PalArch's Journal of Archaeology of Egypt / Egyptology

Geomorphometric analysis of Alfdhay Valley basin using geomatics techniques and the possibility of investing it for water harvesting

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Lect. Dr. Khalid Sabbar Mohammed, Geomorphometric analysis of Alfdhay Valley basin using geomatics techniques and the possibility of investing it for water harvesting, -- Palarch's Journal Of Archaeology Of Egypt/Egyptology 18(10), 1812-1827. ISSN 1567-214x

Keywords: drainage basin, Alfdhay valley, morphometric, Iraq.

ABSTRACT

The study aims to analyze the morphometric characteristics of the Alfdhay Valley basin in northern Iraq, as it is one of the important and promising mountain basins for investment in water harvesting projects through the use of geomatical techniques and their use in morphometric analysis. The deep structure constitutes 48.08% of the total area of the area, and geological formations predominate, most of which go back to the third and fourth times. The morphometric ratio was (0.6) elongation and roundness reached (0.4), while the gradient ratio was (9.8). All morphometric coefficients indicate the basin's youth, the regularity of its water drainage, and the lack of its sedimentary output.

Introduction

The geomorphological study (morphometric) is one of the important studies of water basins, as the drainage basin is a spatial unit in which characteristics and data are determined quantitatively for the purpose of analysis and classification. As the study of water basins is the most important applied achievement using geographic information systems and remote sensing to extract information that contributes to the interpretation of the pattern of landforms and water drainage and its relationship to the topography of the earth's surface through the use and analysis of data and satellite visuals and their digital characteristics, especially the digital elevation model DEM

and its use in radar studies and its use in applied studies such as extracting contour lines, gradient direction and water network (water basins).

The study of the Alfdhay Valley basin, which is one of the largest valleys located within the common borders of the governorates of Kirkuk and Erbil, represents an important area for harvesting water and investing it in agricultural production, as well as for feeding groundwater and benefiting from it during the Chihod season for various economic investments.

Aims of the study:

1- A study of the characteristics of the natural environment of the Wadi Al-Feddi basin area and its effects on the formation of surface sediments in the study area from the characteristics of geological rock formations and surface manifestations.

2- Studying the water characteristics of the Alfdhay Valley basin

3- Studying valley streams, drainage mattresses and their morphometric characteristics to reveal the volume of water and the possibility of investing it in the future by harvesting water.

Materials and methods

The use of modern technologies such as geographic information systems (GIS) programs, remote sensing data and satellite visuals type DEM (Digital Elevation Model) for the year 2015, was used, where the Arc Map 10.5 program was used, where the visual area of the valley basin was cut, and the same program was derived Maps of equal surface heights, deriving the water drainage network, and then extracting all data related to morphometric measurements that were applied in the mathematical equations adopted to study river basins and valleys morphometrically.

search limits:

The research area is located within two governorates, Erbil and Kirkuk, as its sources are located in the southern part of Erbil governorate and its start located on the Little Zab River in the Kirkuk governorate. The interval between the provinces of Kirkuk and Salah al-Din. Astronomically, the basin is confined between longitudes (35º 45‑ 00‑‑ - 35º 15‑ 00‑‑) North, and between two latitudes (34º 50‑ 00‑‑ - 43º 25‑ 00‑‑)

Structure of the research:

In order to become familiar with the merits of the research, it included the presentation and discussion of the following topics:

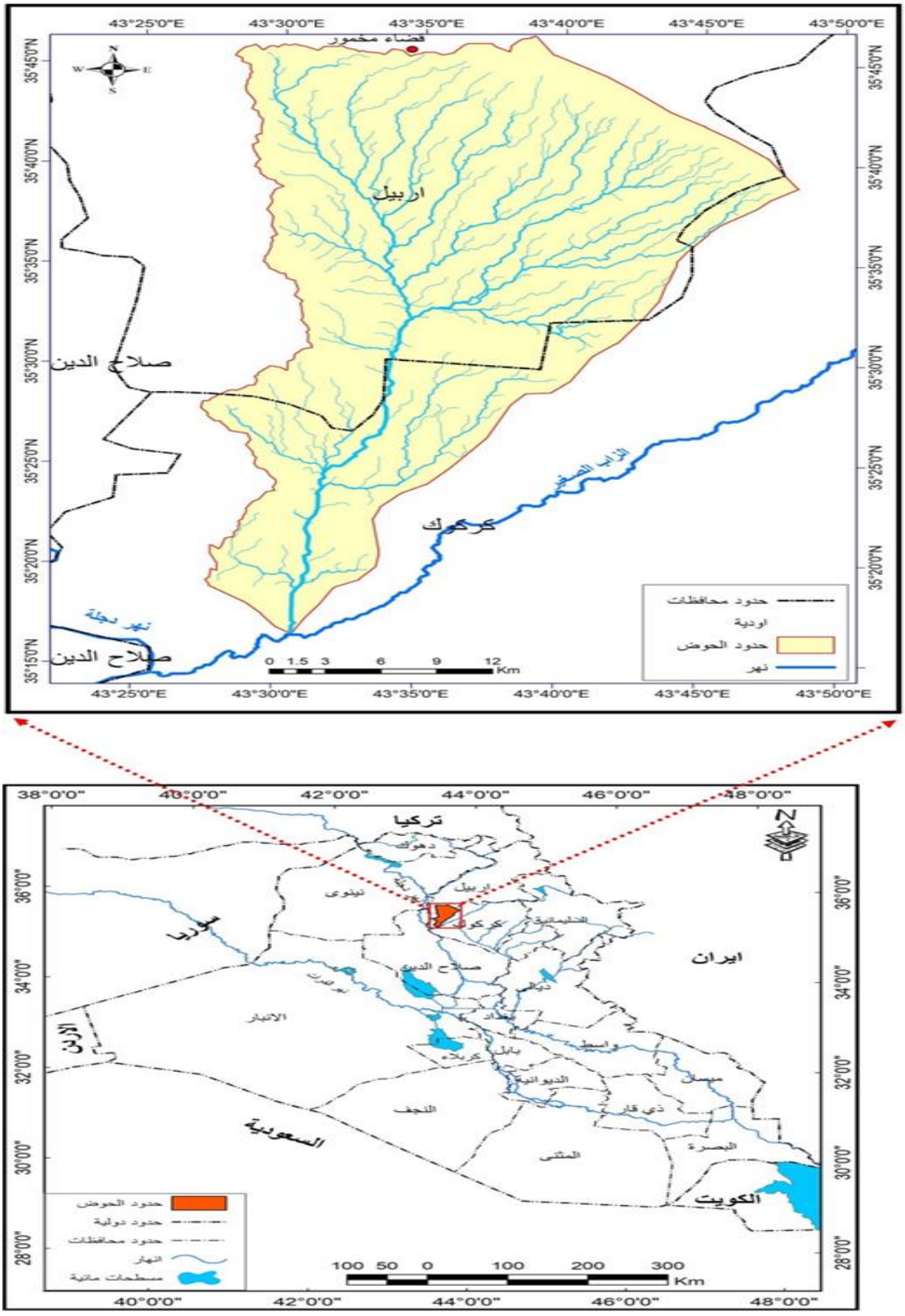
The first axis: the natural characteristics and their impact on the geomorphometric system of the Alfdhay Valley Basin.

The second axis: the morphometric characteristics of the Alfdhay Valley Basin.

The third axis: Promising areas for the establishment of water harvesting projects in the Alfdhay Valley basin.

The research concluded in defining conclusions and recommendations.

Map (1) The location of the Alfdhay Valley Basin in Iraq



Source: Republic of Iraq, Ministry of Water Resources, Directorate of Public Survey, 1814

Anbar Administrative Map, 2010, Scale (500,000:1).

Natural features:

The natural characteristics effectively affect the gemmorphology of the study area, so they will be analyzed in detail as in the following:

First - the geological structure:

The study of the nature of rocks and their tectonic properties is one of the most important natural factors affecting the shapes of valley basins and their drainage nature, through which the state of the water drainage network and its spatial extension are drawn. The geology of the region is that it contains a number of rock formations closely related to human activity. The geological studies that dealt with the stratigraphic succession indicate the presence of intermittent sedimentation cycles in conjunction with the climatic changes witnessed in the region and the building movements of the continents and the continuous change in sea level that resulted in a difference in the nature of the base rocks and their facies, and through Map (2) it is clear that the region included several unfolded formations It can be analyzed from oldest to newest as follows

1. Aperture Configuration (Down Knight):

It is considered one of the most important formations spread in Iraq economically. The hole formation spreads at the intersection of the Tigris River with the Makhoul-Hamrin range 10 km north of the city of Baiji. It consists mainly of anhydrite, gypsum and salt, and overlaps with layers of limestone and marl, thickness of less than about 100, shallow lagoon deposition environment and age of formation is (middle Miocene). (Jassim et al, 1984).

2. Anjana formation (upper Miocene):

This formation unfolds in several areas of the study area from north to south. The characteristic of this formation is the rocky succession of sandstone and mudstone with thin layers of limestone and secondary gypsum, which led to the formation of a transitional stage from the marine environment to the continental environment, a fish that varies from one region to another. It ranges from (36-398 AD) that the boundary between the Anjana formation and the Muqdadiyah formation is the appearance of the first gravel layer extending over it.

3. Muqdadiya Formation (Upper Miocene - Pelocene):

The formation of Anjana is harmonious, as the formation disappears in the plain areas under the cover of sediments of the Quaternary time. The formation is characterized by the abundance of gravel in it as we move up. Its most important components are coarse sandstone, alluvial stone, mudstone and layers of successive compactions that were formed in a continental sedimentary environment to follow the processes of river and wind erosion of the oldest rocks In age, the thickness of the formation ranges from (200 m - 456 m), and its thickness increases from the parts close to the Bay Hassan Formation.

4. The composition of Bai Hassan (Pliocene):

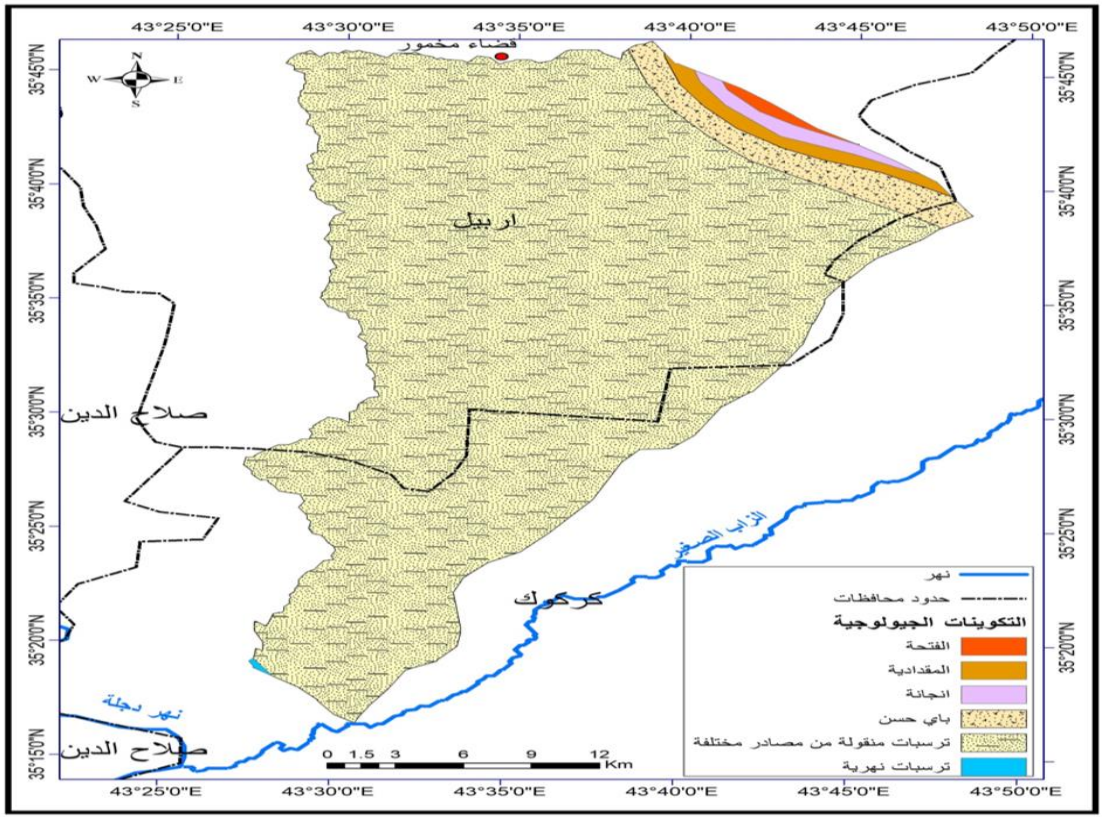
It appears in the form of rugged terrain in the northeastern part of the study area, and its thickness does not exceed (100 m). It reaches (800 m), and these areas are considered important and economical aquifers.

5. Quaternary sediments (Pleistocene - Holocene):

It covers most parts of Kirkuk governorate and the southern parts of Erbil governorate and consists of (gravel - sand - silt and clay) and it is overlapping and in varying proportions between one area and another covering 95% of the surface of the study

area. The groundwater due to its high permeability and is one of the best groundwater reservoirs in the region, and the most famous deposits of this era in the study area are floodplains and valley deposits. See map (2).

Map (2) The geology of the Alfdhay Valley basin



Source: Ministry of Industry and Minerals, Iraqi Geological Survey, Geological Survey Department, Iraq Geological Map Scale (250,000:1), for the year 2018.

Second - the surface:

The surface is one of the natural factors that have an impact on water resources, and it means the variation in the shape of the terrain, the degree of its slope, and the amount of its rise or fall from sea level, where the study of the surface lies in clarifying the extent of its impact on the surface and underground water resources through its control in drawing a network Water ramifications in all their levels, which control the flow system and its speed, as well as its impact on the process of leakage into underground reservoirs, where the leaking water increases and decreases due to the different degree of gradient and the nature of cracks and separators from one area to another.

Third - Climate:

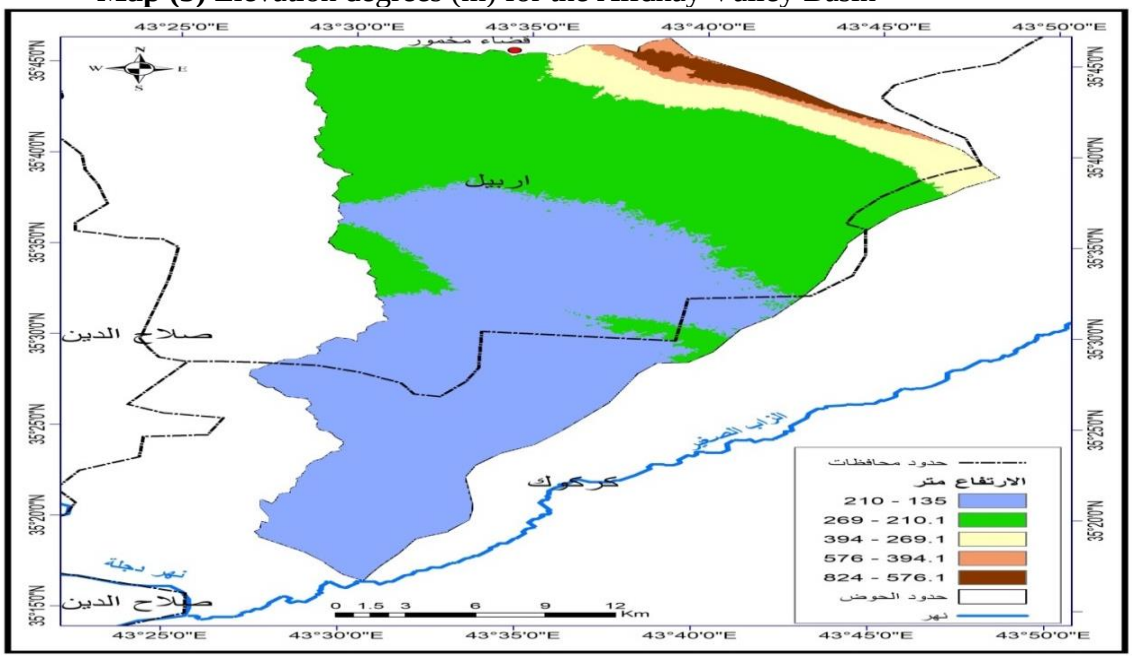
Geomorphological characteristics of the Alfdhay Valley Basin:

The land structure is one of the factors controlling the geomorphic forms in terms of its shape, degree of slope and spatial extent, and thus the geomorphology of the region is reflected on the speed and quantity of water flow along the valley courses, which in turn works in the sculpting and formation of sedimentary erosion manifestations that later invest in planning and development processes, and the study area is characterized by a diversity Its topography is located within the undulating region of the parts of the surface of Iraq.

The general elevation is directed from the south to the north, as the lowest point (135 m) above sea level was recorded in the far south of the basin, while the highest point

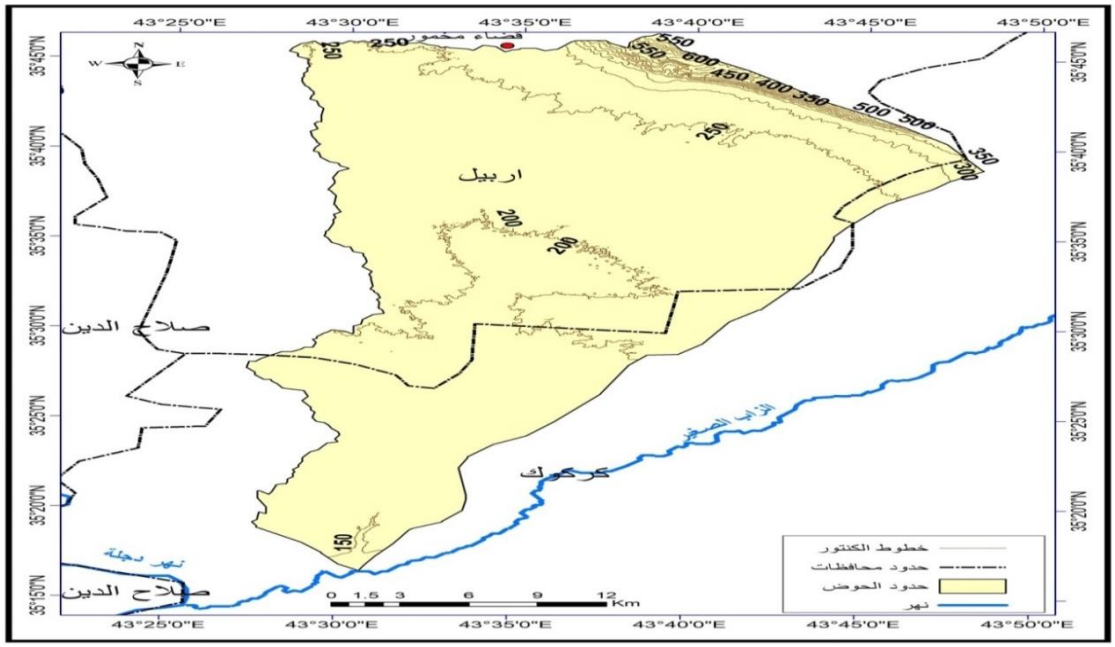
(824 m) above sea level was recorded in the far north of the basin. Based on this, the basin has been divided into five levels in height according to the turning points, as the first region has been determined with the value (135-210 m), and this category dominates in terms of the area it occupies compared to the rest of the categories, the second region (210.1-269 m), and the third region (269.1-394 m) and the fourth region (394.1-576 m) in the fifth region represented by the values (576.1-824 m) and as shown in map (3). Diverse terrain such as cliffs, hills and deep valleys Map (4).

Map (3) Elevation degrees (m) for the Alfdhay Valley Basin



Source: Based on the topographic map, at a scale of 1:250,000, using the ARC GIS 10.6 program.

Map (4) Lines of equal height (m) for the Alfdhay Valley Basin

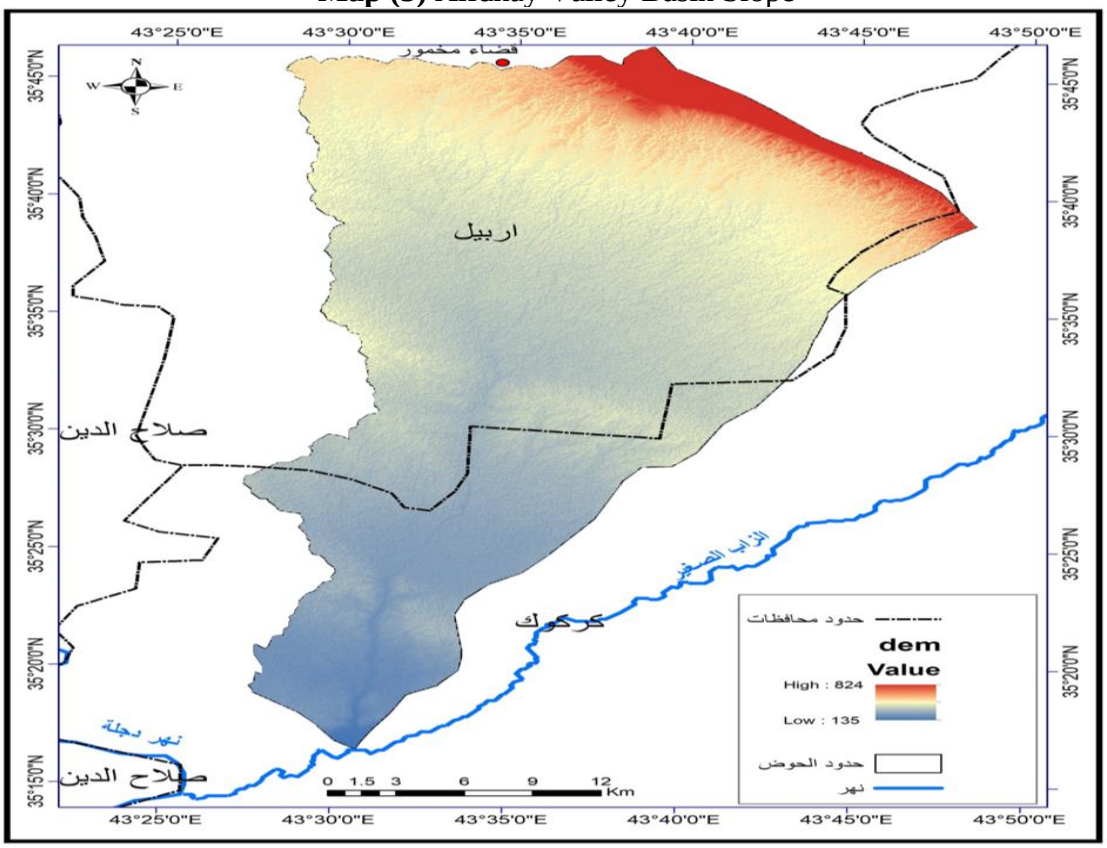


Source: Based on the topographic map at a scale of 1:250,000, using the ARC GIS

10.6 program.

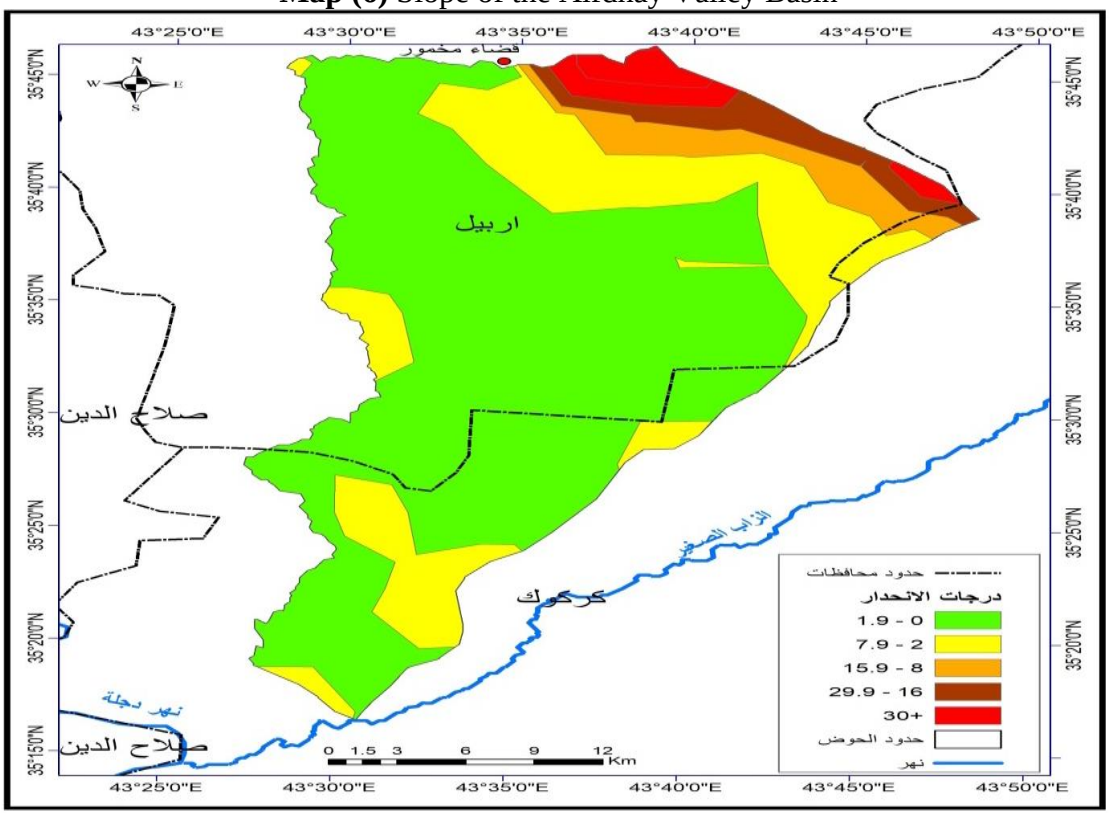
As for the degrees of gradient in the basin, according to the previous data, it started from (1.9) for the first region, which formed an area of (579 km2) and a percentage of (65.35%) of the total area of the basin. 22.9%) of the total area of the basin. As for the third region, whose slope was limited between (8-15.6), it constituted a percentage of (4.8%), and the degree of the fourth region's slope ranged between (16-29.9) and constituted a percentage of (3.72%), while it was recorded The degree of gradient (30+) has an area of (28 km) and a percentage of (3.16%) of the total area of the area, as shown in Table 1. This discrepancy in the degrees of gradient between the source and the estuary reflects the size and strength of the surface runoff of the running water in the Vally network and its hydrographic and morphological importance. In the erosion and sedimentation processes, the Alfdhay Valley basin is one of the most important basins feeding the Little Zab River.

Map (5) Alfdhay Valley Basin Slope



Source: Based on Digital Elevation Model (DEM) using (10.6 ARC GIS)

Map (6) Slope of the Alfdhay Valley Basin



Source: Based on Digital Elevation Model (DEM) using (10.6 ARC GIS).

Table (1) Slope area and percentage in the Alfdhay Valley basin

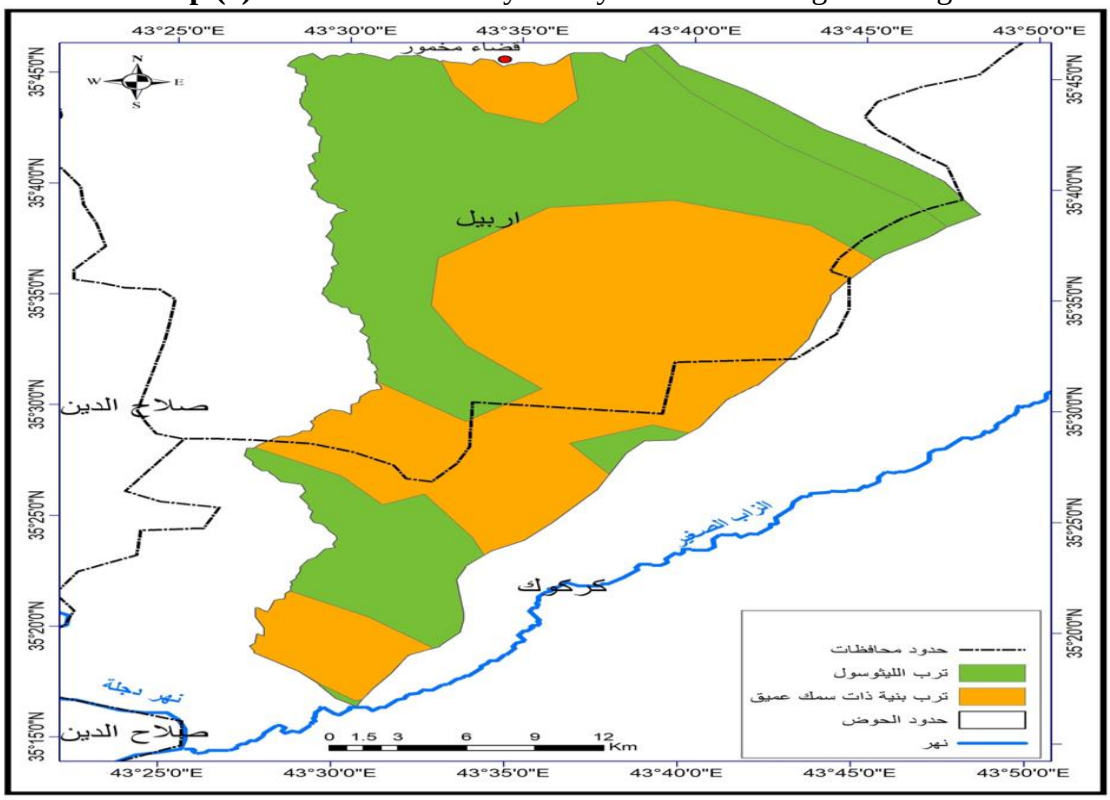
regression classes	Area (km2)	percentage (%)
1.9 - 0	579	65.35
7.9 - 2	203	22.91
15.9 - 8	43	4.85
29.9 16	33	3.72
+30	28	3.16
Sum	886	100

Source: Map 6.

With regard to the soil of the basin, it was divided into two main types, as it appears from Map (7): Lithosul soil, which constituted a percentage of (51.92%) of the surface area of the basin, and brown soil with deep thickness, which constituted a percentage (48.08%), Table (2) Through the map, it is clear that the spatial distribution of soils overlap within the parts of the study area and that the distribution ratio is very close between the two types. Because of the similar structural conditions of the area surrounding the basin and the similarity of weathering and erosion processes, which was reflected in the lack of soil diversity within the basin, and this in turn greatly

affects the volume of water penetrating within the soil particles and its great contribution to feeding reservoirs near the surface, especially since soil is the first storage line for groundwater. Al-Fahdawi, 2020, p. 70).

Map (7) Soils of the Alfdhay Valley Basin according to buringh.



buringh, soils and soil conditions in iraq, ministry of agricultural, baghdad, 1960.P 91.

Table (2) The soil in the study area

items	Area (km2)	percentage (%)
Lithosol soil	460.0	51.92
Deep-thick brown soils	426.0	48.08
Total	886.0	100.00

Source: Map 9.

Climate:

A group of geographical factors participate in drawing the climatic pattern of any region on the earth's surface, as there is no single geographical factor that has absolute sovereignty in giving the final picture of the prevailing climatic conditions. There are overlapping factors affecting among themselves that collectively draw the climatic characteristics of this or that region, with differences in the impact of these factors on the prevailing climatic reality in general (1).

The second axis: the morphometric characteristics of the Alfdhay Valley Basin.

The study of morphometric characteristics is useful in identifying the specifications of the water network spread within the basin through the analysis of topographic maps and satellite visuals. Floods, which in turn serve in providing water in front of dams and investing them in various projects such as drinking, irrigation, tourism and industry, as well as their usefulness in feeding groundwater aquifers and reusing them during the fishing season. The morphometric information of the basin is useful in predicting the drainage peaks and the possibility of controlling them and investing them in a scientific manner (Al-Fahdawi, 2017, p. 50), and from here the importance of the morphometric characteristics appear, which will be analyzed accurately as follows:

First: spatial characteristics:

The natural characteristics of the area represented by the structure, climate and surface play a major role in determining the area of the basin and drawing the final picture of the water drainage network. The relationship is direct between the size of the basin and the amount of its water discharge, and this is reflected in its hydrological properties and the volume of transported sediments that can be invested later in agricultural and industrial investments. The area of the drainage basin of Alfdhay Valley reached (886 km2), map (8). The development of this area was linked to structural and climatic factors. The rock formation played an important role in determining the area of the basin, as well as tectonic movements, the impact of faults and their location, especially within the valley basin in Erbil, as it had an important role. In directing waterways and increasing the process of vertical erosion and deepening.

Second - formal characteristics:

By looking at the water basin, we can derive its geometric shape, but the best is to use morphometric parameters in order to reach accurate results regarding the shape of the basin because of its great importance in determining water drainage and its impact on planning and development processes (Al-Naqqash and Al-Sahhaf, 1989, p. 521), and since The formal characteristics are highly related to the volume of water that prepares the waterways, which has to be studied to determine the landforms resulting from the erosion and sedimentation processes and to predict the drainage peaks and reduce their negative effects on human activities located next to the main and secondary valleys. The formal properties are measured by the following parameters:

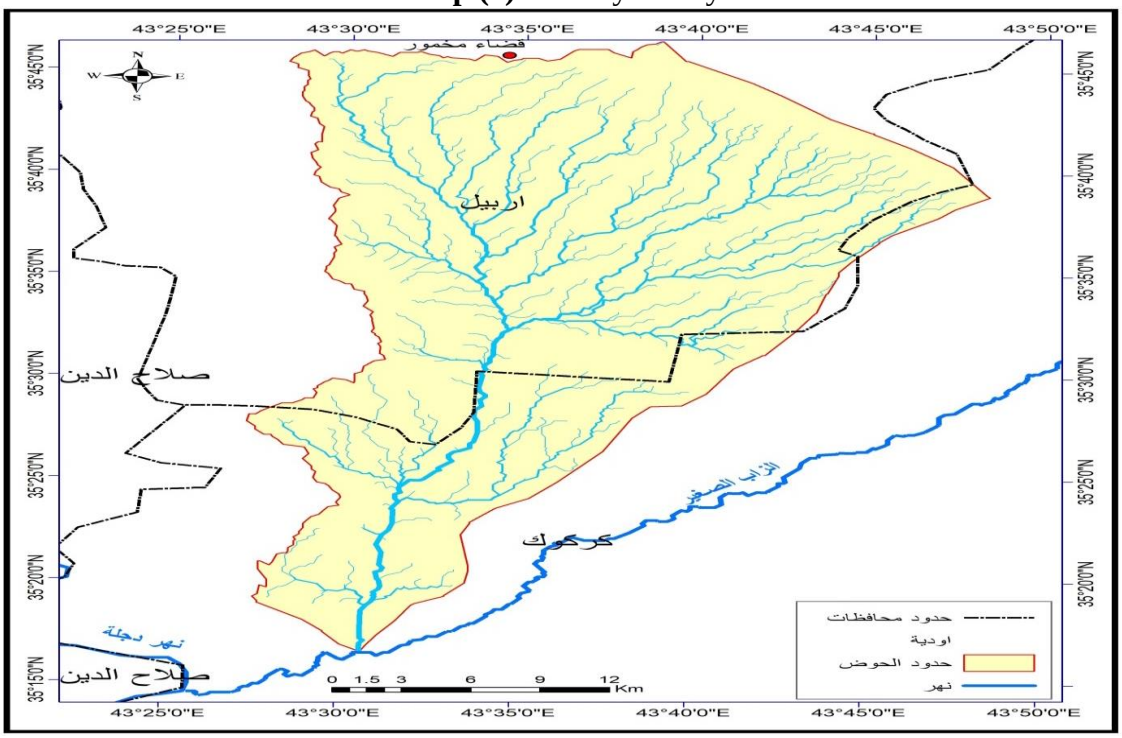
1. Basin Shape Factor:

It is an indicator of the relationship between the pelvic area to the pelvic length, and the value of the coefficient is between (0-1). 2000, p. 182). This parameter gives important hydromorphometric indicators. If the apex of the triangle is at the estuary and its base is at the sources, this is an indication of the low speed of the arrival of the high drainage peaks and their succession from the basin closest to the farthest; Because of the length of the waterways of the upper ranks, which reduces the risk of flooding, but if the base of the triangle is at the estuary region and the tip of the triangle is at the sources, it means the speed of the arrival of the drain wave to the main stream and the occurrence of the flood (Al-Fahdawi, 2017, p. 56), the value of this is extracted The coefficient using the following equation (the shape factor of the basin = the area of the basin in km2 ÷ the square of the length of the basin in km) (Al-Naqqash and Al-Sahaf, 1989, p. 521).

By applying the equation, the results showed that the Alfdhay basin coefficient is

(0.29), which indicates that the basin is close to the triangular shape, and it represents the inverted triangle, which means a decrease in the risk of flooding and the regularity of drainage, and then a decrease in the volume of erosion, with the exception of the headwaters areas located to the north-east of the basin within the Erbil governorate.

Map (8) Alfdhay Valley Basin



Source: The satellite visualization of the study area (DEM) using the program (ARC GIS 10.2).

Table No. (4) Spatial characteristics of the Alfdhay Valley Basin.

Basin name	Basin area (km2)	Basin circumferen e (km)	Basin length (km)	The maximum length of the Basin (km)	Basin width (km)	highest height (m)	less height (m)
Alfdhay Valley	886	162	55	53	28	699	160

Source: based on topographic maps at a scale of 1/100000 using (ARC GIS 10.2).

2- Elongation Ratio:

The elongation ratio describes the extension of the basin area in a semi-rectangular shape or close to it, and is calculated through the following (elongation ratio = length of the diameter of a circle with the same area as the basin in km ÷ maximum length of the basin in km) The ratio ranges between (0 - 1) and the elongation of the basin can be divided between (0 - 0.5) is very elongated, (0.51-0.7) long, (0.71-9) oval and (0.91-1) circular (Al-Adari, 2020, p. 466, and Al-Shujairi 2005, p. 167), and from the

application of the equation, the basin value appeared (0.6), and this result indicates However, the shape of the basin is closer to the rectangular shape than to the circular shape, which is an indication of the lack of its sedimentary output and the regularity of the flow of the network of valleys spread within the basin, due to the long distance that the water travels during its flow from the headwaters to the estuary and the leakage and evaporation that permeates, leading to a decrease in the amount of water.

3- Basin Circularity:

It expresses how far or close the shape of the basin is from the circular, and the result is between (0 - 1). Through the following (the area of the basin in km 2 ÷ the area of a circle whose circumference is equal to the circumference of the basin itself) (Jabouri, 1988, p. 61).

The rotation ratio of the Alfdhay Valley basin is (0.4), which means that the basin under investigation has moved away from the circular shape, and this is due to the nature of the geology of the area located within the undulating area and the fact that its structure contains convex and concave folds, which allows for a long period of flow and the lack of chances of occurrence of high drainage waves and the consequent weakness Weathering and water erosion.

Third: Topographical Characteristics:

The topographic features affect the drainage pattern of the basin and the variation of water flow velocity, which have a clear reflection on the volume of water-borne sediments. The topographic features will be analyzed as follows:

1- Relief Ratio:

It is an indicator of the steepness of the basin's terrain, and it is calculated according to the following equation (the difference between the highest and lowest point in the basin m ÷ the length of the basin m) (Al-Dulaimi, 2017, p. 124), and from the application of the equation it appears that the coefficient of the basin's molar coefficient is (0.01). This indicates the progress of the pelvis in its cycle.

2- Gradient Ratio:

It is a measure of the severity of the steepness of waterways and their effect on accelerating or decreasing the volume of flow, and it is calculated according to the following (highest height m - lowest height ÷ length of the basin km) (Al-Adari, 2020, pg. 470). The results of the equation showed that the value of the Alfdhay Basin is (9.8), which means that the area is rugged, especially in the upstream areas.

3- Highest and Lowest Height:

The basin at the headwaters areas recorded an increase of (699) meters above sea level, while the basin recorded a decrease of (160) meters at the point of its confluence with the Little Zab River, which means a difference in height of (539) meters, and this shows the value of the decline of the main and secondary network. Inside the studied aquarium.

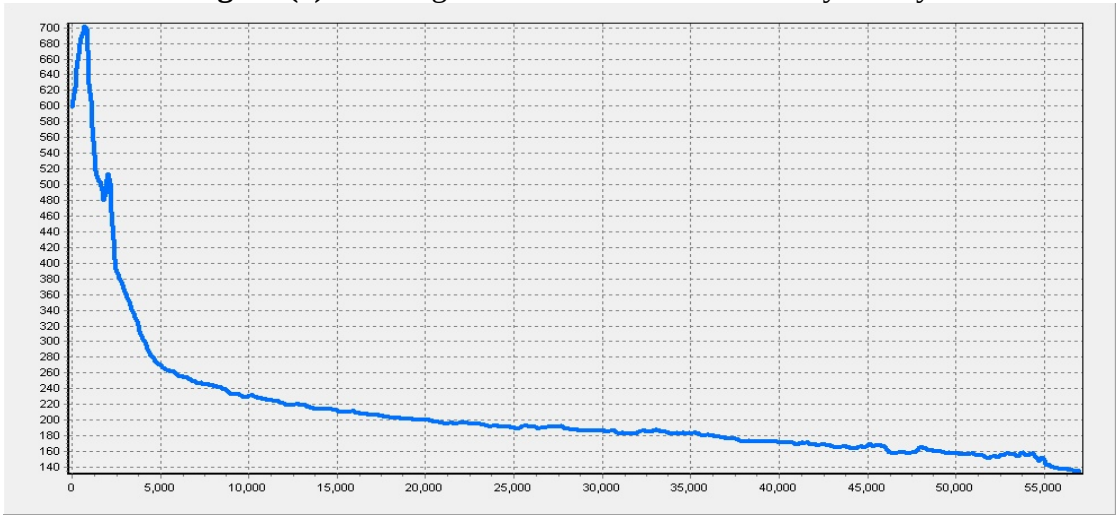
4- Longitudinal section: Longitudinal Profile:

This concept refers to the path taken by the river course during its descent from the headwaters to the estuary (Abu Samour, Ghanem, 1998, p. 12). A group of factors participate in determining the longitudinal section, including the structural movements, the quality of the area’s rocks and its topography, and the longitudinal section reflects the downstream stage of the valley, as the section represents The straight line indicates the development of the geomorphological stage of the valley, and the concave section indicates the youth stage, and through Figure (1) it appears that Alfdhay Valley is characterized by concavity. Its slope was (9.8) m/km.

5- Cross sections:

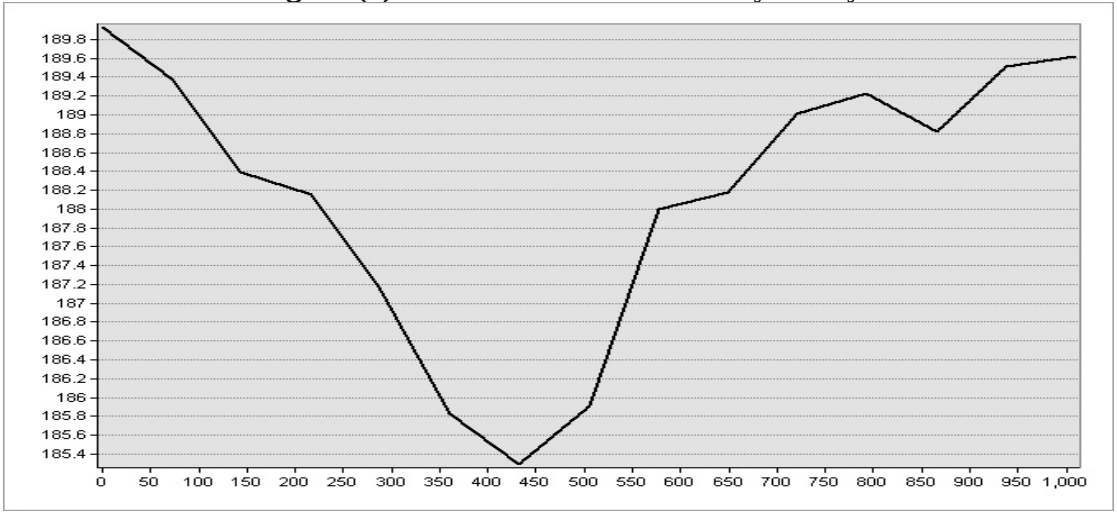
The cross-sections are important in geomorphological studies, as it shows the severity of the gradient that reflects the speed of surface runoff, as well as the possibility of identifying suitable sites for the construction of dams, reservoirs and other development projects. The cross-section of Alfdhay Valley is characterized by its low width relative to its depth, as it takes the form (v), which is an indication of the severity of trench erosion and the increase in the amount of transported sediments, especially since the valley's course follows the areas of rocky weakness and strata bats, in addition to the fact that a valley stream cuts the mountain gorges areas in the upper parts of the valley. The pelvis, which does not allow it to increase the transverse area of its duct.

Figure (1) The longitudinal section of the Alfdhay Valley



Source: Digital Elevation Model (DEM) using GLOBAL MAPPAR

Figure (2) Cross-section of the Alfdhay Valley



Source: Digital Elevation Model (DEM) using GLOBAL MAPPAR

Fourth: The characteristics of the water network:

The study of the characteristics of the valley network is important in the study of environmental factors, as its elements are calculated and analyzed in order to diagnose

its geomorphological indicators. The drainage network reflects the role of the geological structure, topography and climate factors in drawing its final shape. Through map (5), it can be seen that the valley network is distributed according to the ranks of the Alfdhay Valley basin. We will address the characteristics of the water drainage network of the Alfdhay Valley basin as follows:

1- Stream Orders:

The Streller method was adopted to divide the river ranks in order to determine the morphometric importance of the sub-network of the Alfdhay Valley basin, as well as to determine the volume of water drainage and the drainage peaks and the associated increase in the amount of transported sediments. Main and subsidiary by diverting water from distant valleys to nearby valleys to the last water level. It can be seen from the map (9) and table (5) that the values of the first rank amounted to (183), the values of the second rank amounted to (36), and the third rank reached (11) while the value of the fourth rank reached (2) and finally the fifth rank reached the value of (1) , As for the total waterways, it reached (233) ranks, and their total lengths amounted to (730.7) km.

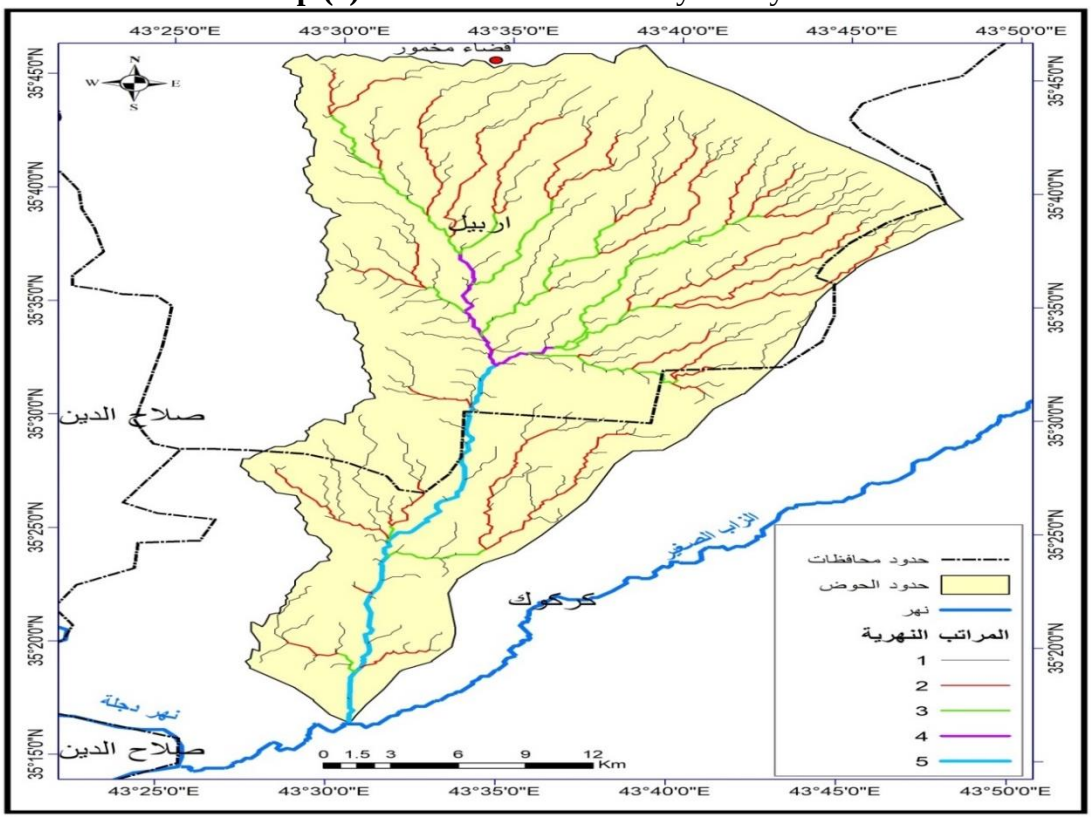
2- Sinuosity Factor Rate:

This coefficient refers to the average unit area needed to feed the longitudinal unit (km) of the sewerage network, and is extracted according to the following (the survival rate of the stream = the area of the basin km 2 ÷ the total lengths of the sewers km) (Al-Dulaimi, 2012, p. 375). The high ratio of this coefficient indicates the expansion of the basin area at the expense of the waterways and vice versa, and the downstream phase of the river affects the expansion of the area of feeding the valleys through retrograde erosion, and the survival values of the valley streams increase with the progression of the downstream phase, and rain has an important role in increasing the effect of this process through Increasing the rates of water weathering at the headwaters areas (Al-Fahdawi, 2017, p. 70), and by applying the equation, it became clear that the survival rate of the stream of Alfdhay Valley is (1.2).

3- Bifurcation Ratio:

It is an important indicator of the effect of natural conditions on the rate of water discharge, and its measurement ratio ranges between (3-5) and is extracted according to the following: (Branchation ratio = number of sewers in a certain rank ÷ number of streams of the next rank), and the data of applying the equation indicate that the ratio of bifurcation for the first rank amounted to (5) and the second rank reached (3.2), while the third rank recorded a value of (5.5), and the fourth rank (2), while the value of the fifth rank was (1).

Map (9) Riverbeds of the Alfdhay Valley Basin



Source: Satellite visualization of the study area using ARC GIS 10.2)

Table (5) Number and arrangement of the waterways of the Alfdhay Valley Basin

Alfdhay Valley Basin	River orders					Total orders Per Basin
	First order	Second order	Third order	Fourth order	Fifth order	
number of valleys	183	36	11	2	1	233
Valley lengths (km)	391	208	86	13.7	32	730.7

Source: Digital Elevation Model (DEM) using ARC GIS 10.2.

Conclusions

1. The majority of the geological region's formations date back to the Tertiary and Quaternary period, and their intensity in resisting weathering and erosion processes varies according to their solid components.
2. The region descends from the north and northeast towards the south with some local differences determined by the mountainous heights, and the region is rugged in the northern parts at the sources, and the degree of its roughness decreases at the central basin and the estuary.

3. The highest rank formed within the basin is the fifth rank according to the Streller classification.

Recommendations

1. Building a concrete dam on the main stream at the middle basin at the beginning of an area that constitutes the fifth rank, in order to benefit from the harvested water for irrigation and drinking.
2. Building flood sedatives and dams for the purpose of reducing the volume of sediments at the estuary, and benefiting from them in the construction operations inside the basin.
3. Placing a hydrological station at the estuary for the purpose of calculating the volume of daily, monthly and annual flow in order to set development plans for water management and investment.
4. Expansion in the field of tourism and the construction of buildings and recreational games, since the region's climate and mountainous topography help to establish projects of this kind.

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