MODELING THE WATERSHED AND ESTIMATION OF DESIGN FLOOD DISCHARGE FOR ALI AL-GARBI STORM WATER BY USING GIS [+]

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Abstract :

In this study the GIS was applied with the aid of the spatial analyst extension's hydrology tools, by using DEM (digital elevation model) to create the watershed and network stream. After delineation the watershed by using GIS, the area value of watershed for Ali al-Garbi water storm was equal to 44211.431 hectare, and the part of this watershed was lied in Iran(Illam governorate) but the major part of the watershed was lied in Iraq (Maysan governorate) .The intersection outlet point of watershed with the Ali al-garbi –Baghdad road, it had the coordinate (657830.15 E, 3595395.16 N), and represents' the location of suggests culvert.Finally and easily, by using the rational method was estimated the design flood for the culvert was estimated equal to 122.80 m^3/sec.

نمذجة حوض التغذية وتخمين التصريف التصميمي لسيول علي الغربي باستخدام نظم المعلومات الجغرافية

احمد سامي ناصر

المستخلص :

في هذه الدراسة تم تطبيق نظم المعلومات الجغرافية بمساعدة الادوات الهيدرولوجية للتحليل المكاني و باستخدام نموذج المناسيب الرقمية، لانشاء حوض تغذية وشبكةمجاري مائية. وبعد تحديد حوض التغذية باستخدام نظم المعلومات الجغرافية وجد ان مساحة حوض التغذية لسيول علي الغربي كانت تساوي 44211.431 هكتار ، وان جزء من هذا الحوض يقع في ايران (محافظة ايلام) ولكن الجزء الاكبر من حوض التغذية يقع في العراق (محافظة ميسان) . وان نقطة التقاطع التي هي نقطة تصريف مياه حوض التغذية مع طريق علي الغربي –بغداد تملك الاحداثيات التالية (657830.15 شرق ،3595395.16 شمال) ،وهي تبين موقع القنطرة المقترح.اخيرا وبسهولة ، باستخدام الطريقة العقلانية تم تخمين التصريف الفيضاني التصميمي للقنطرة وكان يساوي 122.80 م^3/ثا .

Introduction :

In May 2013, storm water (flood) was occurred in north east of" Maysan "city, this storm water was occurred due to extreme rainfall in this area and a part of" Illam" governorate in Iran.

The storm was caused loss of life, damage to crops, and structure such as roads. Therefore, study this area as hydrological is very important.

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The first aim of this study is create hydrological model for the area study by using the GIS with the aid of the spatial analyst extension's hydrology tools.
The second aim from this study are delineation watershed, flood control to avoid the risks on life and the structure in downstream, finding the location of intersection water flow with the road in downstream of watershed, and estimation of design flood.

Background :

GIS:

GIS the geographic information systems, are used to display, manipulate and analyst spatial (map) data. The (G.I.S.) has four separate applications (arc map, arc catalog, arc toolbox, and arc scene) [1].

DEM:

A digital elevation model (DEM) is a raster representation of height data, the heights are of land above sea level [2].

Watershed:

The land area that drains into a stream; an area of land that contributes runoff to specific delivery point .large watershed may be composed of several smaller "sub sheds" each of which contributes runoff to different locations that ultimately combine at a common delivery point (also called outlet point, or pour point) Also called Drainage area, basin, or catchment area [3].

Rational method:

One of methods that used to estimation peak flood in ariver, it is based on application of the formula below [4].

Q=CiA ………………………………………………………………………….. (1)

Where
(A) is catchment area , (Q) is discharge in cumec, (C) is a coefficient depending on the runoff qualities of the catchment called runoff coefficient (0.2-0.8) , and (i) the intensity of rainfall is equal to the design intensity or critical intensity of rainfall i_c corresponding to the time of concentration t_c for the catchment for a given recurrence interval T. The design intensity $i(=i_c)$ can be found from the intensity –duration- frequency curves, for the catchment corresponding to t_c and T . if the intensity –duration- frequency curves , are not available for the catchment and maximum precipitation of (P cm) occurs during a storm of t_R hours , then the design intensity can be obtained from the equation[4].

$$i_c = \frac{P}{t_R}\left[\frac{t_R+1}{t_c+1}\right] \quad , when\ the\ time\ of\ concentration\ , t_c\ is\ not\ known\ , i_c = \frac{P}{t_R} \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots \ (2)$$

Study area :

Area of study is located between the east Ali- al Garbi in the north of Maysan governorate and the west Illam governorate in the west of Iran, the coordinates of study area are bounded by four points, the coordinates are shown in table [1]. The satellite image for the

study area was taken from Google earth program and it georeferncing by GIS; it's illustrated in Fig [1].

Table (1): The coordinate of study area

No.	E	N
1	640417.97	3604736.05
2	680878.16	3583013.77
3	736978.53	3665395.90
4	674678.21	3695555.36

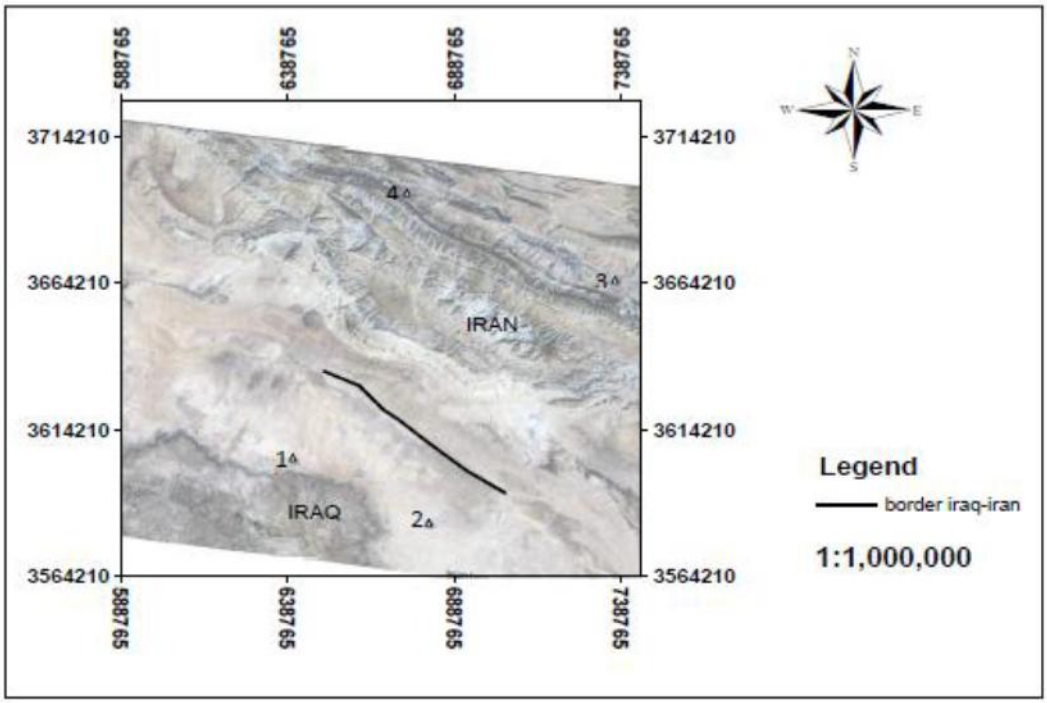

Figure (1): Study area image.

The procedures to generate of watershed :

The digital of data shape of the earth's surface was cell-based DEM. this data was used as input to GIS [5]. It was added the DEM as a defined layer in GIS, its shown in Fig.(2).

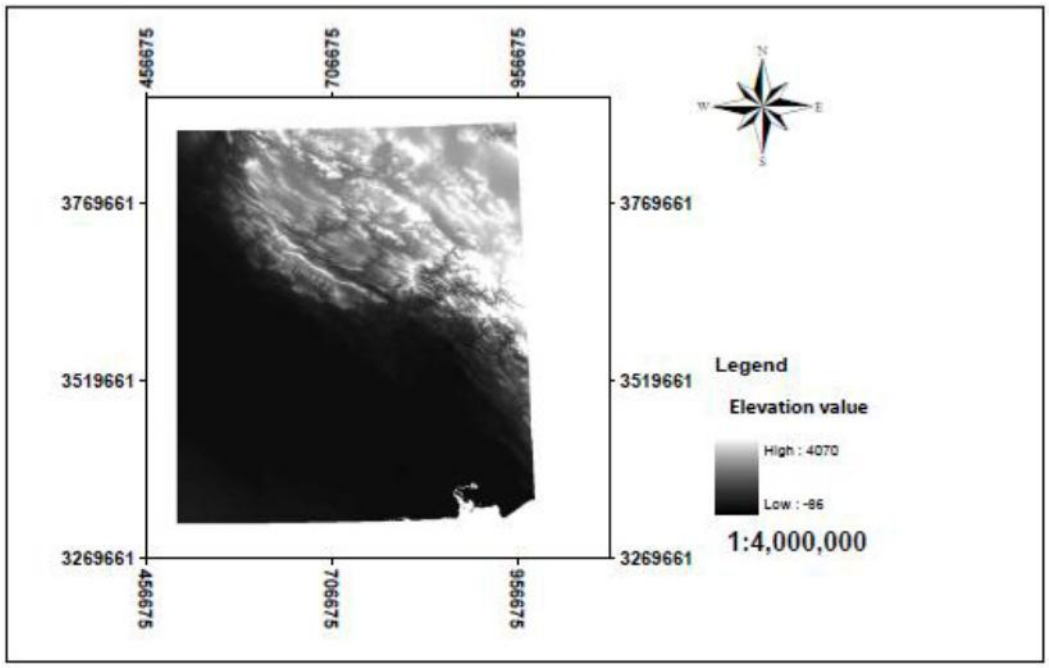

Figure (2): DEM -90m gird ,which included study area.

After that it was extracted the DEM to get DEM just for the study area by using "extraction by polygon" tool. The resulted raster shown in Fig. (3).

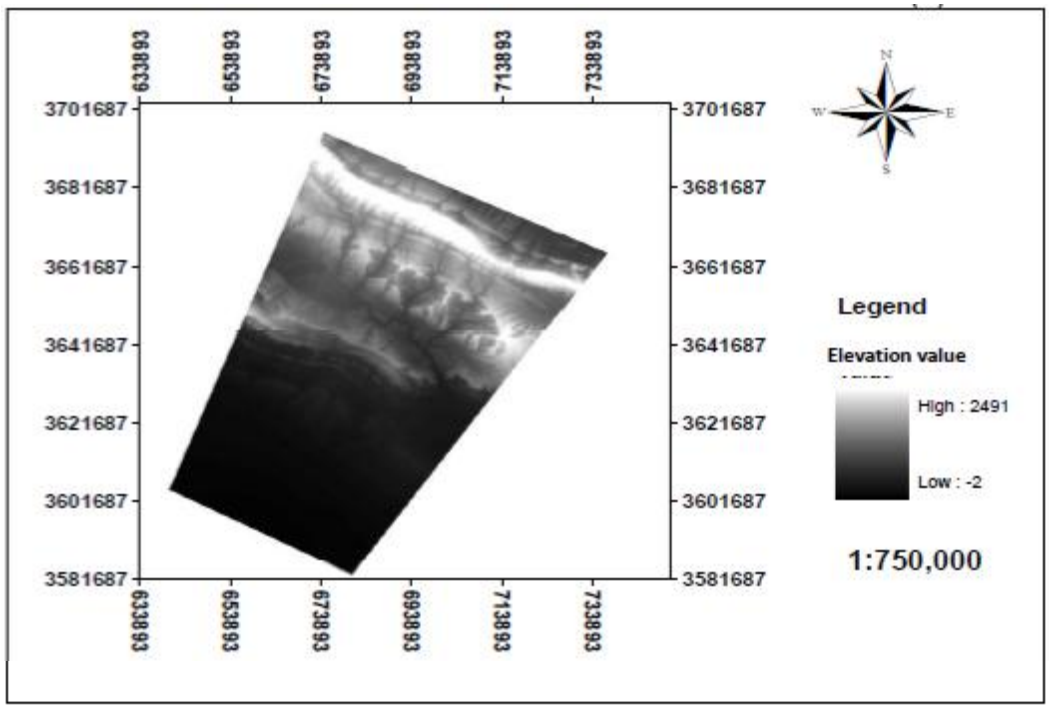

Figure (3): DEM for study area.

Every DEM contains errors; these errors were usually classified as either sinks or peaks. Peaks were less detrimental to calculate of flow direction, but sinks should be removed before attempting to derive any surface information [6].so , the next step was filled sinks in DEM using the order fill from hydrology tools that was arrived from spatial analyst tools icon in GIS,the result is shown in Fig.(4).

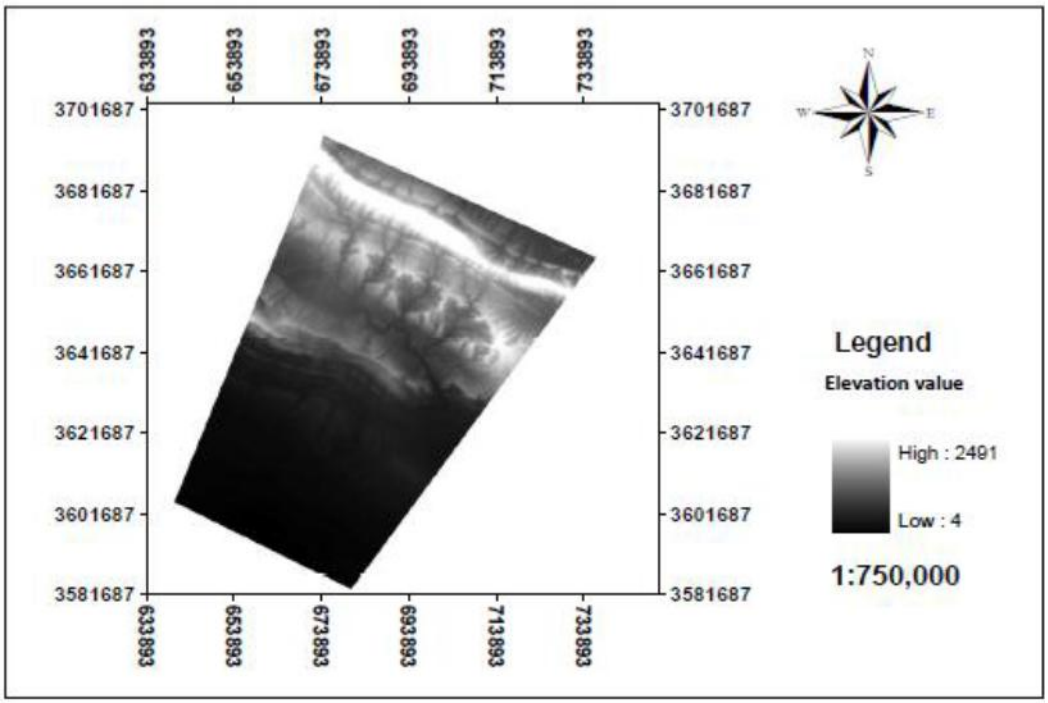

Figure (4): Raster for study area after filling the sinks.

One of the keys to derive hydrologic characteristics about surface was the ability to determine the direction of flow from every cell in the grid. It was based on direction cod [7]. The numbers (1, 2, 4, 8, 16, 32, 64,128) in legend of Fig.(5) its represents the direction flow coded. The direction flow coded is shown in Fig.(6).

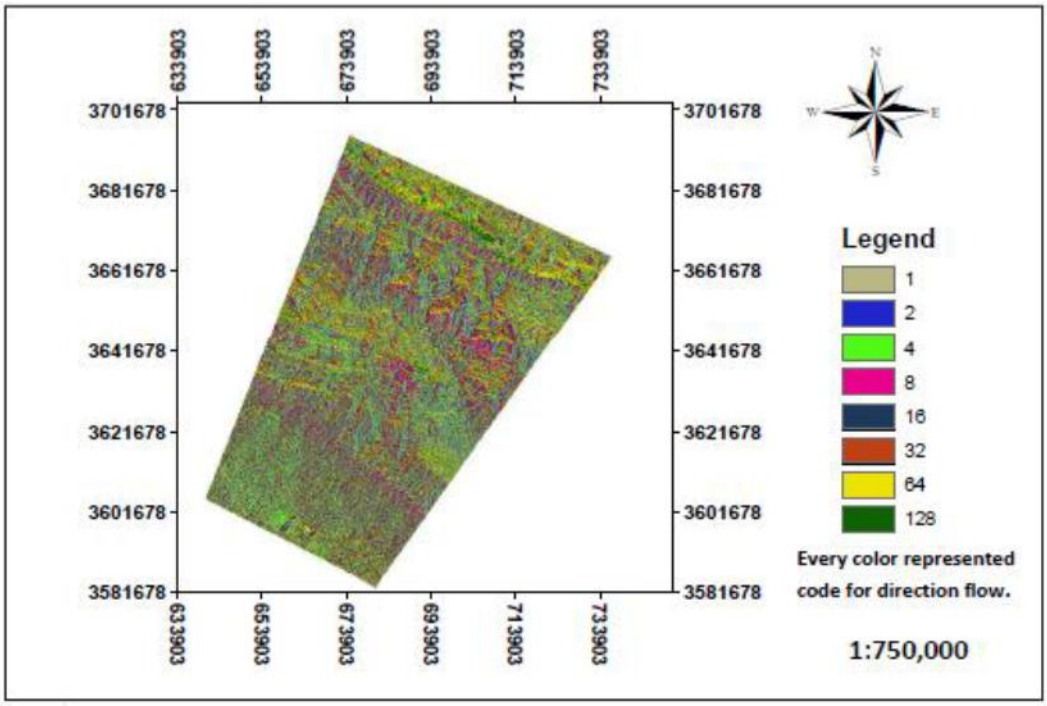

Figure (5): Raster grid indicating the direction of flow for each cell based on the elevation of neighboring cells.

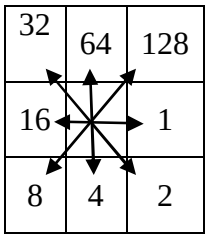

Figure (6): Coding for direction raster.

The Fig.(5) was derived by using the order flow direction from hydrology list under spatial analyst tools list in GIS.

To define stream network, it was done by flow accumulation order under hydrology list from spatial analyst tools in GIS. The flow accumulation window calculates accumulated flow as the accumulated weight of all cells flowing into each down slope cell in the output raster, the value of cells in the output raster will be the number of cells that flow into each cell. The legend in Fig.(7) it was explained that , and the stream network was derived.

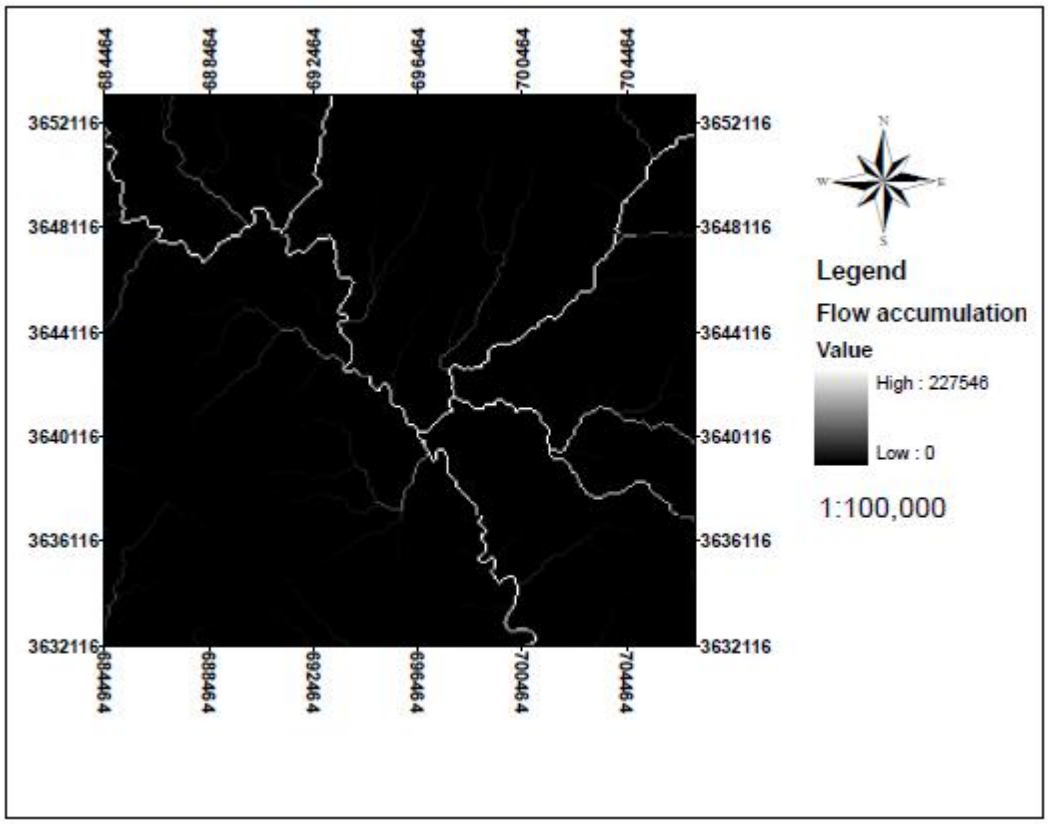

Figure (7): Raster grid indicating where water is likely to accumulate into a drainage network.

From Fig. (7) was extracted the stream network by using icon window under conditional list from spatial analyst tools icon , it result raster layer resymbolize the "0" zero values to be "no data " and the stream network was symbolized "1" values its shown in Fig.(8).

The raster in Fig.(8) was converted from raster to vector (as a shape file) by using stream to feature order under hydrology list from spatial analyst tools icon. Its shown in Fig.(9).

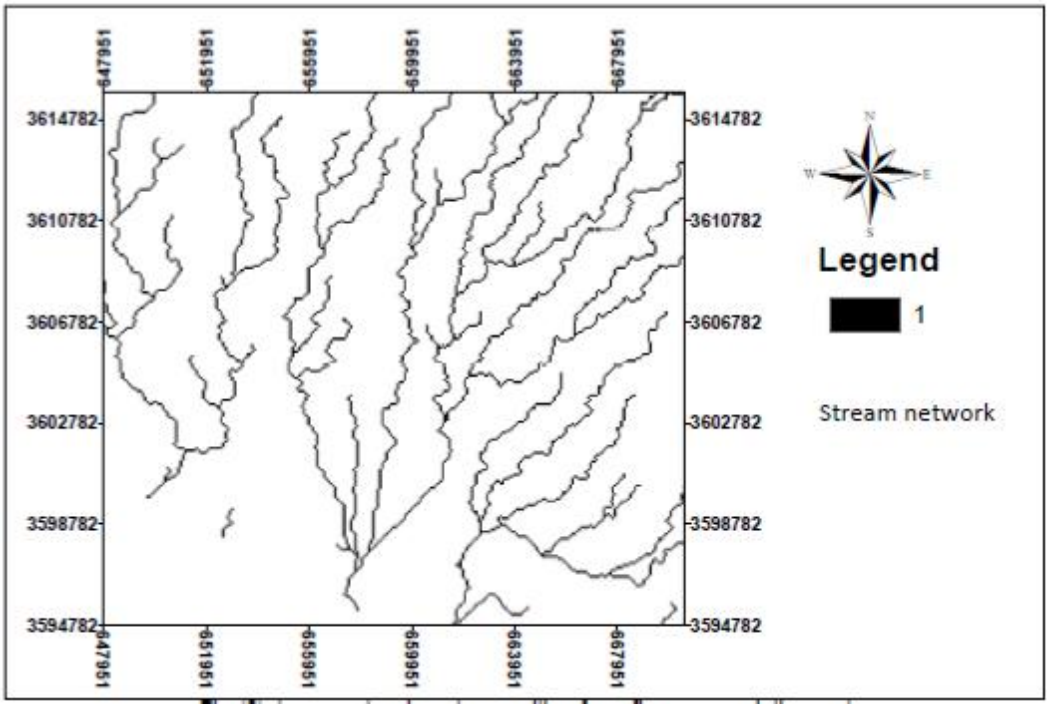

Figure (8): Stream network raster resulting from flow accumulation raster.

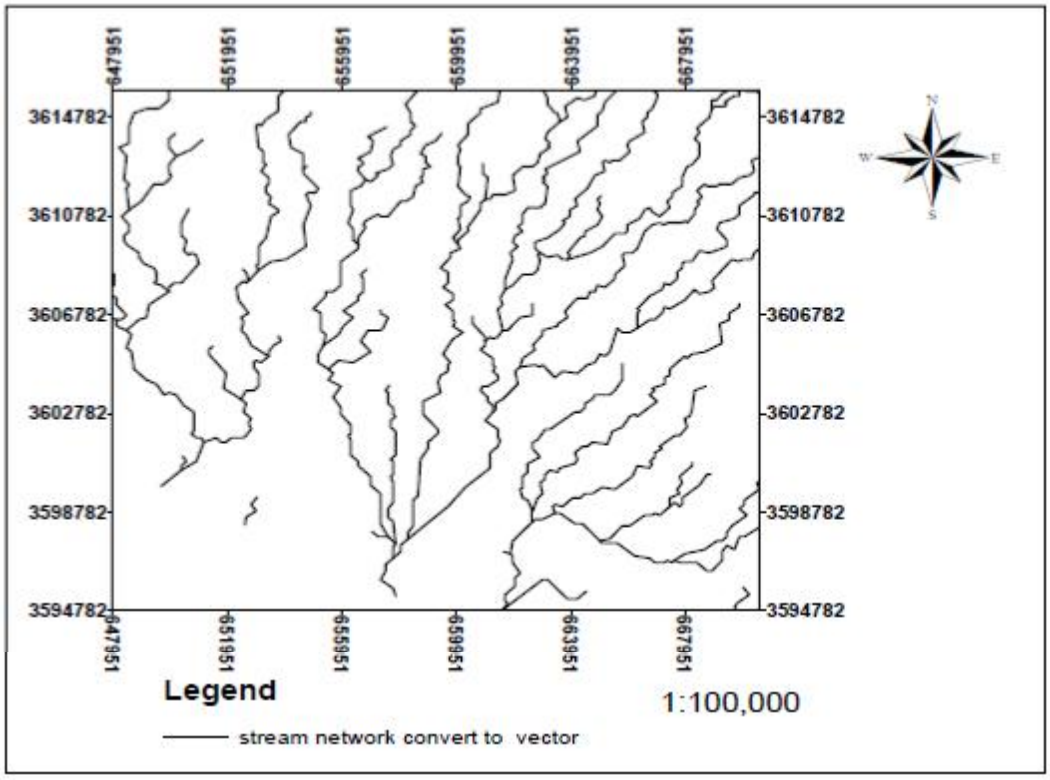

Figure (9): Vectorizing stream network.

All above steps were determined to delineation of watershed for each pour point. In this it was selected pour point that intersection with the road Ali- al garbi, the pour point its represents' a stream network mouth by using visual inspection.

So, by using pour point and flow direction raster in watershed window under hydrology list from spatial analyst tools icon, it was found the watershed as a raster[8], its shown in Fig.(10).

In Fig.(10) all of the cells inside the watershed had the value of zero , those outside the watershed had the value "no data".

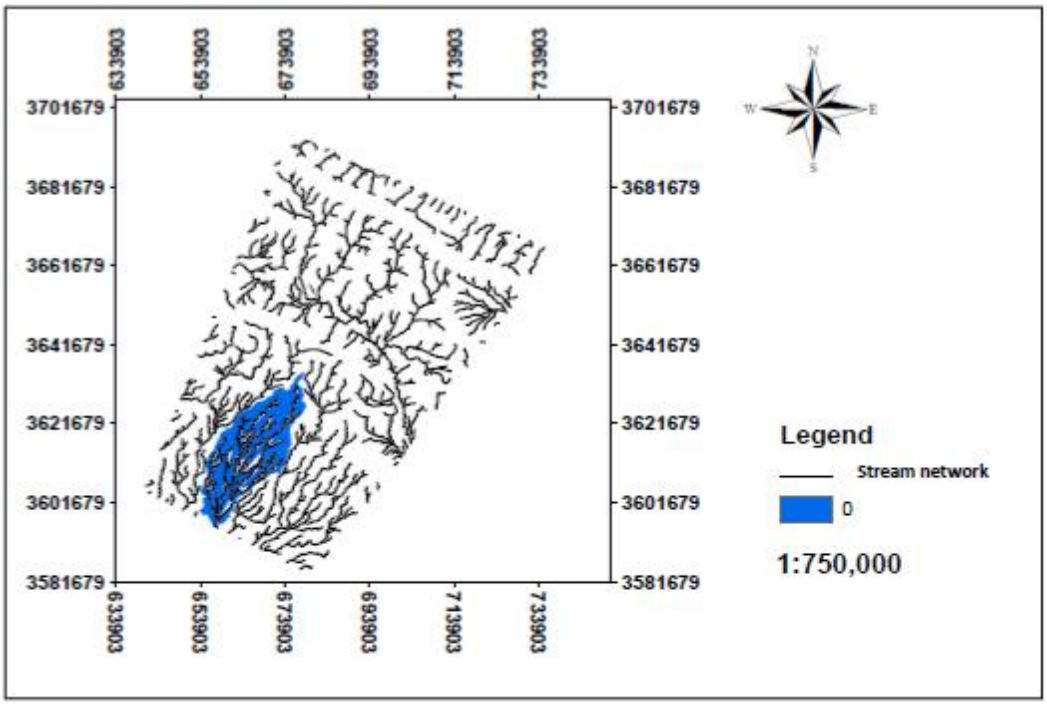

Figure (10): Raster grid of basins draining into the drain end pour point.

In Fig. (11) it was added the shape files such as Ali – al Garbi –Baghdad road file and the Iraq-Iran border shape file.

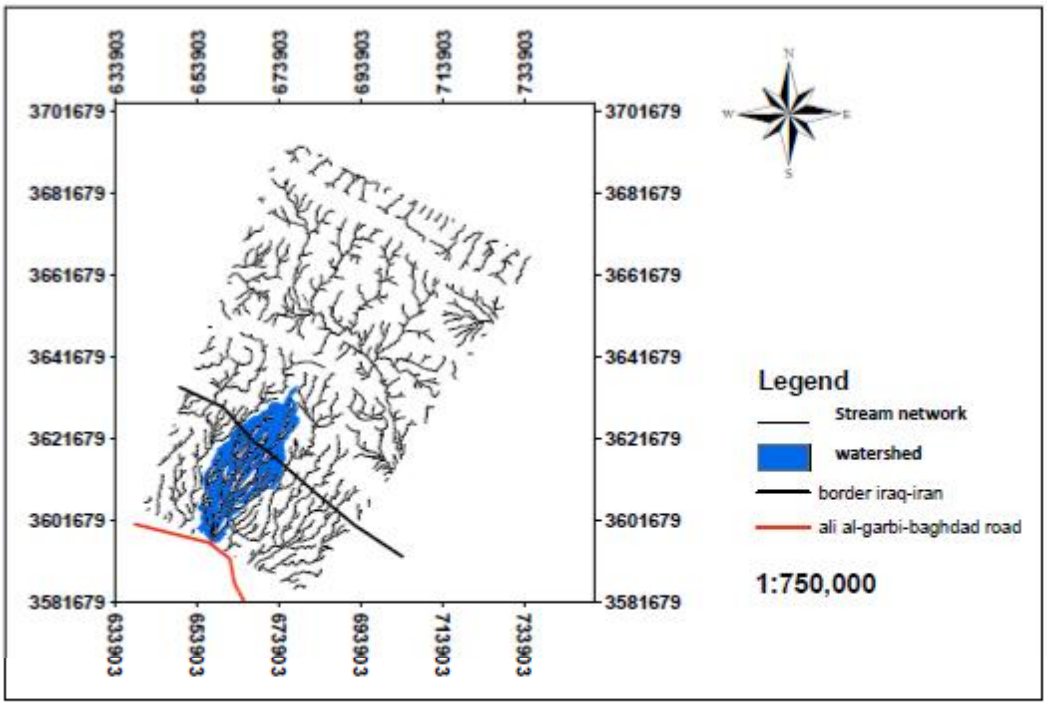

Figure (11): Illustrate watershed raster, the Ali- al Garbi –Baghdad road, and Iraq - Iran border.

To convert watershed from raster to vector in Fig.(11) it was done by using 'raster to polygon "order under "from raster" menu from conversion tools in GIS. shown in Fig.(12),the raster was convert to polygon so can be easily founded the area of watershed.

Finally, it was added the image for the study area and georeferncing it, to identify the location of border between Iraq - Iran, its shown in Fig.(12).

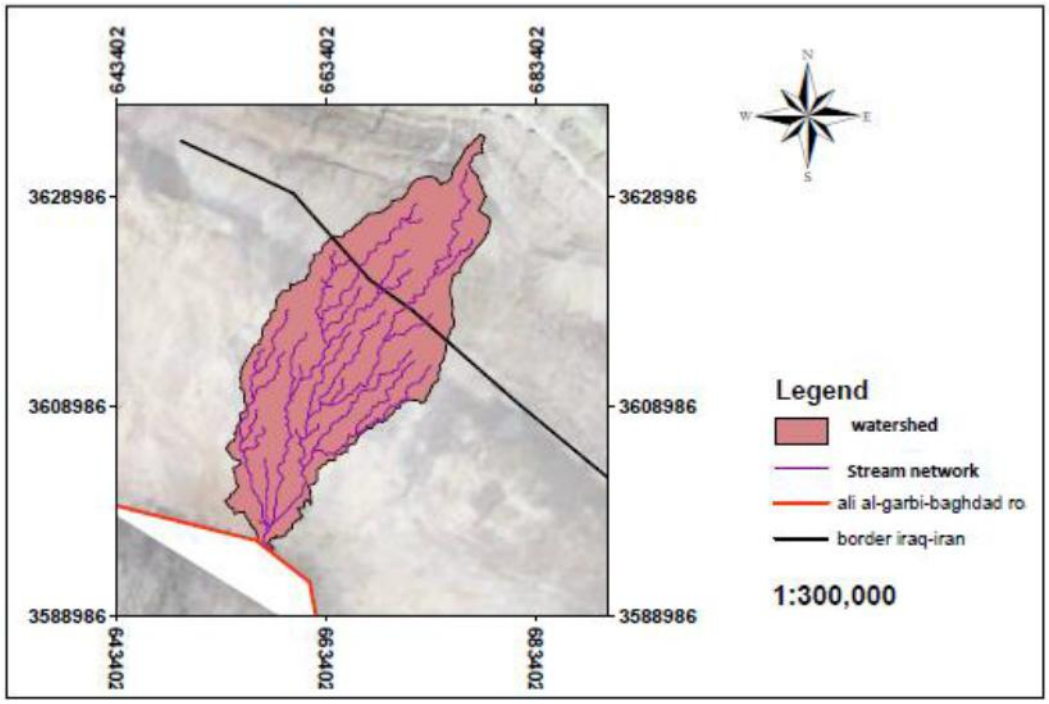

Figure (12): converting the watershed raster to polygon and combined the watershed polygon with image satellite.

Results and discussion :

From Fig.(10) found that the coordinate of pour point was (657830.15 E, 3595395.16 N), that's point represents' the intersection the outlet point with the Ali-al Garbi –Baghdad road ,so culvert should be constructed in this location to protect the road.
From Fig.(12) which showed that the part of watershed was located in Iran(Illam governorate),but the major of watershed it was located in Iraq (Maysan governorate) .
Also the area of watershed was found that equal to 44211.431 hector and the perimeter of watershed 119950.94m as illustrated in Fig. (12).
The runoff coefficient (c) in eq.(1) was equal (0.2) according to the type of soil and to get max. discharge, also the storm precipitation was 120mm[9] ,and the watershed area was found previously.
could be found from eq.(2)and from equation the discharge flood, discharge value can be found was equal to 122.80 m^3/sec , so the culvert should be design on this peak flood.

Conclusions :

1- Construction culvert in coordinate (657830.15 E, 3595395.16 N) to protected Ali- al Garbi --Baghdad road this coordinate point (pour point) its represents a stream network mouth and selected by using visual inspection according to stream network that was estimated from spatial analyst tools in (G.I.S.).

2- Design the culvert on 122.80 m^3/sec flood design discharge (Max. discharge).
3- From Figs. (10-13) it was seen the network stream, our findings suggest detention the water as a storage water in every node in network stream.

Recommendations :

1- Widely study for this area should be done to estimation the other pour points that intersection with the road.
2- Our suggestion to chief Maysan governorate is establishment institute for hydrological studies and collection data in Maysan governorate to provide the perfect projects to storage the storm water and the benefits from rainfall.

References :

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