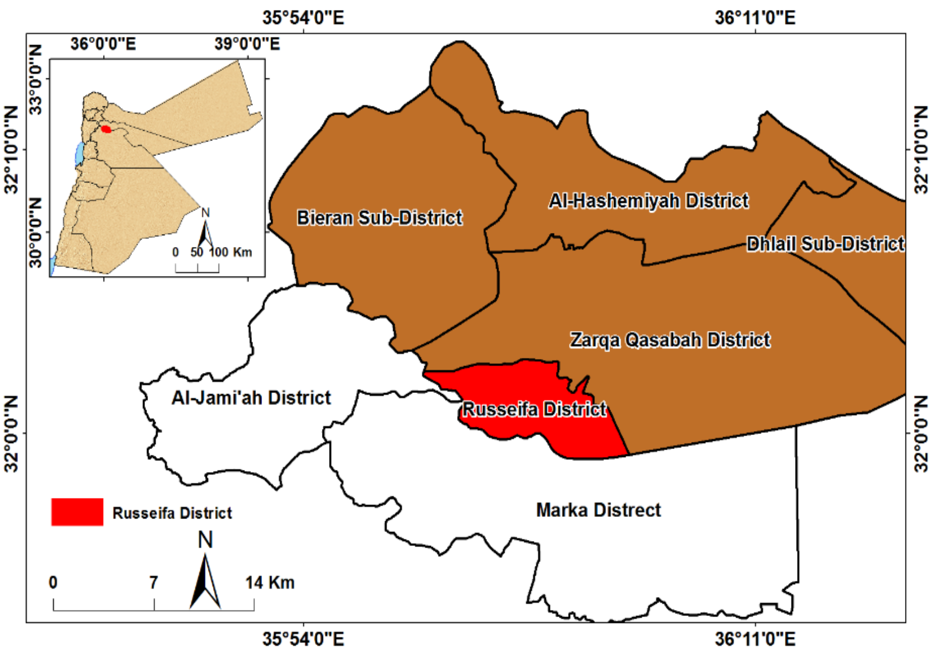

Figure 1: The location of the study area.
Source: Researchers' preparation

Topography and geology of the study area:

The surface levels range from 840 m above sea level in the northwest and southeast parts to begin to gradually decline until it reaches 600 m in the course of the Zarqa River, meaning that the height in the study area is 240 m, and the decrease in the surface level is due to the effect of erosion in Zarqa River, as the topographic and geological maps show the effect of the geological structure on the morphology of the study area. And the structural map shows that the flow arose along a structural movement represented (a concave fold).

As for the geological characteristics, it was found that the study area in the southeastern part contains one of the main faults (Amman - Hallabat), taking a north-east direction. And this part of the fault is distinguished by that it is more pronounced in the region, unlike other regions in the kingdom that it crosses, and in the southeastern part of the region also appears at the fault ridge a convex fold effect accompanied by a group of faults in the same direction as the Al Hallabat fault. A group of secondary faults dating back to the Miocene and Pleistocene epochs with different directions, mostly north-east, was observed, resulting in structural subsidence zones (Al-Farhan, 1979). The study area reveals rock formations described as marine sedimentary units within the Ajloun and Balqa groups, dating back to the High Cretaceous - Triple Era, and covering large areas of the area up to approximately (90%) belonging to the Mesozoic and Triple Cenozoic eras, and few quad deposits consisting of muddy soils. Sandy mixed with pebbles of various shapes, in addition to the presence of overflow materials consisting of sand and gravel carried by the Zarqa River, which passes within the study area. (Natural Resources Authority, 1979).

Climate:

The study area is in the Amman-Zarqa Basin, which is climatically classified into two types of climatic regions: The first is the Mediterranean climate, which covers the northern and northwestern parts of the Amman-Zarqa Basin. And the other is the desert and semi-arid climate that covers the eastern and central parts of the basin and the study area is in it, as it is characterized by hot and dry weather during the summer, and in the winter the weather is cold and rainy and experiences low temperatures, in addition to the possibility of frost formation on different days of the year. The annual rate of rain in the study area according to the rainfall distribution map ranges between 135 mm to 230 mm (average rainfall according to the studied rain stations) The average annual temperature is 18 ° C and the temperature range is 11.4 ° C.

Soils:

The soil in the study area was classified according to the national project for the soil map and land use adopted in Jordan, so that the study area is affiliated to two main regions from which three soil units emerge. They are the region of the fragmented limestone plateau in the northern highlands, and from the soils that emanate from this region within the study area, the Abu Saleh Soil Unit (ALI8), which is a result of the weathering of limestone and is found on heights and slopes whose degree of slope ranges from 5-35% in addition to its presence on valley edges and arboreal drainage areas, it covers approximately 24 km2 of the studied area, with a percentage of approximately 54%. As for the Jordan Highland Plateau region, it includes within the study area the Nisab Soil Unit (NIS11) resulting from the calcareous Balqa group within the hilltops and valleys of the slopes whose slope ranges from (10-20%) and at an altitude of 550-750 meters, containing mainly the concentration of calcium carbonate With a high percentage, silt, moderately saline silt at a depth of more than 80 cm (Ministry of Agriculture, 2017), and occupies an area of 17 km2 from the study area, with a rate of up to (39%). This region also includes the Al-Qayyat Soil Unit (HAT11) resulting from the rocks of the Balqa group and from the Aman Silesia Formation and the Muwaqqar Cretaceous Formation, they are found within the steep slopes at altitudes ranging from 650-850 meters and contain silt and silt in varying proportions. Calcium carbonate is concentrated in quantities that differ from the previous unit, and it occupies an area of 3 km2, i.e., 7% of the study area.

Vegetation Cover:

Vegetation cover is scarce in the study area and is limited to seasonal crops and small shrubs at a rate less than (10%) of its area, according to the classification taken from the Ministry of Agriculture (2017). The decline in vegetation cover in the study area is due to the urban exploitation of the area, which led to the loss of part of a large amount of arable land.

Population distribution in the study area:

The study of population distribution was based on several quantitative and cartographic methods. Among the methods that have been relied upon are:

• The region's focus pattern method. This method expresses the extent of the population's tendency to be concentrated or dispersed in one area within the region (Abdul Jawad and Al-Bilbisi, 2017). The administrative divisions of the district, the number of residents, and their proportions in them for the years, down to the total number of each district of Rusaifa. Table (1) shows the unequal distribution of the population over the regions, as the table shows the proportions of overcrowding in areas such as Hattin (33.99%) and Qadisiya (20.96%), and areas with low population numbers such as Al-Karamah and Abu Sayyah, and it shows the disparity and decline in population numbers in areas without others.

Table (1): The population of the district according to the census (2004-2015) and the ratio of the population to the total number

District	The population of the district according to the census (2004)	The population of the district according to the census (2015)	The Ratio of the population to the total number		The ascending order
			census (2004)	census (2015)	
Amriah	32551	51620	12.14	10.71	5
Al-Qadsyia	57704	101018	21.51	20.96	2
Yarmouk	53840	88476	20.07	18.36	3
Al-Rashid	32834	64798	12.24	13.45	4
Hettin	89307	163781	33.29	33.99	1
Al-Karameh	0	2911	0	0.6	7
Abu Saiah	2001	9296	0.75	1.93	6
Total	268237	481900	100	100	

Source: Researchers' preparation based on Department of statistics data

In 2004, the population of Yarmouk reached (20.07%), while in 2015 it had reached (18.36%). As for the Amiriya region, it was in 2004 (12.14%), and in 2015 (10.71%). It is worth noting that this area was the first area to witness a population gathering in the Rusaifa District from 1957 (Al-Mughayir, 1999). The district is also witnessing the emergence of new residential areas that did not previously exist, such as the Karama area, where the population reached in 2015 (2,911 people).

• Lorenz curve method: The Lorenz curve was used to measure the intensity of population concentration and to determine the extent of balance and distribution in the population numbers within the brigade area. A matrix was constructed that includes the residential areas in the study area and the ratio of population to each one in addition to the area ratio and the cumulative ratio of both population and area.

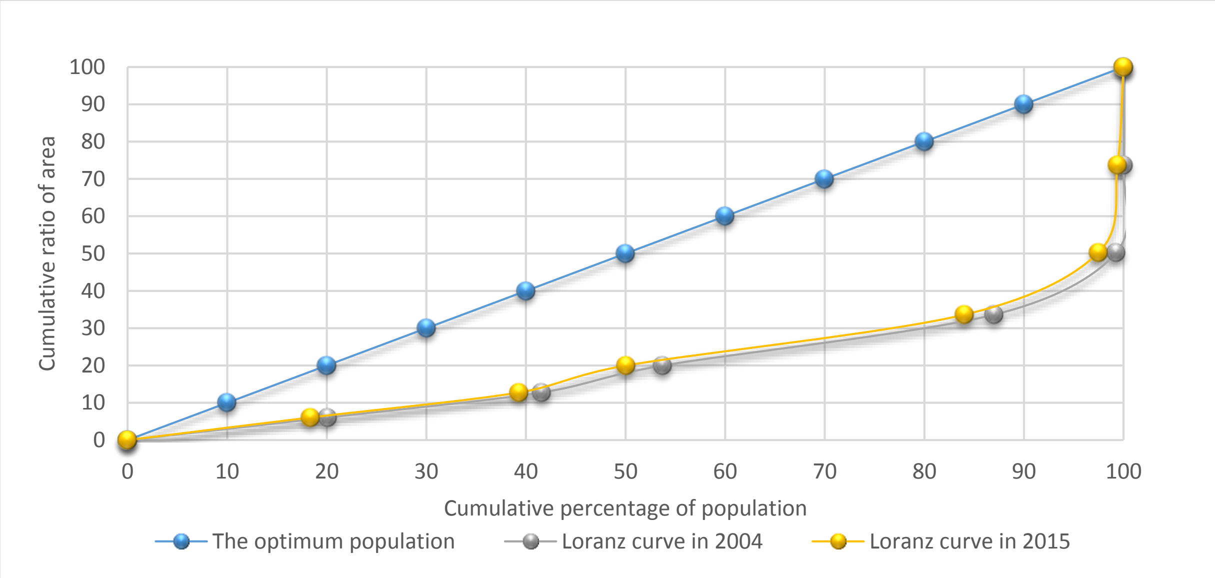

Figure 2. Lorenz curve of population distribution in Russeifa District for the years (2004, 2015) Source: Researchers' work based on general statistics data.

With the application of the Lorenz curve using Excel software, Figure (2), it was found that an inequality and equality in the distribution of the real population in the district compared to the ideal population distribution, as it appears that 53% of the population of the Rusaifa district is concentrated in an area of 20% of the district's area in 2004, and it appears the special curve in the year 2015 of the population distribution that started to move towards the ideal distribution of the population compared to the year 2004. However, it still suffers from dispersion and poor distribution, as 84% of the residents of the Ruseifa district are concentrated in an area of approximately 33%, and the approach of the curve shows in a slight way to the ideal distribution - indicates the spread of some buildings over a wider area than the Rusaifa district after 2004.

Figure (3) shows the population density that was produced by the software (Arc Map10.5) based on the processed data taken from the Department of Statistics in 2015, as Al-Qadisiya neighbourhood occupies the highest population density in the study area, reaching (25873 inhabitants/ km2), followed by each of Hettin camp and Yarmouk camp, where the density of the two reaches respectively (25137 people / km2 and 20652 people/ km2), then Amiriya and Al Rashid (12288 people / km2 and 6704 people/ km2) until we reach the least populated areas in which it is expected to increase In the future, depending on the previous data from natural and human conditions, namely: Abu Sayyah and Al-Karamah regions, as their density reaches (680 people / km2 and 190 people/ km2) respectively.

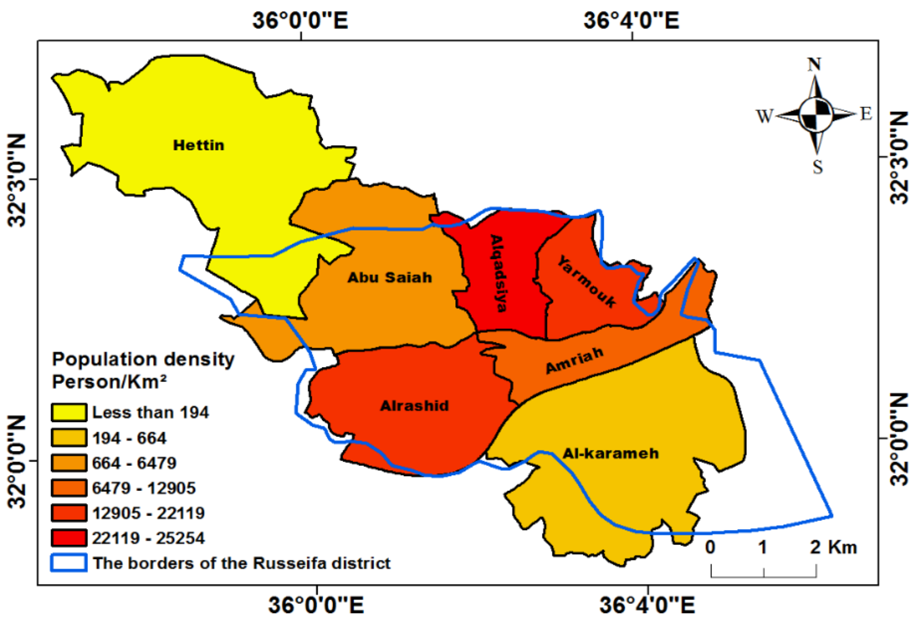

Figure 3. Population density in the Rusaifa district at the level of residential areas in 2015.

Source: Researchers' preparation

Population characteristics:

Statistics were collected on population numbers for different years from 1952 to 2015 (Department of Statistics, 2019), and the following equation was used in calculating the growth rate for the period (1952-2015):

$$\boldsymbol{r} = \left(\boldsymbol{t} * \sqrt{\frac{\boldsymbol{pt}}{\boldsymbol{p}^{\circ}}} - \boldsymbol{1} \right) * \boldsymbol{100}$$

r = population growth rate, t = length of time, Pt = population in the most recent period, P ° = population in the oldest period.

The figures show the gradual increase in population numbers since the late 1950s and early 1960s (Al Mughayir, 1999), when the population in 1952 reached (1608), and the population continued to increase, and housing numbers developed until the population became (61,665). People in 1979 within three neighborhoods (Al-Ruseifa, Al-Musharafa, and Hiteen Camp) with a growth rate of (13.5%). The increase in population numbers continued, bringing the population in 1994 to (214762) people, with a growth rate of (8.32%), after returning to maps Topographic General (1961, 1991, 1997), The direction of expansion was found on both sides of the flood plain, taking east-west directions. With the spread of localities and neighborhoods in the region, the Rusaifa district has become containing two main gatherings, namely: the Rusaifa cluster and this cluster contains five residential areas divided over a large area of the district, and it contains several neighborhoods and a second cluster, which is the Abu Sayyah village gathering.

In 2004, the general statistics carried out a comprehensive census of Jordan, and the population of the district reached (268,237) people with a growth rate of (2.22%). The Department of Statistics continues with an estimated calculation of the population up to the year 2015, when the number of residents in the Rusaifa District reached (481900) people, at a rate of Population growth that has reached (5.33%). In this census, a new residential area belonging to the Rusaifa district was included, under the name of the Karama area (Department of Statistics, 2015). Part of the Karama area is located within the borders of the district and the bulk of it is outside the district, but the area was not considered among the organizational areas of the brigade. During the time period shown. (1952-2018).

Table (2): The evolution of the growth rate in the Rusaifa district from 1952- 2015.

Time-period	Population (person)	Growth rate (%)
1952	1608	0
1979	61665	13.5
1994	214762	8.32
2004	268237	2.22
2015	481900	5.33
2018	520430	2.6

Prepared the researchers based on the data of the Department of Statistics.

The increase and doubling in the population are attributed to several reasons, the most prominent of which is the natural increase that indicates improved health conditions and the development of the district in terms of service and organization, with the decline in land prices in the region compared to the surrounding areas and the presence of job opportunities, as the region witnessed the spread of factories on its area. This is what made it a magnet for workers to settle in, in addition to what preceded the existence of migrations that took place in Jordan in different years.

Human activities and land use in the study area:

The land uses in the study area varied, according to the classification that was approved by the Royal Geographical Center in 2017 (Figure 4), and the classifications in the study area were limited to Table (3), and the percentage and area of each use in the area was determined in the table.

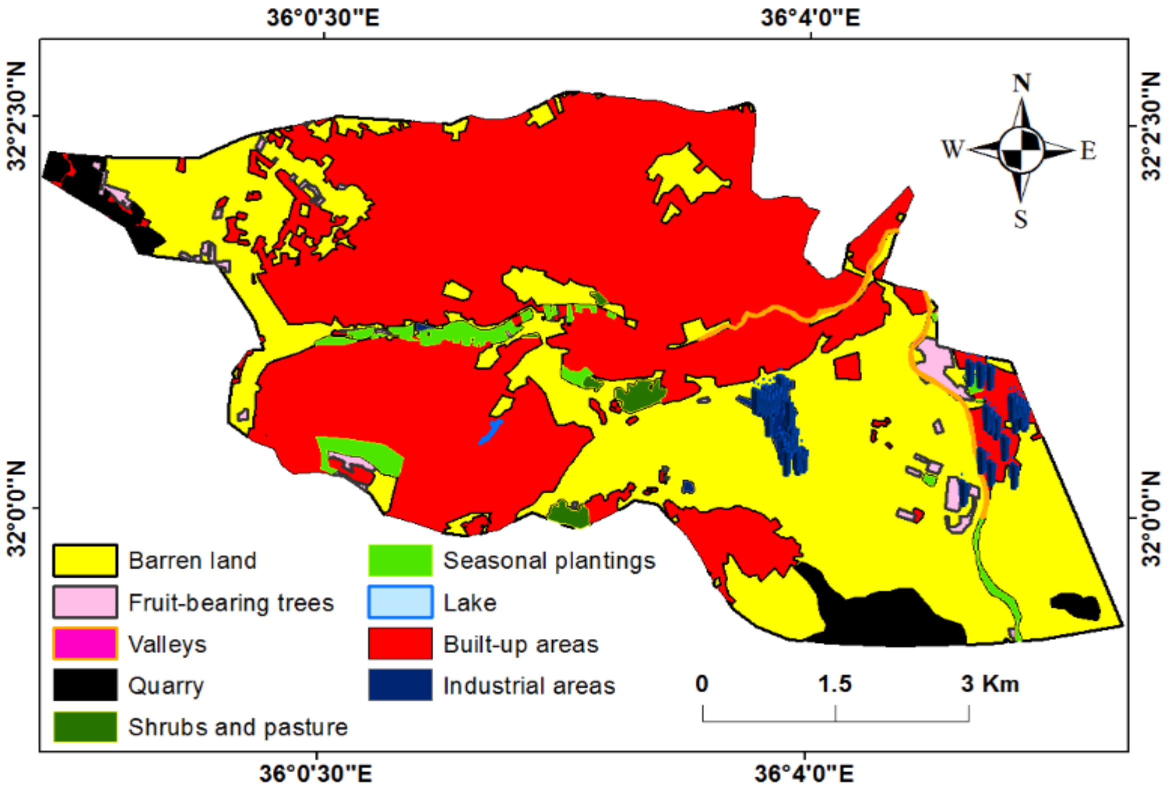

Figure 4. Land use in 2017 (Royal Geographical Center).

Table (3) shows that the highest use within the study area is human use. The area is 22,746 km2, and it is estimated at 51.66% of the study area. The human use in the Rusaifa district is represented in intertwined residential, industrial and artisanal urban areas in the middle of the study area. The barren lands occupy an area of 18.1 km2, that is, an estimated 41%, and the remaining area is distributed among the quarries that are located in the southeastern and northwestern parts of the study area with an area of 1.49 km2, i.e. 3.4%, and another part is on the crops and valleys that interfere with residential uses and part of it is located on the outskirts of the study. Zarqa river is included in the seasonal plantation classification, with a total area of 1.68 km2 and a percentage of 3.87%**.**

Table (3):- the distribution of land uses in the study area

Land cover	Area (km^2)	Percent%
Barren land	18.1	41.1
Tree crops	0.65	1.5
Valleys	0.012	0.03
Quarry	1.49	3.4
Shrubs and pasture	0.27	0.61
Seasonal plantings	0.738	1.7
water bodies	0.0125	0.03
Built-up areas	22.50	51.1
Industrial areas	0.246	0.56
Total	44	100

Prepared by the researchers based on the data of the Royal Geographical Centre 2017

It is worth noting that the industrial areas are distributed within the residential areas, and are considered part of them, and this may generate pressure on the total infrastructure in the study area.

Analysis and discussion:

The discussion of the geomorphological changes that the study area witnessed over the decades indicates the presence of a number of effects resulting from human activities, in addition to the presence of traces of pollution and deterioration of the environment of the area (Al-Omari et al, 2019), as this study used some topographic and morphometric measurements to determine them as follows**:**

First: Topographic measures:

The topographical characteristics in the study area included the following characteristics:

A- *Height*:

It was found that the area witnessed a change in different parts and that the values of change at the edges of the stream and the areas of mining activity (Figure 5), as the area of the height level (600-630 m) was estimated at about (4 km2) during 1961 and decreased to reach later the area to 1.3 km2 in 2010.

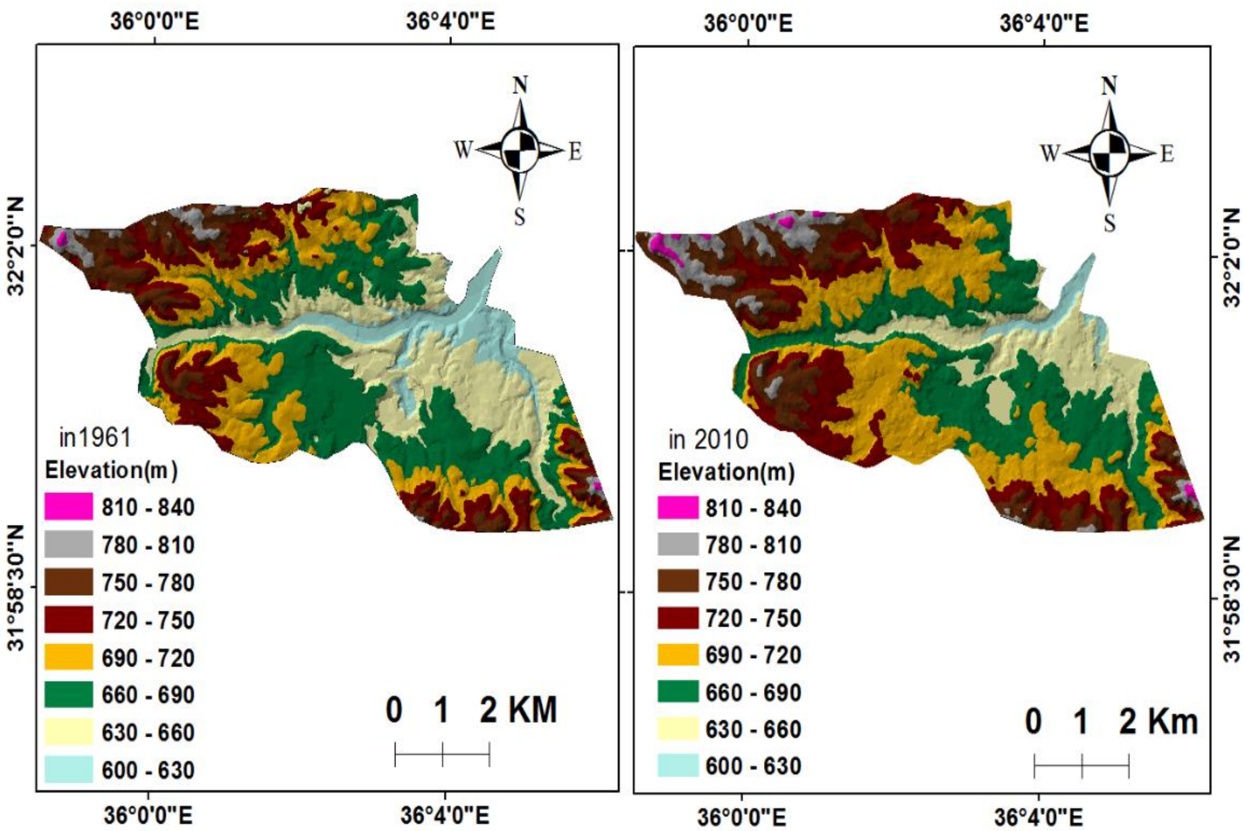

Figure 5. - Comparison of surface levels in the study area between the years (1961 and 2010).
Prepared by the researchers' work based on the two digital elevation models.

Each of the levels (630-660 m) and the level (660-690 m), respectively, decreased from an area estimated at about 9.4 km2 in 1961 to 5.6 km2 in 2010, and an area of 12.69 km2 to 10.8 km2, while the levels bbetween (690-720) increased from 8 km2 to 11 km2, and by a rate of up to 25%, the area of the elevation levels continues to increase, so the area of the level category (720-750) is estimated from 5.55 km2 in 1961 to 7.3 km2 in 2010 and the height of (750-810 m) increased from 4.37 km2 in 1961 to 7.55 km2 in 2010, and the following table No (4) shows the amount of change in elevation levels from 1961 to 2010**.**

Table (4): - The amount of change in the elevation level between (1961-2010) depending on the Arc Map software

Elevation	Area (km^2) 1961	Percentage (%) 1961	Area (km^2) 2010	Percentage (%) 2010
600-630	4	9.1	1.3	3.0
630-660	9.4	21.4	5.6	12.7
660-690	12.62	28.7	10.8	24.5
690-720	8	18.2	11	25.0
720-750	5.55	12.6	7.3	16.6
750-780	3.47	7.9	5.2	11.8
780-810	0.9	2.0	2.35	5.3
810-840	0.06	0.1	0.45	1.0
	44	100.0	44	100.0

Source: Researchers' preparation

B- *Slopes*:

To prove this change, it was necessary to make a comparison of the slopes of the previous two years (1961 and 2010) and determine the amount of change (Figure 6), as the slope is an image that reflects the depth of valleys and the increase of vertical erosion in addition to the effect of increased surface runoff (Makhamrah and Al-Husban, 2016). It illustrates the nature of river activity, as it is related to determinants, most notably the velocity of water and the activity of geomorphological processes, in addition to determining the nature of the land and its exposure to collapses and slips (Awawdeh, 2005). Young's classification was adopted to clarify the nature of the slopes within the study area.

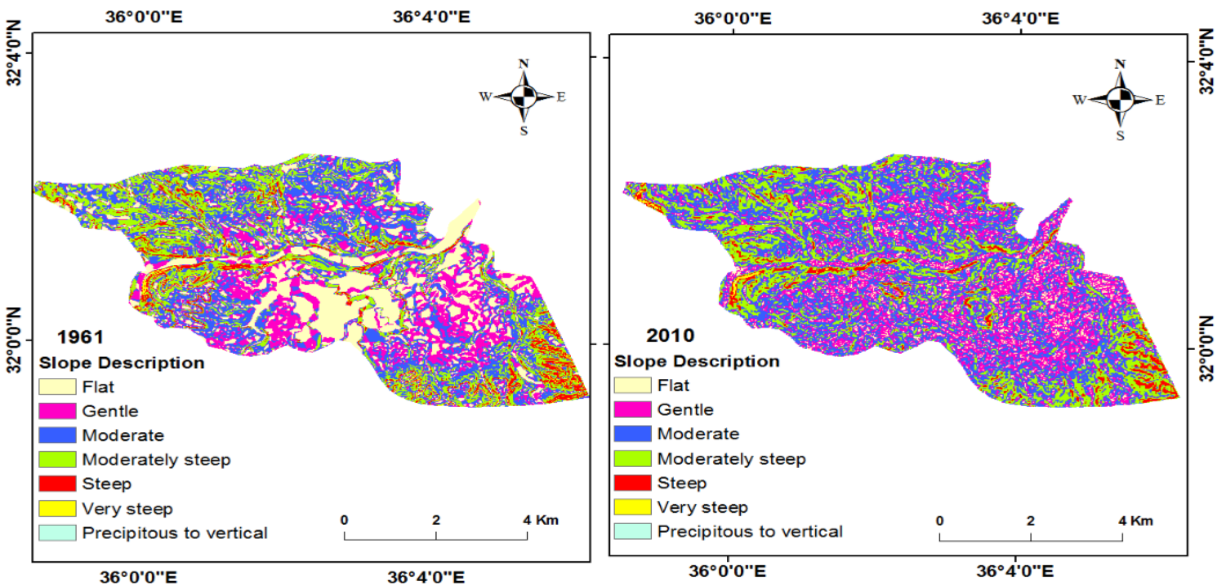

Figure 6. Slopes type in the study area

Prepared by researchers' work based on DEM data for both years (1961 and 2010).

Figure (6) shows the amount of spatial variation evident in the type and area of the slopes. The slope in the study area can be described as an irregular distribution over the study period, and the area has been divided into seven categories Table (5):

1- Category 0-2: It occupies 5.45% of the area's area, and this category witnessed a significant decline from 1961, when it reached approximately 21.14% at that time, and the majority of it was in the Zarqa stream and the mining sites, However, with the expansion of human movement and the expansion of the solid layers, it led to an increase in water flow, an increase in the occurrence of erosion, and the resulting deepening of the stream, and an increase in slope. By reviewing the contour lines at the ends of the stream, it was found that there are many successive terraces in height, and this confirms the deepening of the stream, and it is worth noting here that the change in gradients of the slope in a part of the southern region may be due to the occurrence of mining in it.

2- Category 2-5: The rate of decline in it occupies 26.93%, and as Table (6) indicates that there is an increase in the area of light slope than it was previously estimated at 19.1%, and the change in the study area is distributed over the central and western parts, it was found that the large areas of the previous category (flat) were reduced to the category of light steepness, and this category is distinguished by its ease of use for human service activity.

3- Category 5-10: It is considered a medium-slope category and it occupies the largest category in the study area. It has expanded in recent years to cover approximately 40.84% of the study area compared to its previous level in 1961, as its percentage reached 31% and distributed over all parts of the study area.

4- Category 10-18: There has not been a significant change in this category during the comparative period, but it has witnessed an increase from an estimated rate of 21.9% in 1961 to 23% in 2010, and the category occupies a significant area of the study area as it is located on the outskirts of the study area large parts of quarries, in addition to their presence on the southern edges adjacent to the stream, and parts of the artificial piles left by the mining activity in the study area.

5- Class 18-30: it was classified as a steep category that witnessed a slight increase from 1.1 km2 to an area estimated at 1.6 km2, and Figure (4-2) shows that the increase with a steep elevation in the middle of the mining area was not previously, an artificial mound that reaches Levels of 700 m, and a group of instability cases such as collapses and cracks were observed in the elevation during the field visit, as a result of the fragility of the rocks that make up the elevation. It is worth noting that the high elevation overlooks a secondary road that connects the study area to the Zarqa Highway. And it appears in the satellite images that this area is occupied by industry and demographics, and that part of the buildings were built on rubble and mining waste. Since the slope is directly related to both running water and mudflows, we find that this category of the study area may witness a set of collapses and slides during rainy winter days. It may also lead to the closure of the drainage channels in the study area. There was no significant change in the area of each of the remaining groups in the study area. Perhaps this is due to the detachment of these slopes from human activities, including the expansion of the architectural area. Its percentage is very small in the region, and we note that the study area dominated its shape in the last period before 1961, the flat areas with a slight to moderate slope. But after the multiplicity of human activities, some features of the region have changed.

Table (5):- Slopes distribution and there percentages in the study area (1961-2010)

Slope class (degree)	1961		2010		Slope description
	Area of each class (Km^2)	Percentage (%)	Area of each class (Km^2)	Percentage (%)	
0-2	9.8	22.3%	2.4	5.45%	Flat
2-5	8.9	20.22%	11.8	26.93%	Gentle
5-10	14	31.82%	18.0	40.84%	Moderate
10-18	9.9	22.50%	10.1	22.92%	Moderately steep
18-30	1.1	2.4%	1.6	3.65%	Steep
30-45	0.3	0.68%	0.1	0.22%	Very steep
<45	0	0.00%	0.0	0.00%	Precipitous to vertical
Total	44	100.00%	44	100.00%	

Source: Researchers' preparation

When determining the direction of the slope, it is always associated with the degree of slope, and through it we can determine the direction of the points of collection of valleys (Al-Hasan and Zureikat, 2015). Figure (7) where we can say that there has been no change in the directions of the slope, and that the northeastern direction still occupies the largest percentage in the direction of inclination, and that all directions in most of the study area are towards the stream and the tributaries of the stream, and this is what made the water network adopt a dendritic drainage pattern, in addition to a slight retreat in the flat direction.

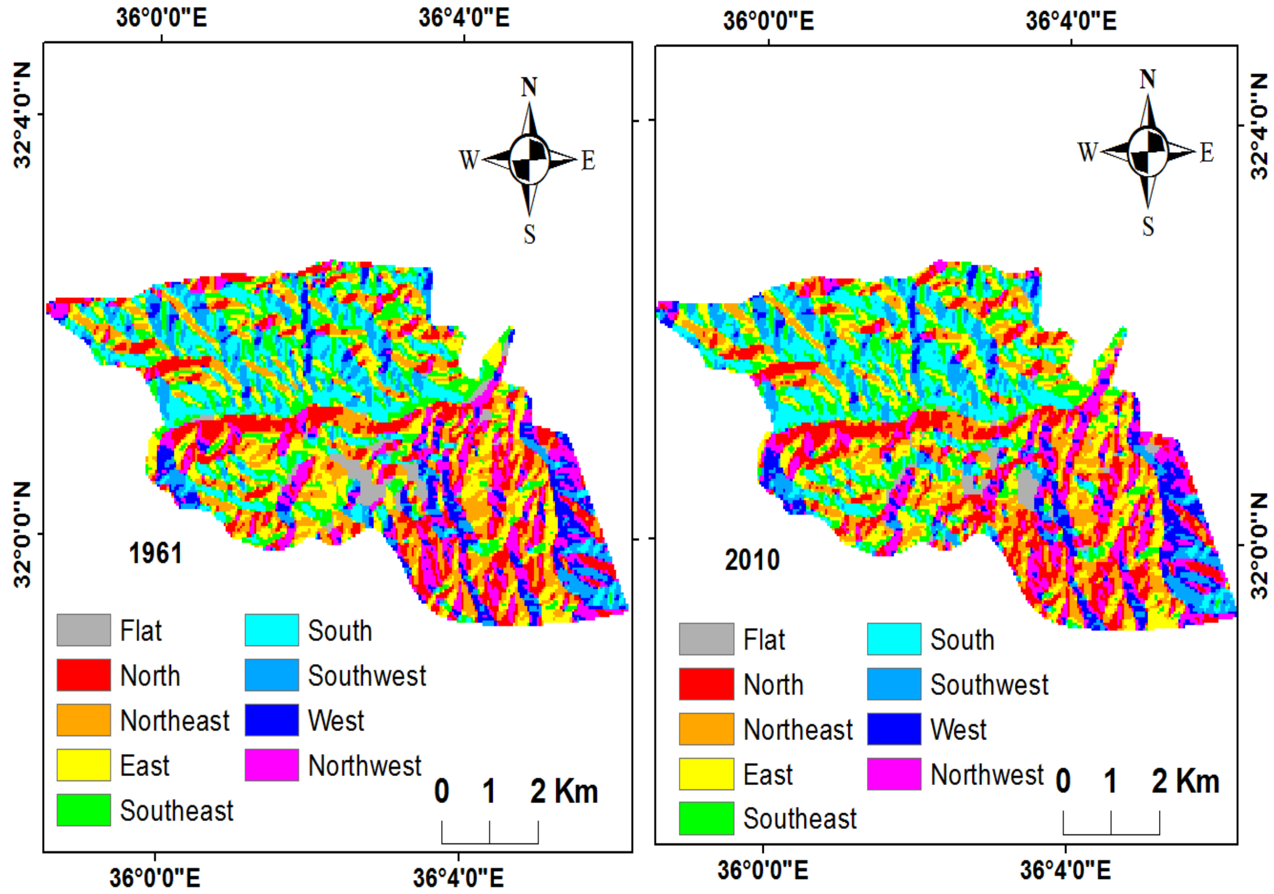

Figure 7. Slopes trends in the study area during the period of 1967 – 2010.

Source: Researchers' preparation

Table (6) shows each direction of the slope and its percentage in percent, where the directions of the slope were divided into 10 directions, starting from 0 degree and ending at 360 degrees, and the numbers indicated an irregular distribution of the percentages and areas of the trends, but the areas and ratios converged between 1961 and 2010, and witnessed the northern and eastern direction is a slight decline from what it was previously, while the southern and western direction witnessed an increase in its area, due to the nature of the slope and the behavior of water erosion, and it was evident that the area of the flat directions decreased by an amount of up to 600 square meters, and in 1961 it was estimated (1.1 km2) And it decreased to reach (0.5 km2), due to the presence of a group of slopes that were not previously, and the presence of the north and east direction at its highest rates during the period of time for the nature of the region geologically and tectonically, as it was previously indicated that a group of secondary faults take most of their directions north-east. It reported a structural landing in the region.

Table (6): Slope's direction area and its percentages in the study area during 1961-2010.

Slopes degrees	1961		2010		Aspect Class
	Percentage (%)	Area (Km^2)	Percentage (%)	Area (Km^2)	
0	2.45	1.1	1.1	0.5	Flat
337.5-22.5	14.86	6.5	12.9	5.7	North
22.5-67.5	15.36	6.8	14.5	6.4	Northeast
67.5-112.5	13.87	6.1	13.2	5.8	East
112.5-157.5	12.49	5.5	13	5.7	Southeast
157.5-202.5	13.36	5.9	13.4	5.9	South
202.5-247.5	9.87	4.3	12	5.3	Southwest
247.5-292.5	7.48	3.3	8.5	3.8	West
292.5-337.5	10.27	4.5	11.4	5	Northwest
0-360	100.01	44	100	44	Total

C-Stream changes (Zarqa River):

Notable changes occurred during the period from 1967 to 2017, such as the flow of the Zarqa River, which decreased significantly compared to its historical flow (Al-Omari et al, 2019). The change in the characteristics of the water basin, as several factors participated in the natural change represented by the climate, the natural vegetation, the geological structure, and the water drainage. This change has shown a clear role in flood days and dry days, which produced disturbance on the erosion and sedimentation in the banks of the stream, and such activity has appeared in other similar studies, (Yin, 2001) Human factors have strongly contributed to effecting change by reducing the area of natural plants on the land of the study area, and the resulting weak role of soil and its fragmentation, velocity of water inside the stream, and the effect on leakage, as mentioned by Al Kuisi et al. (2014) in his study of the impact of human activities.. Industrial activities and the expansion of urban activities on the outskirts of the stream also contributed to the disposal of wastewater to keep quantities of water in the the stream, with the increase in the amount of surface runoff, the increase of sediments at the ends of the stream, and the presence of a sewage line inside the stream. All these factors continued for periods of time, causing changes in the characteristics of the stream (Zarqa River) in the study area. The stream water flow in the study area was tracked by relying on aerial photos dating back to 1967 from the (corona cast) satellite of the CIA in the United States of America, which was used in the early 1960s as a mission to spy on the regions of the Middle East, and compare it with satellite images the latest data from Google Earth Pro, using ArcMap-10.5, for the purpose of correcting and making morphometric measurements of the course of the river, and Figure (8) shows a comparison of the meandering behavior that is a product of water movement.

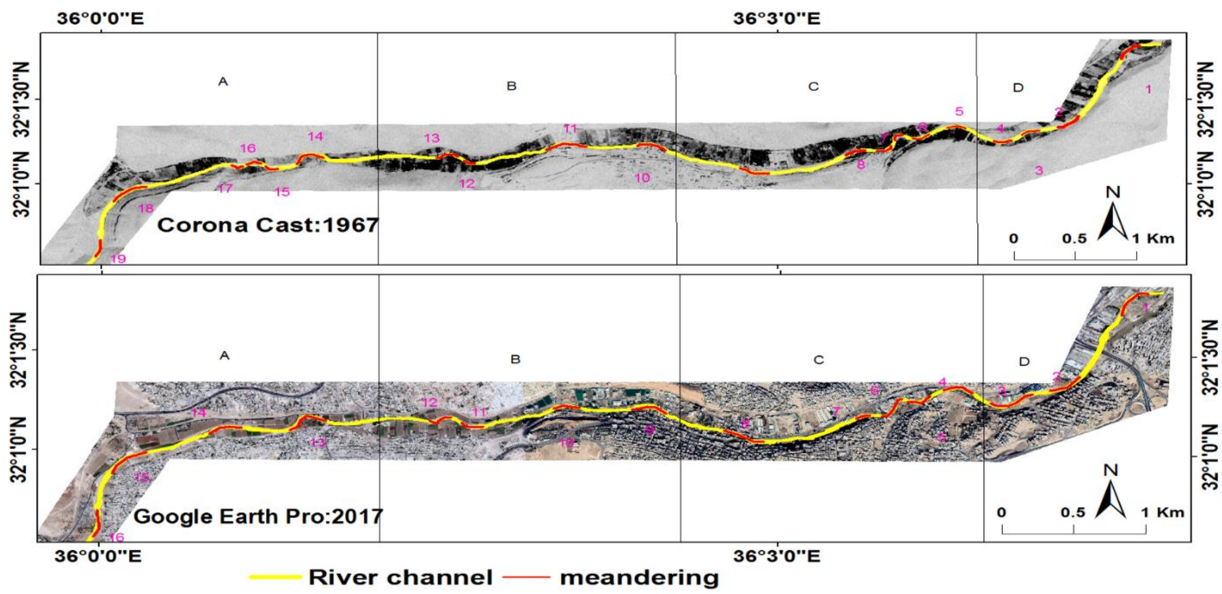

Figure 8. - Comparison of the meandering of the two streams for both years (1967 and 2007). Prepared by researchers' based on site data corona cast and google earth.

Figure (8) shows the change of the stream and the change in the meandering of the river in the study area. To compare the characteristics of the riverbed during the period from (1967 to 2017). See Table (7), which shows the following:

Table (7): Characteristics of the Zarqa River in the study area between (1967 to 2017)

Characteristics	1967	2017
Stream Length (Km)	9.40	9.29
Length of the north bank (Km)	9.47	9.36
Length of the south bank (Km)	9.5	9.4
Stream area (km2)	0.11	0.099
Ratio of meandering stream (%)	1.26%	1.24%
Meanders number	19	16

Source: Researchers' preparation

By analyzing the data in Table (7), it was found that slight changes occurred in the characteristics of the stream during the study period, which are estimated at several meters, as:

1- The length of the stream of the river decreased by about 110 meters, as it was estimated in 1967 about 9.40 km, to turn to 9.29 km in 2017, and the reason for the change is due to the response of the stream to the conditions of the slope, and it was previously indicated that a large part of the area of the stream of the river has shifted from flat slopes to light slopes, and the resulting figure (8) indicates a decrease in the number of meanders.

2- The number of meanders: the turns are explained according to the nature of the river flow imposed by the flood flow, which is evident in the different degrees of slope along the stream and the characteristics of the river in terms of increased river load, and the fluctuation of the water drainage seasonally, and indicated for such activity (Aher et.al, 2012). It can be said that there has been a disturbance in the equilibrium of the stream, so the number of meanders along the course changed from (19) to (16) meanders.

3- The meander expresses the significance of the river's inability to carve into solid rocks and the low velocity and quantities of water in the river due to human intervention (Samantha and Pal, 2012. The meandering coefficient (which is the length of the stream divided by the length of the valley), (Al-Masha'leh, 1999), recorded a decrease from 1.26% in 1967 to 1.24% in 2017, and previous values indicate that the course of the river is twisted, and the previous difference shows a decrease in the meandering rate, and this indicates the progression of the inevitable stage and explains the reason for the occurrence of floods in the study area, as studies indicate that the decrease of the meandering coefficient accelerates This reduces the ability of water to evaporate and the chance of water to leak (Al Maghazi, 2015).

4- The area of the stream: over a period of 50 years, the area of the stream witnessed a decrease of approximately 10,000 square meters, or about (0.01 km2). This decline is attributed to two factors, namely: the sedimentation factor dominance and the fluctuation of the river drainage and the resulting narrowing of the stream width that leads to a decrease in the stream area.

Results:

The study found the following results:

1- The study area witnessed a diversity in the uses of the land from its inception to the present time, and this diversity can be described as unorganized, lacks planning methods and standards, and depends on randomness in its distribution, as industrial uses are intertwined and overlapped with the housing and extractive industries within a narrow spot in the study area. The land use map for the year 2017 showed the percentage of the area of land exploited for human activity, as it occupied the highest percentage and was estimated at about 55% of the percentage of the study area. Whereas barren areas occupied an area of 41%, as included in a large part of the former mining areas and became unsuitable for human activities.

2- The study area was previously exploited by mining, and the mining activity resulted in a group of rugged areas and artificial hills, which caused the creation of narrow valleys and resulted in breakage of the rocky masses, and deep pits that produced dangerous swamps. This confirms the negative impact of mining. The remaining area of the impact of the mining activity is estimated at 2.15 km2, the Karama area has the lowest population density, respectively, and is (68 people / km2 and 190 people / km2).

3- A change in the topographical characteristics was found in the period from 1961 to 2010, and the change included areas of elevation in the study area, where the percentage of elevations that fall within the category 690-720 m increased from 18.2% to 25%. Each of the following categories 720-750 m, increased from 12.6% to 16.6%, and 750-780 m category increased from 7.9% to 11.8%, however the category 780-810 m increased from 2% to 5.3%, and the categories 810-840 from 0.1% to 1%, while the percentage of elevations that fall within the category 600-690 m decreased from 59% to 40%.

4- The slope characteristics of the study area changed from 1961 to 2010 from flat and medium slope areas to light and medium slopes, the study showed a decline in the proportions of flat slopes in 1961 from 22.3% to 5.45% in 2010, while the remaining slopes witnessed an increase from previous years, light slopes from 20.22% in 1961 to 26.93% in 2010. The average is from 31.82% to 40.84% in 2010 and moderate steep decreases of 22.50% to 22.92% in 2010. The study shows the absence of runoff slopes and explains the change of slopes from 1961 to 2010 to the nature of human activities from mining, which contributed to phosphate piles and steep slope areas, and urban expansion, which played a role in surface runoff and its role in the activity of erosion processes.

5- The directions of the slope did not differ much from the year 1961 and their area is still close, and most of the directions are towards the stream, i.e., the water channel. It was found that the north-eastern trend still occupies the highest percentage, reaching 15.3%, while the western trend occupies the lowest percentage, reaching 7.48%.

6- Human activities resulted in a deepening in the stream of Zarqa river, which led to slight changes in the formal characteristics of the river, according to the analysis during the period (1967 to 2017), and it was found that all of the meandering percentage in the river decreased from 1.26% in 1967 to 1.24% in 2017, however the area of the stream decreased from 0.11 km2 in 1967 to 0.099 km2 in 2017, the study indicates a decline in the number of meanders in the stream from 19 meandering in 1961 to 16 meandering in 2017, with the length of the stream decreasing from 9.40 km to 9.29 km, and the circumference of the stream from 19 km to 18.78 km.

Recommendations:

Based on the results of the study, it recommends the following:

1- Dredging the Zarqa stream in the study area, and cleaning the associated culverts permanently and continuously, especially before the rainy season, in order to avoid the occurrence of floods and to increase the water network’s ability to transport debris and water.

2- Removing built-up areas from the stream banks, because they are subject to floods in any heavy runoff during rainy days, in addition to creating drainage networks for running water on main and secondary roads to take advantage of reducing the occurrence of sudden surface runoff that causes floods.

3- Legislate regulations that prohibit vertical and horizontal urban expansion on tunnel areas and stop urban expansion in abandoned mining areas before they are addressed. Work must also be taken to remove homes built on rubble and silt, and to compensate their residents with special areas for housing.

4- Expanding the cultivation of trees on the stream banks and the, to reduce the effect of surface runoff and to increase soil cohesion and increase leakage.

5- Rehabilitation and settlement of abandoned mining areas and mines.

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