Morphotectonic Analysis of Euphrates River Basin/ Iraq

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Abstract

Morphological and morphotectonic analysis have been used to obtain information that influencebasins. Study area includes the Euphrates river basin in Iraq. Tectonically this area within Stable shelf,The Stable Shelf which covers the vast majority of focal south and west of Iraq reaches out into Syria and Jordan and Southwards into Kuwait and Saudi Arabia. It is separated in Iraq into three considerable structural zones. Discrimination of morphotectonic indices of Euphrates basin by using sevenindices. The Euphrates basin (main basin) was divided into four sub basin (s.b) Wadi Horan, Wadi Ubaiyidh, Shuab Hwaimy and Shuab Qusair.Which have been completed for each drainage basin utilizing remote sensing and GIS techniques. So as to identify tectonic activity, different indices including Drainage density (D), Sinuosity index (S), Hypsometric integral (HI), Drainage basin asymmetry (AF), Basin Shape (BS), Transverse Topographic Symmetry (T) and Active tectonic index (Iat). The study demonstrates that intensity of tectonic activities in different parts of the basin and sub basins are different. The values of Drainage density (D) main basin and sub basins are in high classes which mean that the study area has resultant of slight or impermeable subsurface material, little vegetation as well as a good discharge for water and sediments. The Sinuosity index (S) of all study area are sinuous and its semi equilibrium. Hypsometric integral (HI) of Horan, Ubaiyidh and shuab Hwaimy sub basins shows high values of HI which means high rates of geological erosion while the shuab Qusair and main basin shows moderate of erosion rates, HI high values shows that study area is tectonically uplifted. According to calculation of Drainage basin asymmetry (AF) the study area reflects inactive tectonic activity. The Basin Shape (BS) all of basins are in third class and it reflects inactive tectonic activity. After compute Transverse Topographic Symmetry (T) index in the area of investigate, the outcome demonstrate that all the sub basins lies in low active tectonics except wadi Horan and the main basin were moderate active tectonics. Based on Active tectonic index (Iat) all the basins were moderate active tectonics except Horan sub basin is active tectonically. These basins have evolved as a result of plate movements, subsidence, uplift and various erosional processes. The study shows variable relationship between faulting and valleys but most of the trends of faults are sub- parallel to Euphrates River. Faults orientations in the study area are parallel to NE-SW direction and NW-SE direction. And also the type of drainage network in study area which is varied from dendritic to parallel with SW-NE trending and its indicate that study area may be structurally control.

1. Introduction

The crash of the Arabian plate with the Iranian and Turkish plates continues to present day because the Red Sea divergent and the Arabian Plate Movement towards North and Northeast, which is in charge of the neotectonic and seismic events in the region (Al-Janabi, 1996). The area under investigate is part of the stable shelf, so its tectonic evolution was associated with the tectonic evolution of the stable shelf. The region was influenced by the pre-cambrian tectonic movements (Kibaran, Hajaz and Najd).These movements were affecting in the basement rocks appears of faults in the direction northeast-southwest, northwest- southeast. These faults have an essential role in the structural and structural development of the study area. Water resources of Iraq historically have depended largely on the surface water of the Tigris and the Euphrates Rivers since the Mesopotamian civilization. More than 75% of the available water of Iraq comes from outside the territory. Both the Tigris and the Euphrates are international rivers, their sources originating in Turkey. [1].

Euphrates River, The longest river in southwest Asia, it is one of the two main constituents of the Tigris-Euphrates river system. The river rises in Turkey and flows southeast across Syria and through Iraq. Formed by the confluence of the Karasu and Murat rivers in the Armenian Highland, the Euphrates descends between major ranges of the Taurus Mountains to the Syrian plateau. It then flows through western and central Iraq to unite with the Tigris River and continues, as Shatt Al-Arab, to the Arabian Gulf. The length of the Euphrates from the source of the Murat River to the confluence with the Tigris at 3,000 kilometers (1,900 mi), of which 1,230 kilometers (760 mi) is in Turkey, 710 kilometers (440 mi) in Syria and 1,060 kilometers (660 mi) in Iraq. In length of the Shatt al-Arab, which connects the Euphrates and the Tigris with the Gulf, is given by various sources as 145–195 kilometers (90–121 mi). Euphrates River is located between the Sedimentary Plain in the east and the Western desert of Iraq in the west. [2] Describes the Sedimentary Plain as a large sedimentary basin that represents a large syncline with active tectonic surface. This basin passes through a subsidence or depression, with small local elevation motions, which is associated with the Alpine movement of the mountains that occurred in the highlands Zagros, which is still active. So far, this basin receives the products of erosion and weathering of the mountainous area as the downward movement continues.

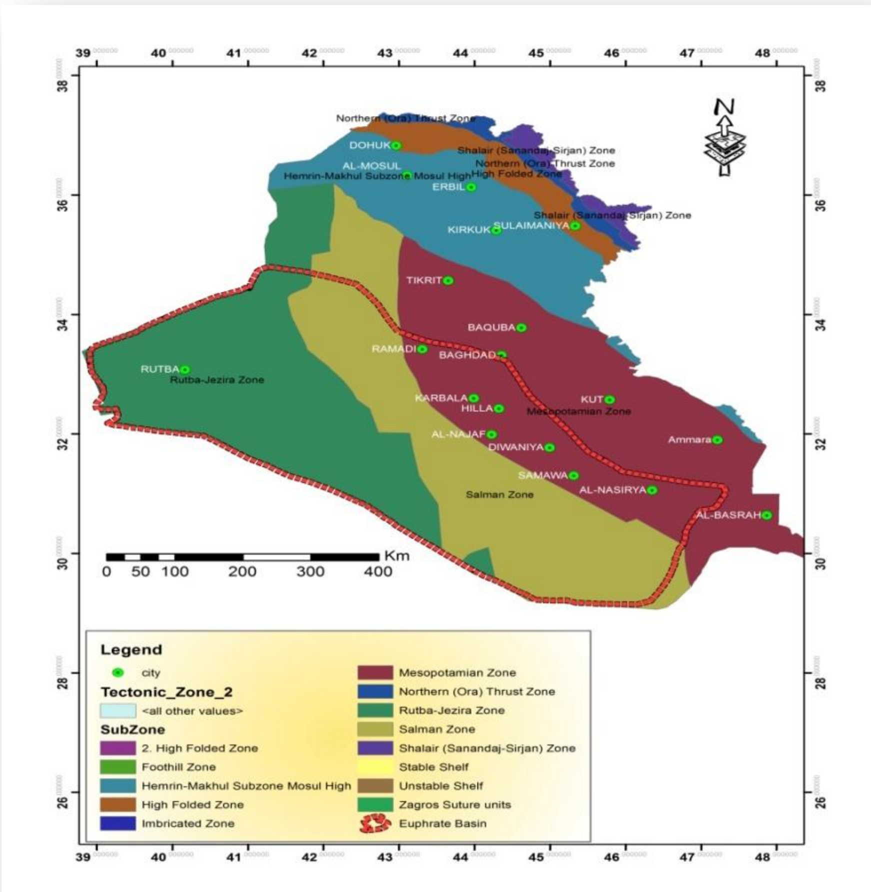

Figure (1) Tectonic partition of Iraq after [3]

2. Location of area under investigate

Study area includes the whole Euphrates river basin and it is represent the western and southern Iraqi desert. As in Fig (2).

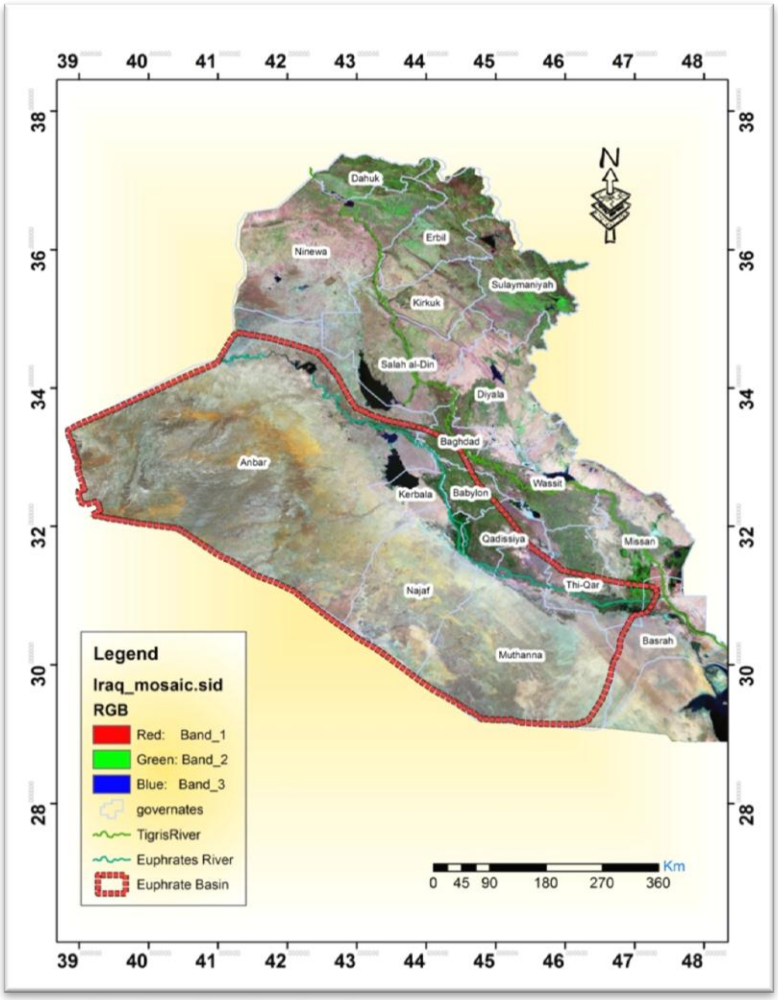

Figure (2) shows position of Euphrates basin

3. Aim of study

The principle point of present investigation is to compute different morphotectonics indices and relation between patterns with faults that affect Euphrates River basin.

4. Methodology and Materials

In this searchDigital Elevation Model (DEM) with 30 m resolution, geological map 1:1000000 are utilized to investigation and extraction of vigorousindicators and drainage networks. Arc GIs 10. Excel software's were utilized to get distinctive maps.. The methodology was done by following steps.

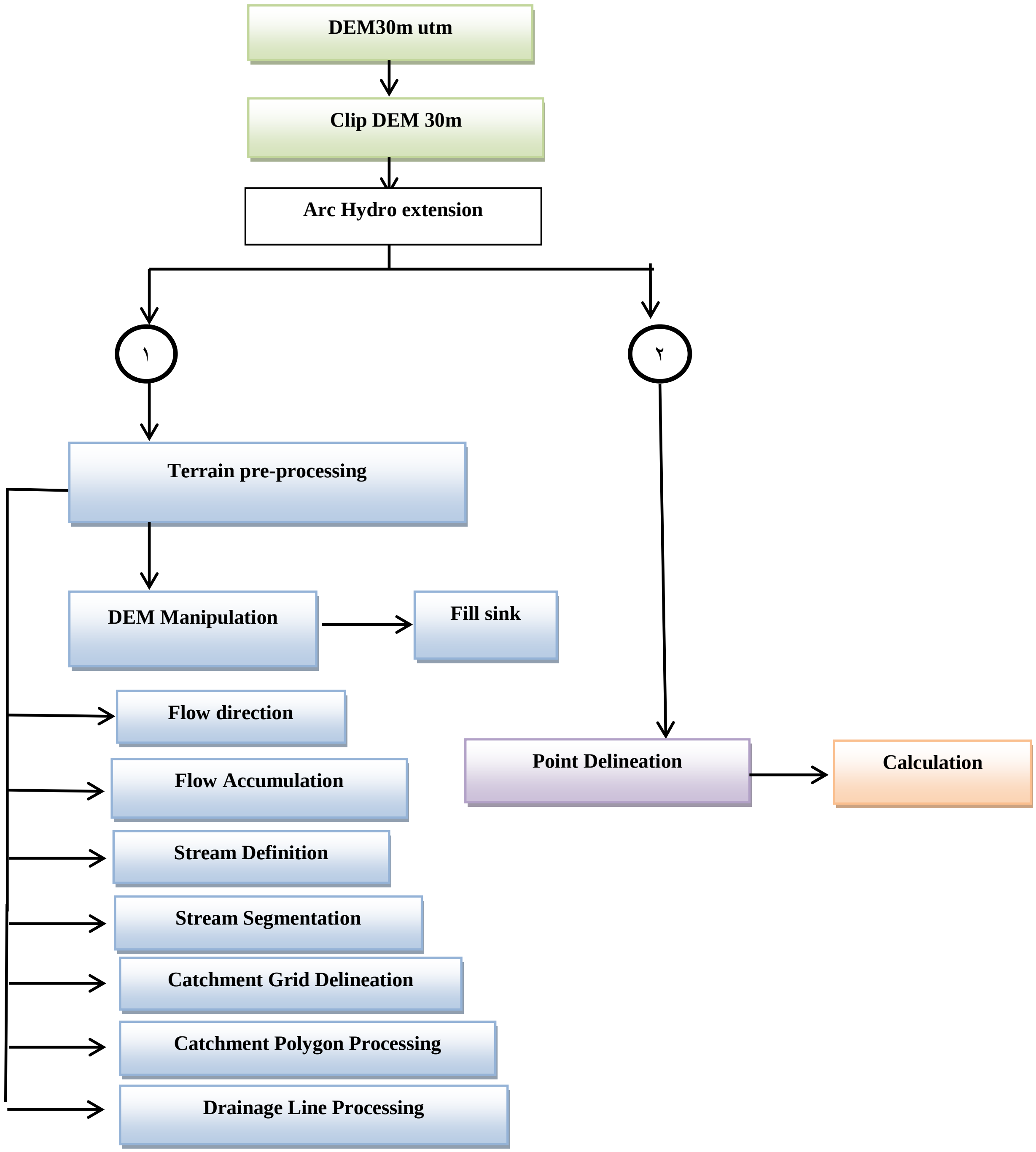

Figure (3) schematic Diagram of study

5. Morphotectonicsindices

It has been known that the study area lies in Western and the Southern Deserts. There are no structural or physiographic boundaries between the two deserts, and the distinction is strictly geographic. [4].

Morphotectonic is the study of landforms created by tectonic processes. We implemented different indices including Drainage density (D), Sinuosity index (S), Hypsometric integral (HI), Drainage basin asymmetry (AF),Basin Shape (BS), Transverse Topographic Symmetry (T) and Active tectonic index (Iat). In this research, the Euphrates basin (main basin) was separated to four sub basin (s.b) which is adapted from the geological map scale 1:1000000, 1998.First: Wadi Horan, Second: Wadi Ubaiyidh, Third: Shuab Hwaimy and Shuab Qusair as in Fig(4).

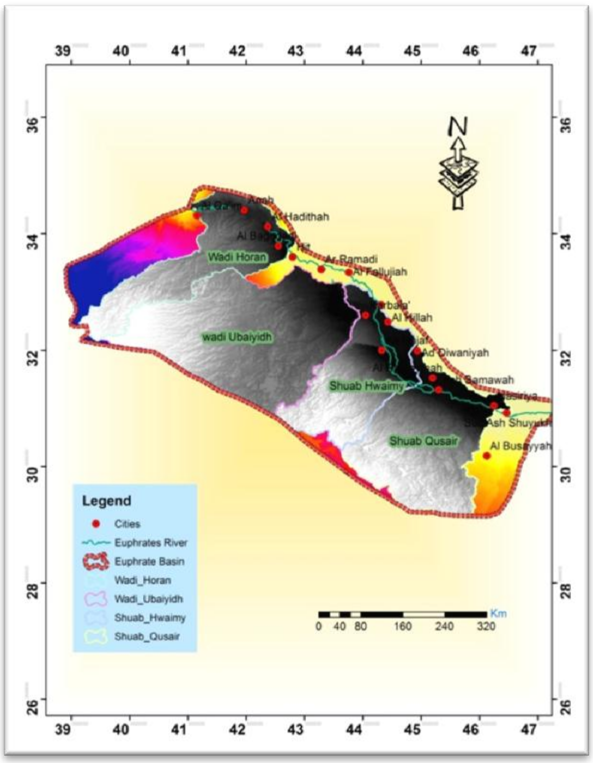

Figure (4) Shows the main & sub basin in study area

Some of indices were calculated by using geometry and measure tool in Arc GIS program such as (the basin area, basin length, basin perimeter, Maximum & Minimum elevation, Form parameter whichis the ratio of Basin area (A) divided by (length of the Basin)^{2}and Percentage of the basins). As in table (1).

Table (1) characteristics of main and sub basin representsAreas in Km^{2}and Length in Km.

Sub basin characteristics	Wadi Horan S.B	WadiUbaiyidh S.B	ShuabHwaimy S.B	ShuabQusair S.B	Euphrates Basin
Basin Area Km^2	32193	64947	32820	45744	232205
Basin Length Km	370	272	193	253	793
Basin Width Km	166	326	221	251	346
Basin Perimeter Km	1814	2002	1155	1690	2240
Maximum elevation	909	868	411	454	933
Minimum elevation	58	31	14	2	1
Form	0.2	0.8	0.8	0.7	0.3
Percentages of Basins	13.8%	27.9%	14.1%	19.7%	------

5.1. Drainage Density index (D)

The drainage density shows the closeness of distance of channels, hence giving a quantitative measure of the normal length of stream channel for the entire basin. High drainage density is the resultant of feeble or impermeable subsurface material, inadequate vegetation. Low drainage density prompts coarse seepage surface while high drainage density prompts fine waste surface. [5].

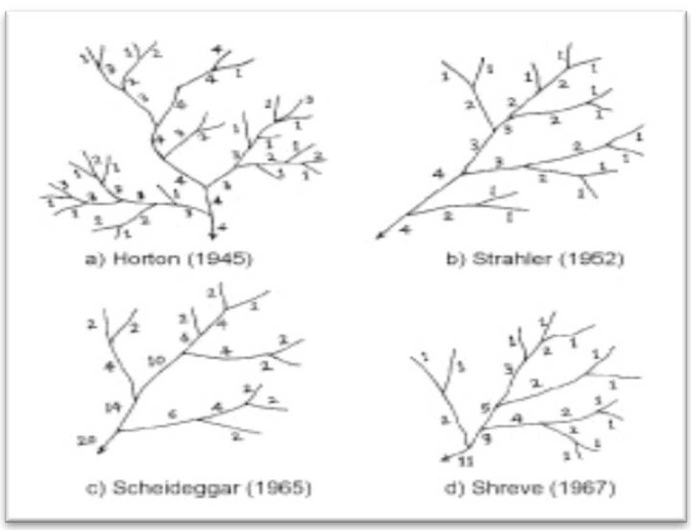

Figure (5) System of stream ordering

Ten stream orders were adapted in this study for main and sub basin, the length was calculated to each basin separately.As well as the Euphrates basin (main basin).

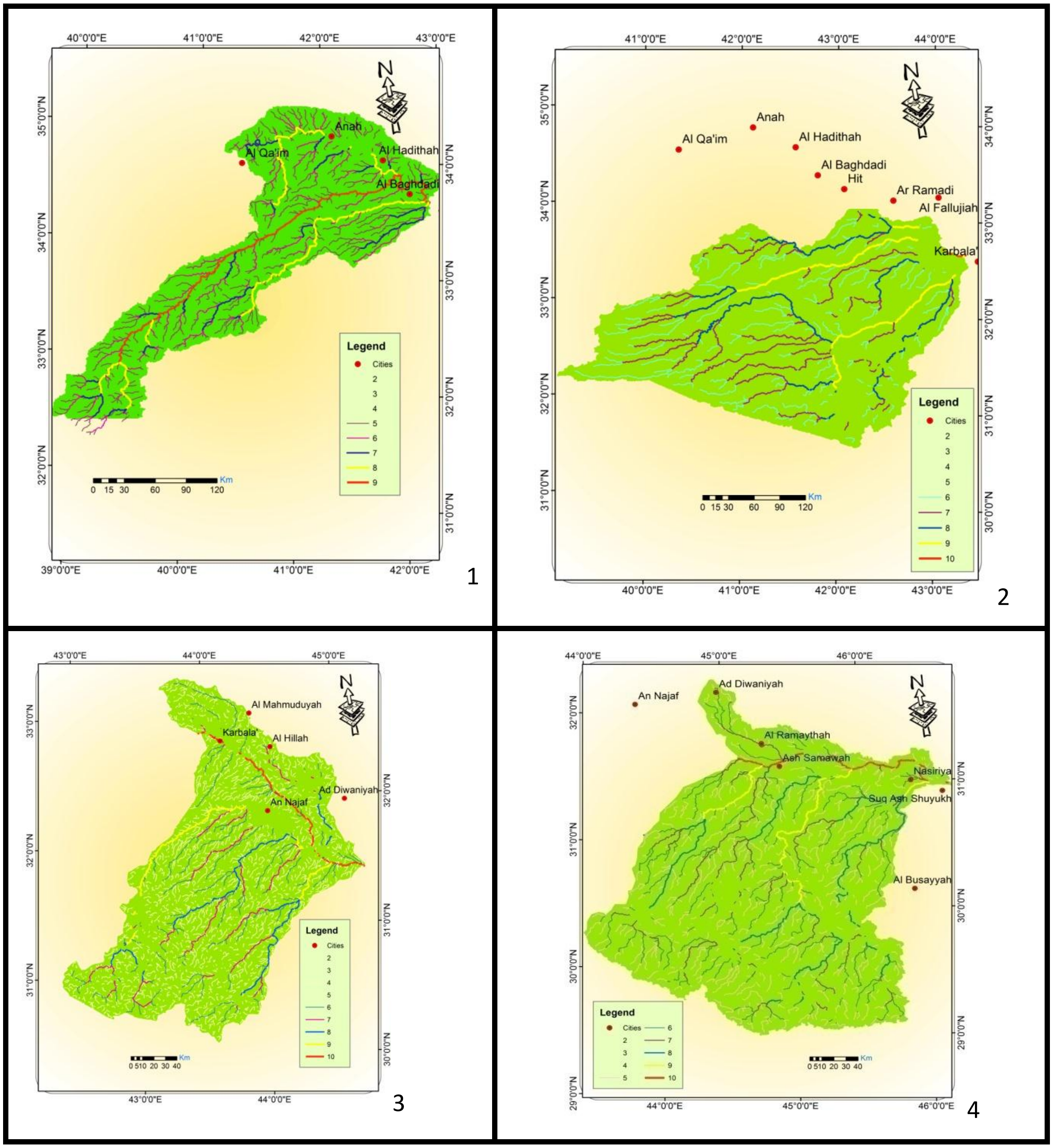

Figure (6) shows stream order in sub basins1-Wadi Horan, 2-Wadi Ubaiyidh,3-ShuabHwaimy and 4-ShuabQusair respectively

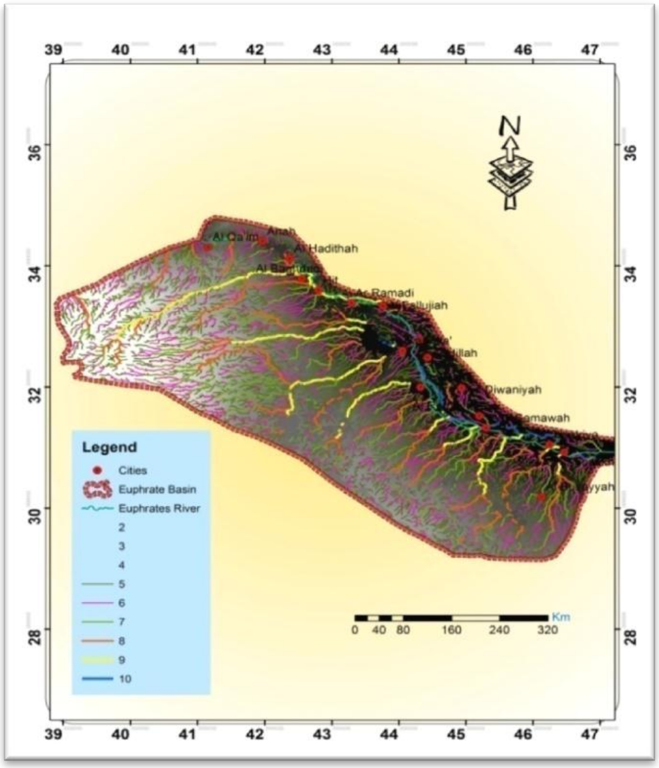

Figure (7) shows stream order in Euphrates basin

Drainage density is the proportion length of the stream to area of the region as below:

$$D = L/A \quad \text{.............} \quad 1$$

D = Drainage density index
L = total length of streams in km
A = total area in square kilometers

Low density is below0.6, average between 0.6 and 0.9, high if it is above 0.9 [6]. Appling equation no.1 on table no.1 we get the result as in table 2.

Table (2). Values of Drainage density (D)

Sub basin Name	Drainage Density	Class of D
Wadi Horan	**1.8**	**3 High**
WadiUbaiyidh	**1.7**	**3High**
ShuabHwaimy	**1.7**	**3High**
ShuabQusair	**1.7**	**3High**
Main Basin	**1.7**	**3High**

5.2.Sinuosity of River index (*S*)

Sinuosity parameter isobtained by using the Equation. [7].

:

$$S = C / V \text{ ....2}$$

S = Sinusitis or the twists and turns of the river
C = length of the river
V = length of the valley

Rivers that have turns are near to be harmony, while the immediate river course speaks to more youthful and presence of neotectonic exercises in the territory. Rivers having a sinuosity of 1.5 are called sinuous, or more 1.5 are called meandering [8].Appling equation no.2 on table no.1 we get the outcome as in table 3.

Table (3).Values of Sinuosity (S)

Sub basin Name	Sinuosity	Class of S
Wadi Horan	1.33	1 sinuous
WadiUbaiyidh	1.05	1 sinuous
ShuabHwaimy	1.12	1 sinuous
ShuabQusair	1.31	1 sinuous
Main Basin	1.4	1 sinuous

5.3 Hypsometric integral (HI)

The hypsometry may reflects the interaction between tectonic and level of non stability in the balance of erosion, beside it could provide a valuable geomorphic index that constrains the relative importance of these processes, In general, land areas with higher rates of tectonic uplift have higher HI values as basins are less concave, and land areas that have been subject to net long-term erosion have lower HI values and basins are less convex. [9]. And it calculated by equation:

HI= (mean elevation – Min.elev) / (Max.elev – Min.elev) -----3

Classified this parameterinto three categories: 1) Hi≥0.5, 2) 0.4 ≤Hi<0.5, and 3) Hi <0.4. [10].Appling equation no.3 on table no.1 we get the result as in table 4.

Table (4). Amounts of Hypsometric index (HI)

Sub basin Name	Hypsometric integral	Class of HI
Wadi Horan	0.5	1
WadiUbaiyidh	1.03	1
ShuabHwaimy	0.5	1
ShuabQusair	0.4	2
Main Basin	0.4	2

5.4 Drainage Basin Asymmetry Index (AF)

Asymmetry index for determining the tectonic tilting of the drainage basins and larger areas are as follows in Equation

$$AF = 100\ (Ar / At) \qquad \text{.......4}$$

Ar: right area of the river, *Ar*: total area of the drainage basin.
Af-50 < 7 inactive, 15 > Af-50 > 7 semi-active and Af-50 > 15 is placed in active class.

The parameter is critical to change in slop perpendicular to the heading of basin. An AFfactor above or underneath 50 may because from basin tilting, coming about either from active tectonics or lithologic structural dominate. To evaluate the relative active tectonics, the vital difference is what is important, and values of AF-50 range estimate 1 to 28. [10]. AF-50 < 7 not vigorous, 15 > AF-50 > 7 semi-vigorousand AF-50 > 15 is placed in vigorous class. [11].Appling equation no.4 on table no.1 we get the result as in table 4.

Table (4). Values of Drainage basin asymmetry (AF)

Sub basin Name	Drainage Basin Asymmetry AF	Class of AF
Wadi Horan	2.95	1 inactive
WadiUbaiyidh	2.96	1 inactive
ShuabHwaimy	2.46	1 inactive
ShuabQusair	2.99	1 inactive
Main Basin	0.72	1 inactive

5.5. Basin Shape Index (BS)

Also called "Elongation Ratio" it describes the horizontal projection of a basin, and it classified into three classes: 1) (BS ≥ 4) vigorous, 2) (3 ≤ BS< 4) semi-vigorous and 3) (BS ≤ 3) not vigorous. [10]. It is defined as in equation:

$$BS = B1/ Bw \text{ ----------------------- } 5$$

B1: is the length of a basin estimated from elevated point.

Bw: is the width of a basin estimated at its extensive point.

Appling equation no.5 on table no.1 we get the result as in table 5.

Table (5). Values of Basin shape (BS)

Sub basin Name	Basin Shape BS	Class of BS
Wadi Horan	2.22	3 inactive
WadiUbaiyidh	0.83	3 inactive
ShuabHwaimy	0.87	3 inactive
ShuabQusair	1.0	3 inactive
Main Basin	2.29	3 inactive

5.6. Transverse Topographic Symmetry Factor (*T*)

Index T is a vector with a certain orientation and different values between 0 - 1. In perfectly symmetrical Basins, the value of this index is zero. By reducing the symmetry of the basin, T index increases and gets closer to 1 which is computed by Equation (6):

$$T = Da / Dd \quad (6)$$

Da = the distance between Midfielder of drainage basin and main river route
Dd = the distance between Midfielder of drainage basin and Water dividing line

Regards to present search, we were indicate class 1 for T >0.4high, class 2 for T between 0.2 and 0.4 moderate and class 3 for T < 0.2 low.[12].Appling equation no.6 on table no.1 we get the result as in table 6.

Table (6) Values of Transverse topographic symmetry (T)

Sub basin Name	Transverse Topographic Symmetry T	Class of T
Wadi Horan	**0.3**	**2moderate**
WadiUbaiyidh	**0.09**	**3low**
ShuabHwaimy	**0.1**	**3low**
ShuabQusair	**0.1**	**3low**
Main Basin	**0.4**	**2moderate**

5.7. Active Tectonics Index (Iat)

After calculating the geomorphic indices in the study area is estimated tectonic activities in the area using Iat index. *Iat* index is achieved from the average of different geomorphic indicator classes according to the following equation:

$$Iat = S / N \quad 7$$

S: Total classes geomorphic indicators that is calculated
N: Number of indicators
The values of the index were divided into four classes to define the degree of active tectonics: 1—very high (1.0 ≤ Iatb1.5); 2—high (1.5 ≤ Iatb2.0); 3—moderate (2.0 ≤ Iatb2.5); and 4—low (2.5 ≤ Iat)

[10]. Appling equation no.7 on indices we get the result as in table (7).

Table (7).Amounts of Active tectonic index (Iat)

Sub basin	Class D	Class S	Class HI	Class AF	Class BS	Class T	Value Iat	Class Iat	Tectonic activity
Wadi Horan	3	1	1	1	3	2	1.8	2	High
WadiUbaiyidh	3	1	1	1	3	3	2	3	Moderate
ShuiabHwaimy	3	1	1	1	3	3	2	3	Moderate
ShuiabQusair	3	1	2	1	3	3	2.1	3	Moderate
Main Basin	3	1	2	1	3	2	2	3	Moderate

As in figure (8).

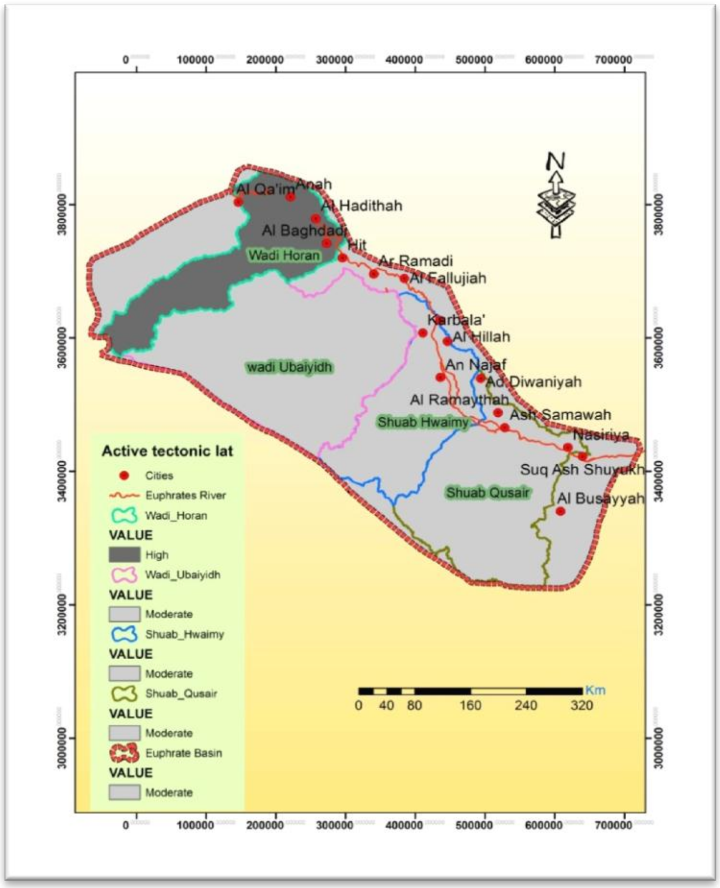

Figure (8) Shows the Iat Index

6. Faults and Drainage network in study area

The study area contains several sub-basins that lie in the western and southern of Iraq. These sub-basins were observed from the interpretation of using Digital elevation model processing, these basins have evolved as a result of plate movements, subsidence, uplift and various erosional processes.

The observation of Figure (7) shows different and variable relationship between faulting and valleys but most of the trends of faults are sub- parallel to Euphrates River. Faults orientations in the study area are parallel to NE-SW direction and NW-SE direction. Besides the type of drainage network in study area which is varied from dendritic to parallel with SW-NE trending and it’s indicate that study area may be structurally control.

7. Discussion &Conclusion

In present research, in view of geomorphic parameters the aspects of tectonic activities in Euphrates basin territory were discussed.

1. Seven indices were achieved as well as the basins characteristic as in table (1) so as to elicit tectonic efficiency for Euphrates basin.

2. Ten stream order recognized in study area for main basin (Euphrates basin) starts with tenth order and end with second order, Horan sub basin starts with ninth stream order and end with second order, Ubaiyidh sub basin starts with tenth order and end with second order, Shuab Hwaimy sub basin starts with tenth order and end with second order, Shuab Qusair starts with tenth order and end with second order.

3. With regard to the value of Drainage density (D) main basin and sub basins are in high classes which mean that the study area hasconsequence of slight or impermeable subsurface material, little vegetationas well as a good discharge for water and sediments. The Sinuosity index (S) of all study area are sinuous and its semi equilibrium. Hypsometric integral (HI) of Horan, Ubaiyidh and shuab Hwaimy sub basins shows high value of HI which means high rates of

geological erosion while the shuab Qusair and main basin shows moderate of erosion rates, HI high valuesshows that study area is tectonic uplift. According to calculation of Drainage basin asymmetry (AF) the study area reflects inactive tectonic activity. TheBasin Shape (BS) all of basins are in third class and it exhibit inactive tectonic activity. Aftercompute Transverse Topographic Symmetry (T) parameter in the area under investigate, 10 isolated areas were estimated and the outcomedemonstrate that all sub basins lies in low active tectonics except wadi Horan and the main basin were moderate active tectonics. Basedon Active tectonic index (Iat) classification as in table (7) all the basins were moderate active tectonics except Horan sub basin is active tectonically.

4- Overall, intensity and tectonic vigor in different parts of the Euphrates basin and sub basinswere differentia, the results of morphotectonics parameters and the tectonic assessments demonstrate that study area considered as a modestlyvigor's territory as far as tectonic activity.

5- Different and variable relationship between faulting and valleys but most of the trends of faults are sub-parallel to Euphrates River. Faults orientations in the study area are parallel to NE-SW direction and NW-SE direction. Moreover the type of drainage network in study area which is varied from dendritic to parallel with SW-NE trending and it's indicate that study area may be structurally control.

CONFLICT OF INTERESTS
There are no conflicts of interest.

8. References

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التحليل المورموتكتونك لحوض نهر الفرات/ العراق

الخلاصة

تم استخدام التحليل الموفولوجي والتحليل الموفوتكتونك للحصول على المعلومات التي تؤثر على الأحواض. تشمل منطقة الدراسة حوض نهر الفرات في العراق. من الناحية التكتونية تقع منطقة الدراسة ضمن منطقة الرصيف المستقر، يمتد الرصيف المستقر والذي يغطي معظم وسط وجنوب وغرب العراق إلى سوريا والأردن وإلى الجنوب إلى الكويت والمملكة العربية السعودية. وهو مقسم في العراق إلى ثلاث انطقة تكتونية رئيسية. التمييز بين المؤشرات المورفوتكتونك لحوض الفرات تم باستخدام سبعة مؤشرات. تم تقسيم حوض الفرات (الحوض الرئيسي) إلى أربعة أحواض فرعية (s.b) وادي حوران ووادي الابيض وشعيب الحويمي وشعيب القصير. وقد اكتملت دراسة هذه الأحواض باستخدام تقنيات الاستشعار عن بعد ونظم المعلومات الجغرافية. من أجل تحديد النشاط التكتوني، مؤشرات وعوامل مختلفة تم استخدامها خلال البحث ومنها كثافة التصريف (D)، مؤشر التعرج Sinuosity (S)، مؤشر الهايبوسومترك Hypsometric integral HI،عدم تناسق حوض التصريف (AF)، شكل الحوض(BS)، التناظر الطبوغرافي المستعرض (T) و مؤشرالتكتونية النشطة (Iat). وأظهرت الدراسة أن شدة ودور الأنشطة التكتونية في أجزاء مختلفة من الأحواض والأحواض الفرعية متباينة. إن قيم كثافة التصريف (D) للحوض الرئيسي والأحواض الفرعية ذات قيم عالية مما يعني أن منطقة الدراسة قد نتجت عن مواد تحت سطح الأرض ضعيفة أو غير منفذة، ونباتات متفرقة بالإضافة إلى التصريف الجيد للمياه والرواسب. مؤشر التعرج Sinuosity S لجميع منطقة الدراسة هي متعرجة وشبه متوازن. تُظهِر مؤشر الهايبوسومترك (HI) لأحواض حوران و الابيض و شعيب الحويمي قيمًا عالية لــ HI مما يعني ارتفاع معدلات التعرية، في حين يُظهِر شعيب القصير والحوض الرئيسي للفرات معدلات معتدلة من التعرية، تُظهر القيم المرتفعة HI بان منطقة الدراسة مرتفعة تكتونيا. واستنادا لحساب مؤشرعدم تناسق حوض التصريف (AF) فان منطقة الدراسة تعكس نشاط تكتوني غير فعال. إن مؤشر شكل الحوض (BS) لجميع الأحواض موجودة في الدرجة الثالثة وتعكس نشاطًا تكتونيًا غير نشط. بعد حساب مؤشر التناظرالطبوغرافي المستعرض (T) في منطقة الدراسة، تظهر النتائج أن جميع الأحواض الفرعية تتميز بنشاط تكتوني منخفض باستثناء وادي حوران والحوض الرئيسي كانت تكتونية نشطة معتدلة. بناءً على مؤشر التكتونية النشطة (Iat)، كانت جميع الأحواض عبارة عن تكتونية نشطة معتدلة باستثناء حوض حوران النشط تكتونيا. لقد تطورت هذه الأحواض نتيجة لحركات الصفائح، وهبوطها، ورفعها، وعمليات التآكل المختلفة. توضح الدراسة وجود علاقة متباينة بين التصدع والوديان ولكن معظم اتجاهات الصدوع تكون متوازية مع نهر الفرات. تكون اتجاهات الصدوع في منطقة الدراسة موازية لاتجاه NE–SW واتجاه NW–SE. وكذلك نوع شبكة تصريف الجريان في منطقة الدراسة التي تتغير من الشكل الشجيري الى الشكل المتوازي مع اتجاه SW–NE وتشير إلى أن منطقة الدراسة قد تكون مسيطر عليها العامل التركيبي (البنيوي).

الكلمات الدالة: المورموتكتونك، الاحواض الثانوية، كثافة التصريف، معامل التعرج، معامل الهايبوسومترك، معامل تناظر الحوض، شكل الحوض، معامل تناظر الطوبوغرافي المستعرض، معامل التكتوني الفعال.