Simulation Rainfall-runoff of Al-Teeb and Dwerege Rivers Using HEC-HMS Model

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Abstract

Floods are classified as one of the important matters that must be studied and controlled. A study was prepared for this purpose to calculate the surface runoff coming from Al-Teeb and Dwerege rivers. The hydrological modelling Software HEC_HMS Version 4.10 was used to calculate the maximum surface runoff coming from these rivers and entering the Assanaf Marsh, which in turn flows into the Al-Hawizeh Marsh. ArcGIS Software Version 10.5 was also used to analyse the maps of the study. After completing the simulation, it was found that the area of the Teeb and Dwerege river basins amounted to 7891 km^2, of which 4850.7 km^2 was for Dwerege River basin and 3040.9 km^2 for the Teeb River basin. Actual rainfall data was used from the Meteorology and Seismic Monitoring Authority of the Ministry of Iraqi Transport for the period (2012-2022), and no processing was done for longer periods due to the Authority's policy. Simulations were made using actual rainfall data and it was found that the maximum discharge within Assanaf Marsh is 2969.7 m^3/sec on (3/March 2013) including 735.7 m^3/sec for Al-Teeb basin and 1909 m^3/sec for Dwerege basin, as this year is considered a flood year according to the data of the Iraqi Ministry of Water Resources. NASA rain data was also used for the same period above, and it was found that the maximum discharge into the Assanaf Marsh from Al-Teeb and Dwerege rivers was 4398.9 m^3/sec on (25/February/2020), and through these results it was found that NASA rain data did not give real results comparison with the actual rainfall data. It was concluded that the NASA rainfall data cannot be relied upon due to its significant difference with the actual rainfall data. The simulation results of the HEC-HMS Software were not calibrated with the actual data of the discharges of Al-Teeb and Dwerege rivers due to the lack of sufficient observations of these data, especially at the dams of these rivers.

Keywords: Modelling, HEC-HMS, Al-Teeb, Dwerege, Al-Sansf.

نمذجة الامطار والجريان السطحي لنهري الطيب ودويريج الداخلان لهور السناف باستخدام الموديل الهايدرولوجي HEC-HMS

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الخلاصة :-

تعتبر الفيضانات من الامور المهمة التي يجب دراستها والسيطرة عليها، حيث تم اعداد هذه الدراسة لغرض حساب السيح السطحي القادم الى هور السناف من نهري الطيب ودويريج. تم استخدام برنامج النمذجة الهايدرولوجية HEC_HMS version 4.10 لحساب السيح السطحي الاقصى القادم من هذه الانهر والداخل الى هور السناف الذي بدوره يصب في هور الحويزة. تم الاستعانة ايضا ببرنامج ArcGIS version 10.5 لتحليل الخرائط الخاصة بالدراسة. بعد اتمام المحاكاة تبين ان مساحة حوضي نهري الطيب ودويريج بلغت 7891 كم2 منها 4850.7 كم2 لحوض نهر دويريج و 3040.9 كم2 لحوض نهر الطيب.تم استخدام بيانات حقيقية (مقاسة) للامطار من هيئة الانواء الجوية والرصد الزلزالي التابعة لوزارة النقل وللفترة (2012-2022) ولم يتم التجهيز لفترة اطول حيث تعتبر هذه الفترة هي اقصى فترة تم تجهيزها من قبل الهيئة اعلاه. تمت المحاكاة للبيانات المطرية الحقيقية ووجد ان اقصى تصريف داخل لهور السناف هو 2969.7 م3/ثا في (3/اذار2013) منها 735.7 م^3\ثا لحوض نهر الطيب و 1909 م^3\ثا لحوض نهر دويريج حيث تعتبر هذه السنة هي سنة فيضانية حسب بيانات وزارة الموارد المائية العراقية. تم ايضا استخدام بيانات امطار NASA ولنفس الفترة اعلاه ووجد ان اقصى تصريف داخل الى هور السناف من نهري الطيب ودويريج 4398.9 م3/ثا في (25/شباط/2020)، ومن خلال هذه النتائج تبين ان بيانات امطار NASA لم تعطي نتائج حقيقية (واقعية) مقارنة مع بيانات الامطار الحقيقية حيث تم الاستنتاج انه لا يمكن الاعتماد على بيانات امطار NASA لاختلافها الكبير مع بيانات الامطار الحقيقية. لم يتم معايرة نتائج المحاكاة لبرنامج HEC-HMS مع البيانات الحقيقية لتصاريف نهري الطيب ودويريج بسبب عدم وجود رصودات كافية لهذه البيانات وخاصة عند سد الطيب وسد دويريج.

الكلمات الدالة:- موديل , برنامج HEC-HMS , الطيب ودوريج , سناف

1. Introduction

Water is considered one of the most important natural resources necessary for the continuation of life, and the need for it increases in arid and semi-arid regions. Managing and investing these resources requires to implement the hydrological models to calculate the amount of surface runoff. Al-Teeb River is considered a seasonal river that flows from Iranian territory and enters Iraq at Al-Teeb station and empties opposite the Assanaf Marsh located east of the city of Amarah. Dwerege River is also considered a seasonal river, whose level drops dramatically in the summer in Maysan Province and extends into Iranian territory within Ilam Province, southwest of the Islamic Republic of Iran. The length of Al-Teeb River within Iraqi territory is about 60 km. The climate of Al-Teeb region is characterized by being hot, dry in summer and wet in winter. Dwerege region is also located within the arid and semi-arid climate, where the dry climate prevails in the southern parts, while the semi-arid climate prevails in the northern parts.

(A.M. Atiaa, et., al., 2013) studied the effect of two climate parameters (rain and temperature) on an index to assess the impact of global warming on the oasis of Al-Teeb River basin in southern Iraq. Some climate data of Amara station were relied upon such as rain, temperature, humidity and wind data. The water of Al-Teeb River was analysed and it was found that the pH = 7 and TDS = 3055. The results indicated a linear relationship for the flow response to changes in the above factors (rain and temperature). The results proved that an increase in rainfall by 50% in Al-Teeb River basin results in an increase in the river flow by 10% at the normal temperature, but there is no increase in the decrease by (20-30%). There was 10% decrease in the flow rate at the average temperature. There was no increase in the flow when the temperature increases to 1.5 degrees Celsius, and the results also indicate that a decrease in precipitation by 20% leads to a decrease by (20-30%) in the flow rate at the average temperature, also, only 10% decrease in flow rate when temperatures increased by 1.5 °C.
(Riyadh Z. Al Zubaidy, et., al., 2008) studied the hydrological modelling of ASSANA'F marsh, the relation between water level with the storage and surface area was done. It was concluded that the level of packing surrounding the marsh must not be less than 11 m above sea level, especially the southeastern part of Assanaf marsh near the Al-Mashrah River, to increase the marsh discharge towards the Al-Hawizeh marsh, also found that Ghzayla bridge width must be increased 30m in order to develop its discharge capacity.

(Sawsan A.R. Ibrahim, 2018) studied some morphometric parameters affecting the hydrological situation of the Teeb River basin in southeastern Iraq, where mathematical equations, geographic information techniques and the Digital Elevation Model were used to calculate the above parameters. Rain, wind, temperature and evaporation data were used for Ali Al-Gharbi station as it is an influential station on the study area, where it was found that the total monthly average of rain from 1983 to 2012 was 126.27 mm, the average temperature was 25.19 degrees Celsius, and the average wind speed was 3.95 m/s. The results showed that the basin is characterized by a steep slope, and the area of Al-Teeb River have an average width of 17.83 m / km, and the value of the erosion ratio of 17.3 m / km, which reflects the effectiveness of water erosion.

(Salwan S. Al-Hasnawi, 2016) studied the morphometric analysis of Al-Teeb river basin based on the space data of the Landsat satellite. The ArcGIS Software was used based on the digital elevation model (DEM of 30m accuracy) to draw the drainage network and link these results to the visual interpretation of the satellite. The results showed that Al-Teeb River basin is fed from rain water more than the surface water. The results also showed that there is a high permeability, while there is a lack of vegetation cover, as a result of the permeability, which led to an increase in the infiltration of rainwater under the surface. The results showed that the basin of Al-Teeb River has a more triangular shape than it is circular, and that the surface of this basin has a large slope.

(Isaac salih alakam & Nawal Kamel alwan, 2017) using the sensor technology and Geographic Information Systems (GIS) Software, where two mathematical models were applied to Dwerege River basin and according to the SCS-CN equation that depends on the curve number using the morphological characteristics of the basins of the study area and the GIUH model which depend on the storage coefficient R and the concentration time Tc, which in turn depends on the simple regression technique, and the surface runoff for this method is more sensitive to the fact that the values of R and Tc represent the main factor for the emergence of runoff, unlike the SCS-CN equation, which is sensitive to soil type and ground cover. In the study, the main basin of Dwerege River was divided into three basins. As for the actual rainfall data, it was relied on the Ilam rain station for the period 2001-2010, where it was found that the highest daily rainfall recorded during this period was for the year 2007 by 172 mm. It was concluded from this study that the discharge of Dwerege by SCS-CN method was 1052 m3/sec, while the discharge by GIUH method was 1370.2 m3/sec.

(Ali Majeed Yassin, 2017) used geographic information systems and the Wadi analysis input method (it is an application within the ArcGIS Software applications to detect the morphometric characteristics of Dwerege River Basin represented by the longitudinal and spatial characteristics and the characteristics of the water drainage network and topography in order to build geographical information for Dwerege River Basin inside Iraq). The study showed that the height of the centre of the basin is 25-50 meters above sea level, while the western and eastern sides of the basin range between 75 and 125 meters above sea level. It was also found in the study that the average width of the basin was 29.4 km, and the circumference of the basin was 251.5 km. The elongation averaged 0.33, and the roughness value was 0.27. This is due to the type of rock and the degree of its resistance, in addition to the fact that the basin is ranked sixth in terms of the number of valleys, as the fourth, fifth and sixth ranks include the number of valleys (63, 28, 4) respectively.

1.1 Objective of the study

1) Calculation of the Peak discharge coming from Al-Teeb and Dwerege rivers to the Assanaf Marsh.
2) Calculating the maximum discharge of basins and rivers within the study area.
3) Use rainfall data from free websites such as NASA and compare it with actual rainfall data for the purpose of being able to adopt it in the future.

1.2 limitations of study

1) The absence of rain data for the stations of the Iranian side, and if there is any in the future, it must be rain data with continuous and uninterrupted time series for a long period for the purpose of extracting the best result through simulation of the HEC-HMS Software, in addition to that the number of stations must be multiple stations to cover the basins in Iranian side.
2) The lack of sufficient funds for the discharges of the Teeb and Dwerege rivers within Iranian territory.
3) The lack of sufficient funds for the discharges of Al-Teeb and Dwerege rivers inside Iraqi territory, including the dams of these rivers.
4) It is not possible to calibrate between real and simulated charges by software HEC-HMS due to lack of data.

2. Methodology

The hydrological study of Al-Teeb and Dwerege rivers is considered one of the important studies, as it is one of the most important rivers that enter the water balance of Iraq for the southeastern regions of Iraq in addition to its importance in feeding the Marshes and flats. HEC-HMS model is used for these rivers to estimation the runoff at Assanaf Marsh. Software interface, taskbar, Subbasins bar and display progress messages as shown in Figure (1).

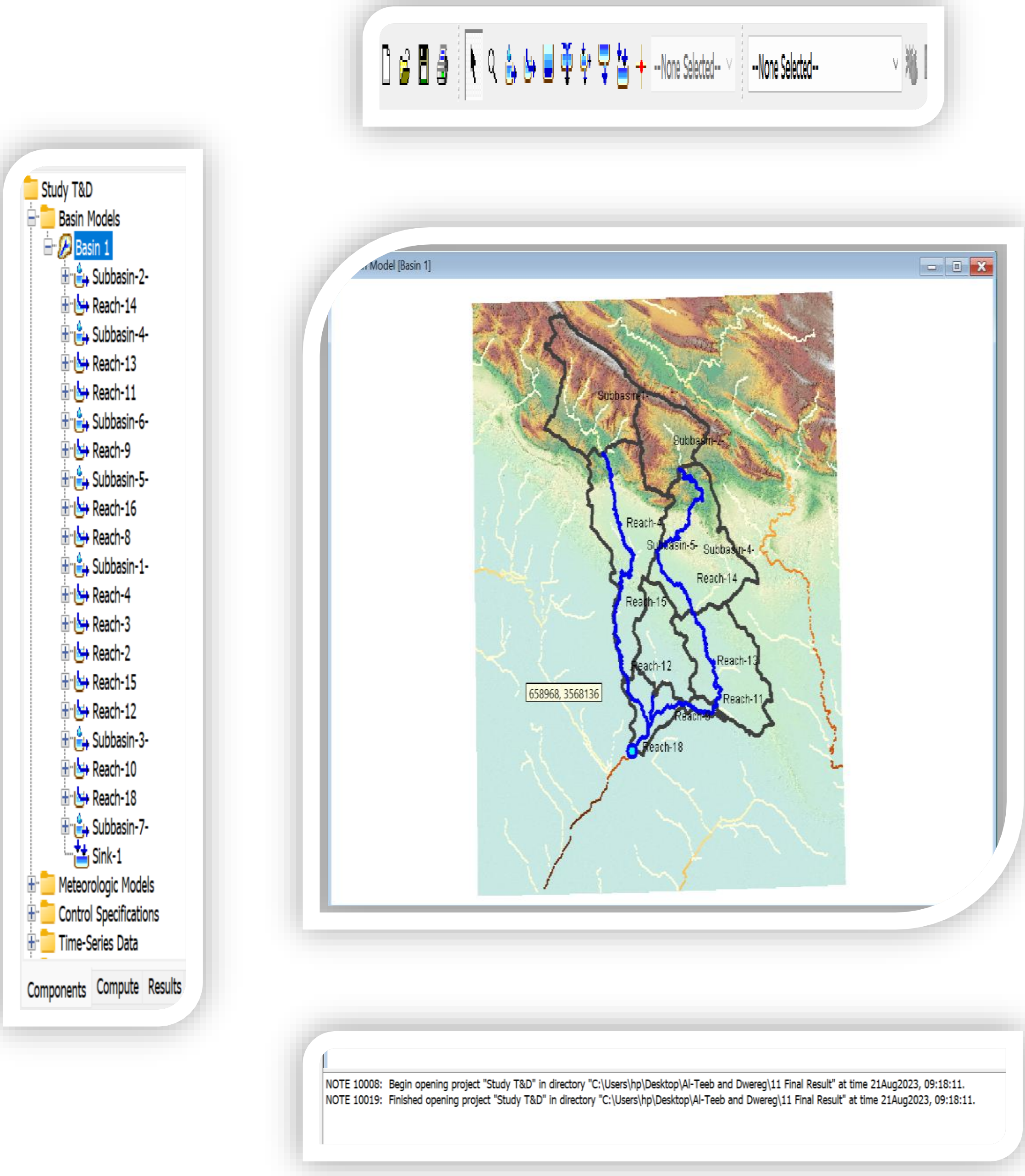


Figure (1): HEC-HMS interface.

2.1 Study Area

Al-Teeb River is one of the most important rivers that flows from the Iranian Zagros Heights from the areas located to the east of the districts of Badra and Jassan. Al-Teeb River enters the north of Al-Teeb police station, then flows in Iraqi lands through the Al-Jazeera region, east of Al-Amarah city and heads south until it ends in the vicinity of the Assanaf Marsh which empties into the Al-Hawizeh Marsh. It is 101 km long and feeds from its basin of five thousand square kilometres. The source of the water of this river is the rains that is why it becomes dry in the summer season. As for Dwerege River, its sources are also located in Iranian territory and enters the Iraqi-Iraqi borders at the Fakkah outpost. More than 85% of the water of this river is used by the Iranians during the spring, summer and autumn to irrigate their crops and the river continues to flow until it ends in Assanaf Marsh at a point about 17 km from the mouth of Al-Teeb River, as shown in Figures (2), and Dwerege dam as shown in Figure (3).

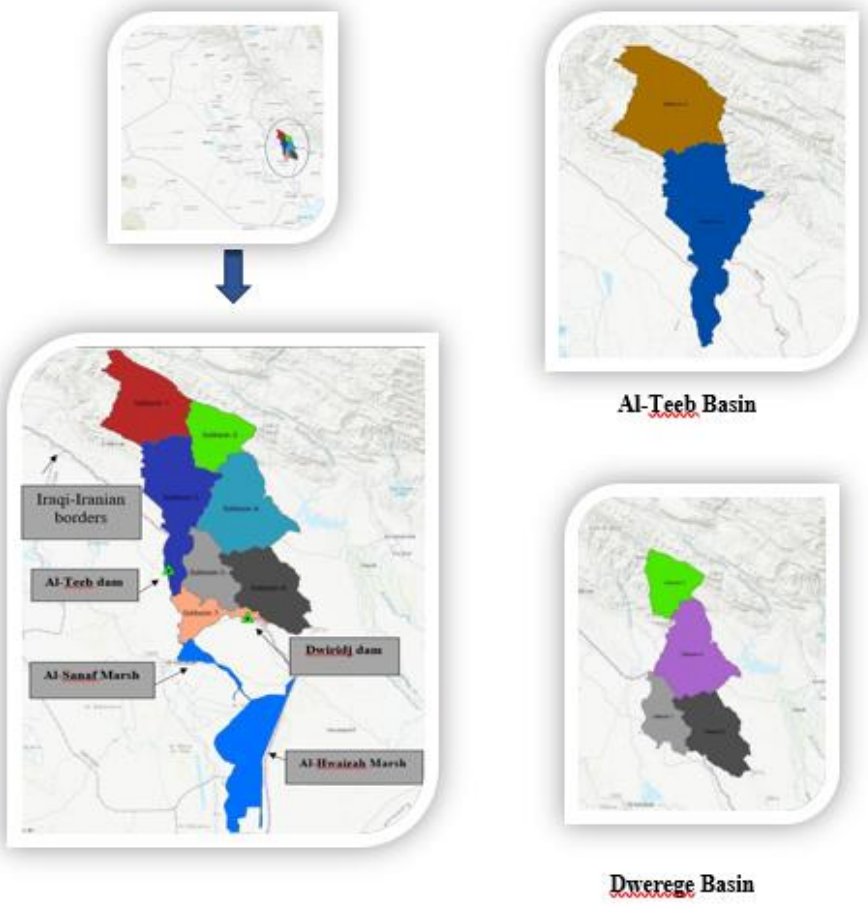


Figure (3): Dwerege dam

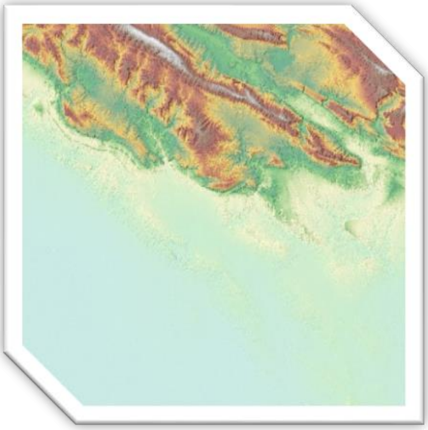
Figure (3): Dwerege dam.

2.2 Formation of subbasins

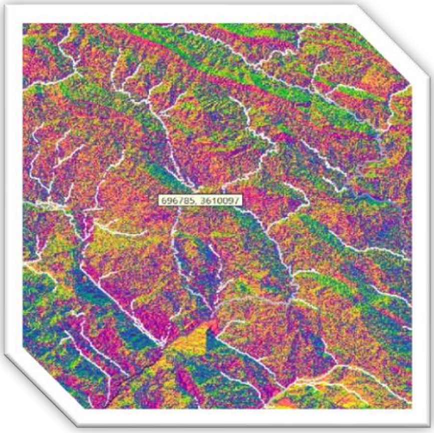
For the purpose of implementing the HEC-HMS Software and calculating the amount of water coming to Marsh Assanaf from Al-Teeb and Dwerege rivers, it requires collecting topographic information, rainfall, vegetation cover, and soil type, the Outlet was also prepared, which in this study is the entry point of Al-Teeb and Dwerege rivers to Marsh Assanaf, where the designation was made by means of the (Break point tool), and then the basins were formed by means of (Delineation element). ArcGIS Software was also used in order to display maps and complete some of the requirements of HEC_HMS.

2.2.1 GIS Steps

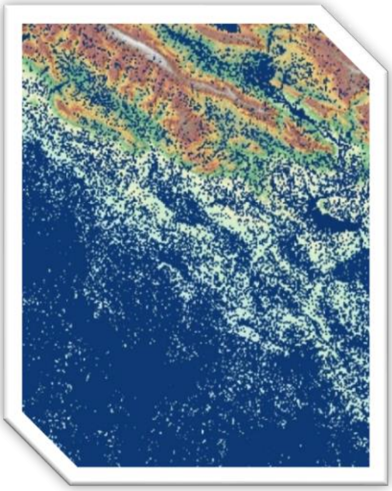
Terrain data, sinks, flow direction, drainages, streams, delineation elements and creating subbasins are prepared from GIS steps, as shown in Figure (4).



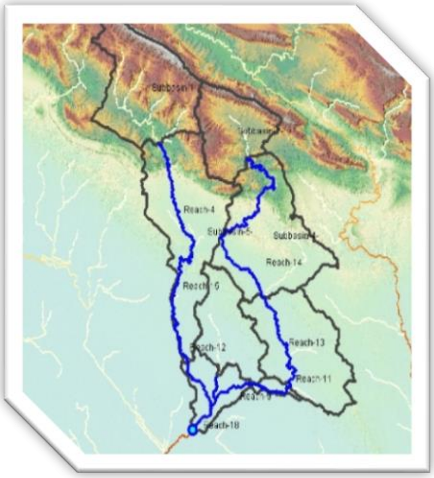
1) Terrain data



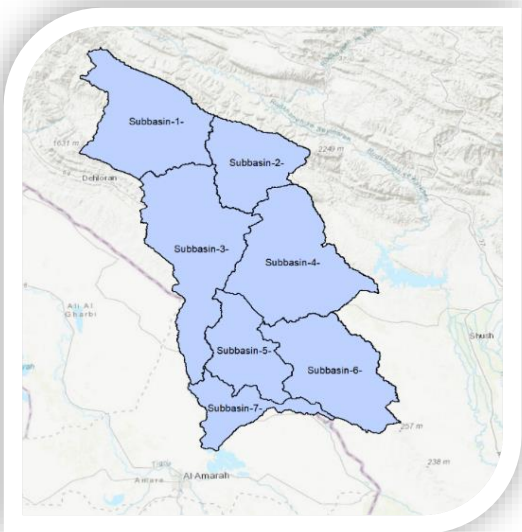
2) Prepare sinks



3) Prepare flow directions, Drainages, and Streams



4) Delineate elements



5) Creating subbasins

Figure (4): GIS Steps.

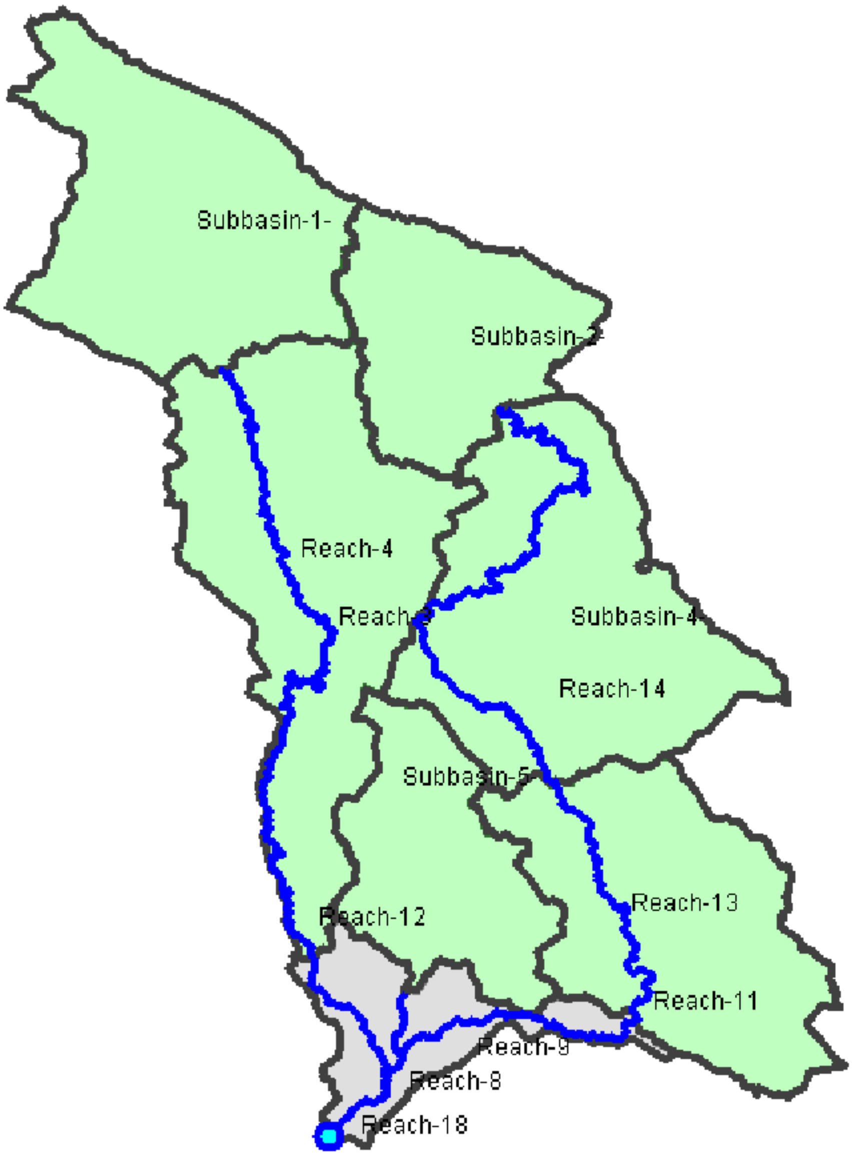


Figure (5): Subbasin (7) of Catchment area.

After the formation of the basins, it was note from Figure (5) that the seventh basin (which has been misled) shares the Al-Teeb and Dwereg rivers and empties into the Assanaf marsh according to the delineation. That is, the discharge coming from the Assanaf marsh is the sum of the discharges of the Teeb and Dwerege rivers and the seventh basin.

2.2.2 Prepare Digital Elevation Model (DEM)

The United States Geological Survey (USGS), with an accuracy of 30 m, relied on obtaining digital elevation data (DEM) that represents the topography of the study area. This data was used to determine the drawing of the borders and the indication of elevations and depressions within the study area, according to Figure (6).

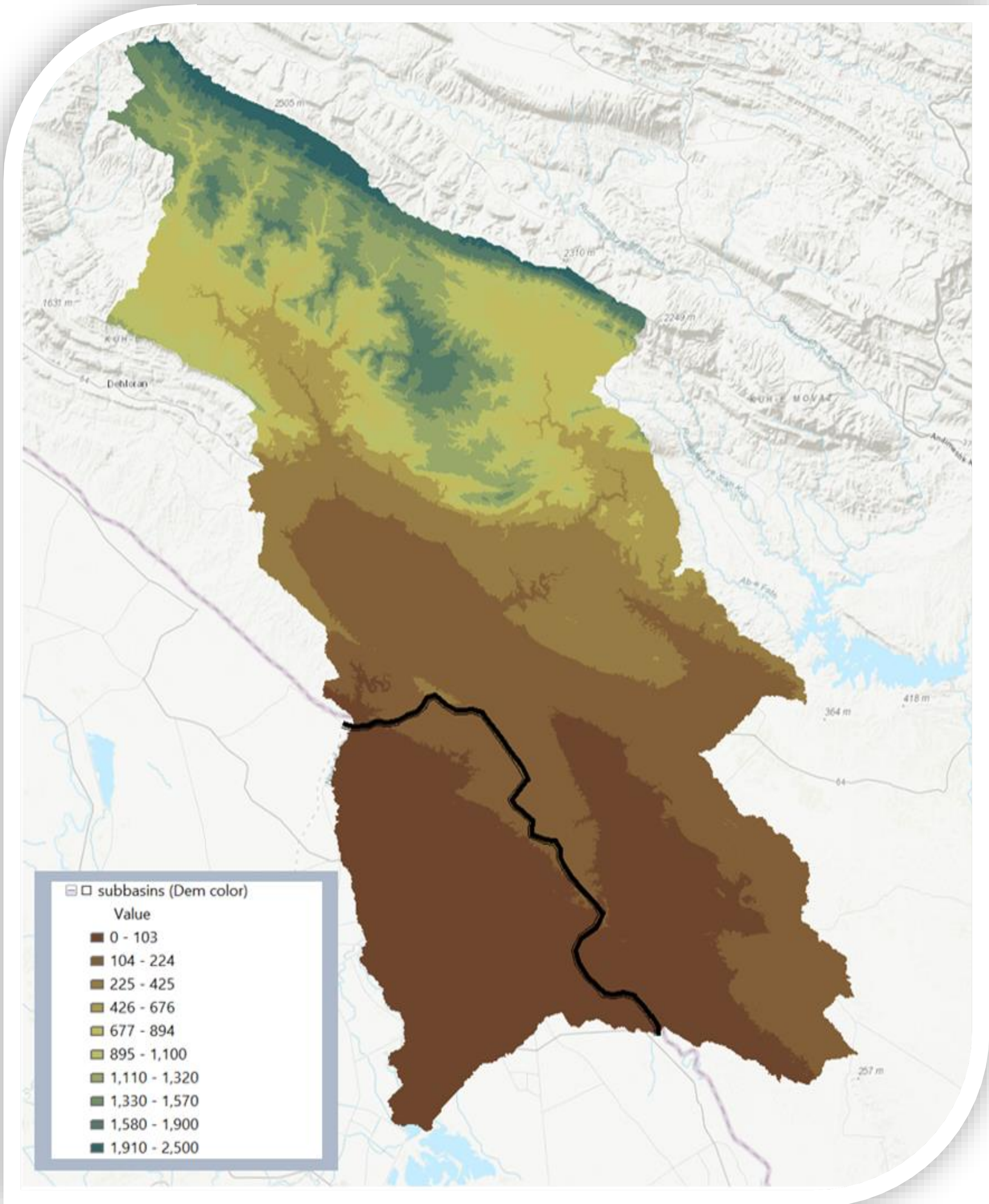


Figure (6): Digital elevation model of the study area.

2.2.3 Prepare land Cover

The global map of vegetation cover was used in the simulation as it was obtained from the European Space Agency with an accuracy of 300 meters and for the time period from the tenth month of 2004 to the sixth month of 2006, where it was used within the ArcMap Software to find a map of vegetation within the study area, as shown in the **figure (7)** Which shows the vegetation cover of the Iranian and Iraqi sides, where it is noted that the whole of catchment area inside the Iraqi territory is barren, uncultivated lands, while the Iranian side contains forests and agricultural lands along the study area.

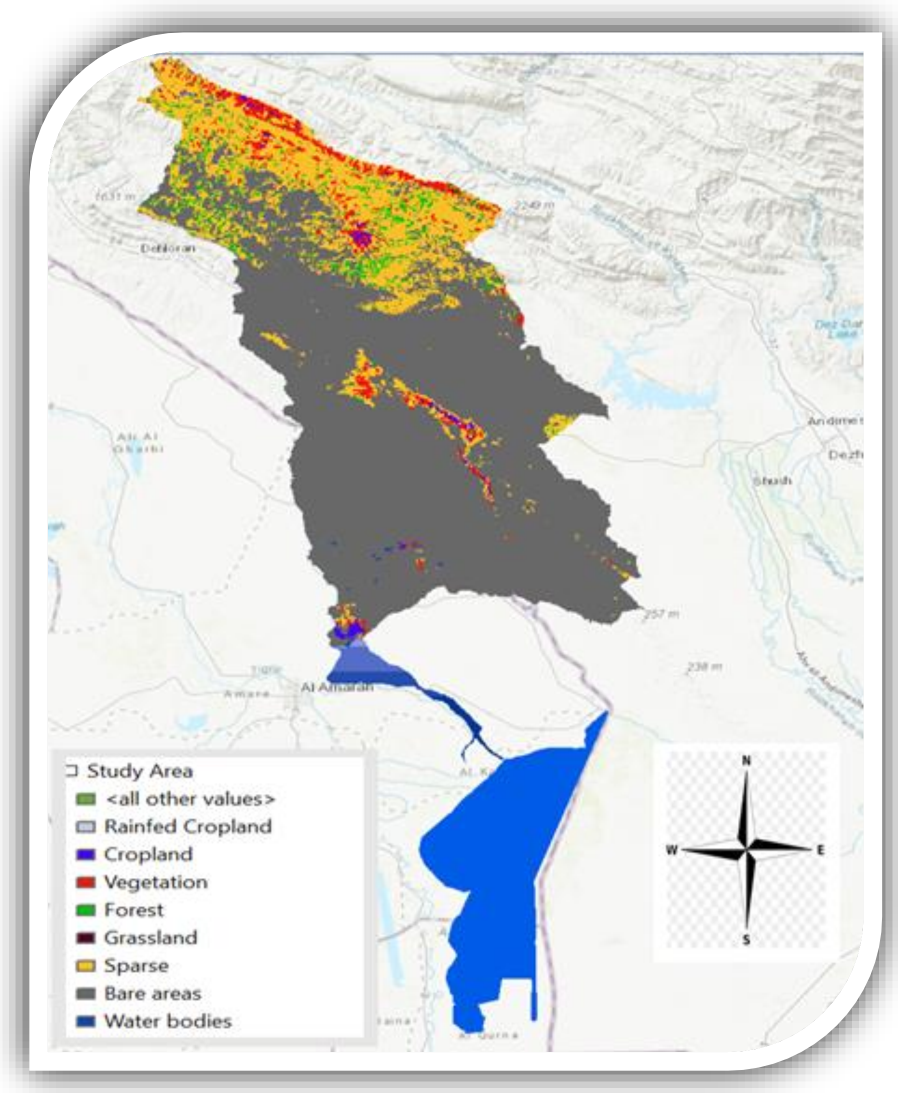


Figure (7): Land cover for the study area.

2.2.4 Prepare soil type

Depending on the World Food and Agriculture Organization (FAO), global soil data were obtained and used within the ArcMap Software to find a soil map within the study area only in order to analyse it and determine its type, as shown in Figure (8), which shows the types of soils within the study area, where it was found that the basins are within the study area is between alluvial, sandy and loamy alluvial.

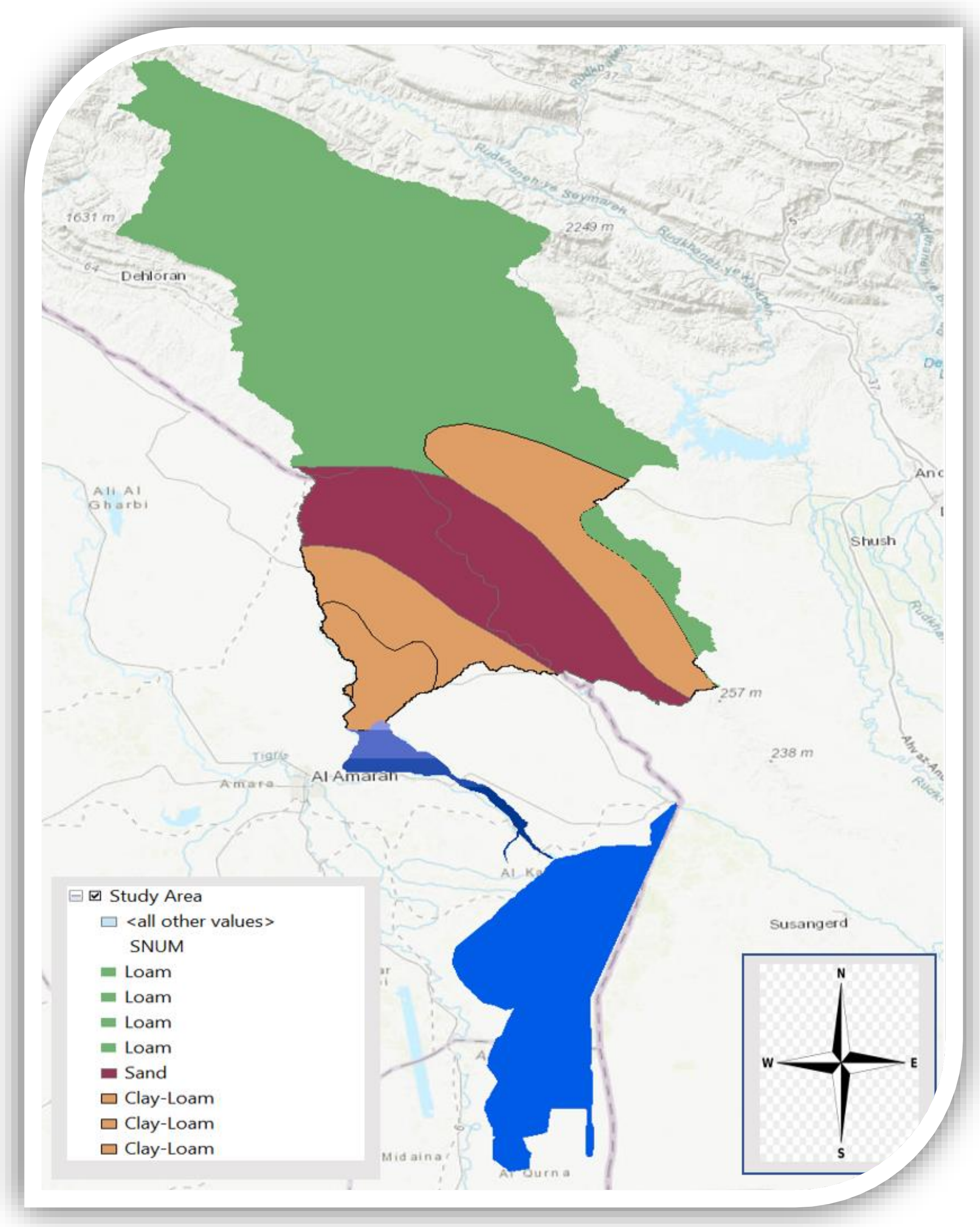


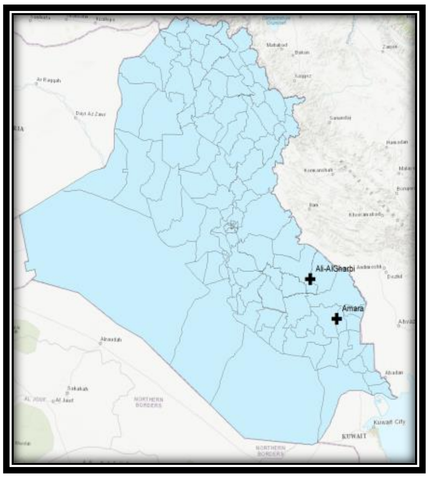
Figure (8): Soil type of the study area.

2.2.5 Prepare rainfall data

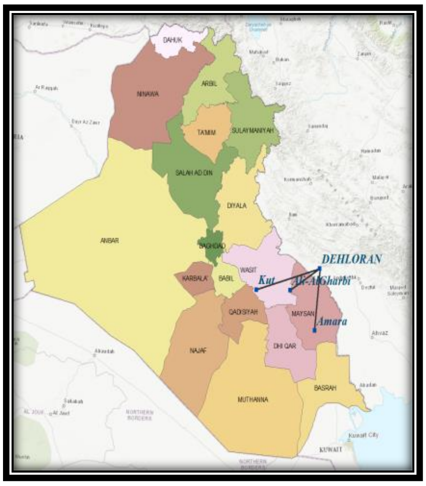
Actual rainfall data was used for the purpose of running the hydrological model, daily rain data was used from the Iraqi Meteorology and Seismic Monitoring Authority for stations that have an impact on the study area inside Iraq, including stations (Al-Amarah, Ali Al-Gharbi) and for the period (2012-2022), as shown in Figure (9A), the data was not processed by the Authority for a period longer due to the Authority's policy. The Thiessen polygon method was used for the purpose of showing the effect of this stations used in the simulation (Al-Amarah, Ali Al-Gharbi) on the basin of the study area, according to Figure (9E).

The Inverse Distance Method (IDM) was used due to the lack of actual rainfall data for the Iranian side, this method was also used in the strategic study to find rainfall station in the centre of Al-Teeb River basin was found based on the rainfall stations Mehran, Ali Gharbi and Dehloran, and another station in the centre of Dwerege basin based on the stations of Dehloran, Dezfel and Amarah. This method was used to extract rainfall data for Dehloran station on the Iranian side, based on the stations of Ali Al-Gharbi, Al-Amarah, Al-Kut, as shown in Figure (9B), and it is not possible to find other stations in Iranian foreigners using this method because there are not enough other real stations to be relied upon.

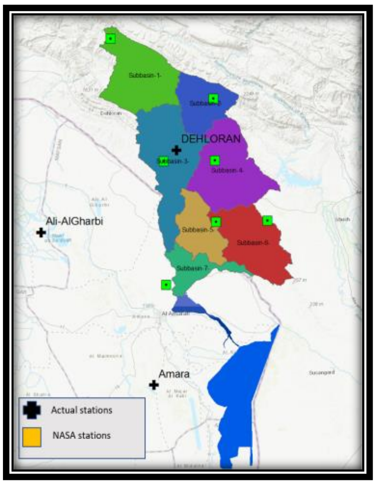
The National Centres for Environmental Prediction (NCEP) or what is called (SWAT) has been approved, which prepares rainfall data on a daily basis from 1979 to 2014 for the stations that belong to the study area, but there is a lack of data processing for several months and the range of processed data ends with the year 2014 only, and there are no years higher than this, so another site was relied upon, which is the NASA Prediction of Worldwide Energy Resources, which provides data for rain and the required period without shortage, in this study the data for the period 2012-2022 was prepared for the purpose of comparison with the results of the actual rainfall data and also for the purpose of approving the data of this site for periods longer than (2012-2022) in case the results are close to the real results, as Figure (9C) shows the locations of the rainfall stations chosen according to the NASA site.



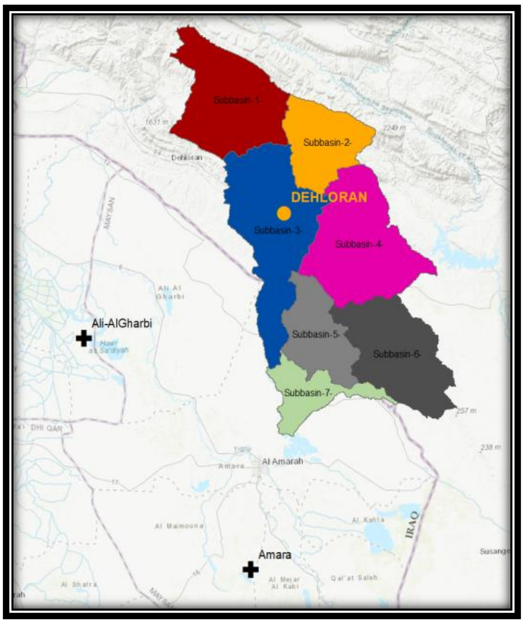
A) Iraqi Rainfall Stations.



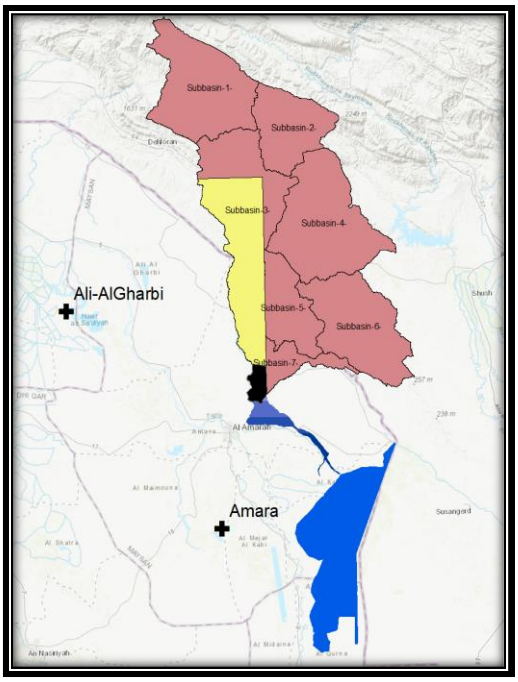
B) Iranian Rainfall Stations.



C) NASA Rainfall data.



D) Rainfall stations of study area.



E) Thiessen polygon method

Figure (9): Actual rainfall data.

3. Theory and Calculations

3.1 Subbasins results

After forming the basin of the study area, the area of each basin, the longest flow path and the inclination of each basin were extracted to explain the operation of the subbasins mechanism with the value and date to understand the downstream process of the entire catchment, according to Table (1).

Table (1): Subbasins Characteristics.

Subbasins	Area (km2)	Longest flow path (km)	Subbasin inclination
Subbasin 1	1380.766	96.34648	0.34759
Subbasin 2	800.1501	46.51860	0.31760
Subbasin 3	1660.195	148.33332	0.13642
Subbasin 4	1548.399	124.60651	0.14391
Subbasin 5	748.1611	61.87753	0.04161
Subbasin 6	1242.464	70.54041	0.04129
Subbasin 7	511.6141	69.84991	0.01503

The area of the Teeb River basin within the Iraqi and Iranian territories, according to the results of the HEC-HMS Software, is about 3040.9 km2, while the area of Dwerege basin within the Iraqi and Iranian territories is about 4850.7 km2, while the area of these basins within the strategic study is 3020 km2 and 4707 km2 for the Teeb and Dwerege rivers, respectively.

3.2 Runoff results

The SCS Unit Hydrograph method was adopted to calculate the transformation method, that is, the conversion of rainfall into surface runoff by calculating the value of the time of concentration, and it depends on the ground inclination of the basins, their areas, and the type of vegetation cover. These data were calculated and estimated using the equation of (NRCS 1997) below**.**

$$Tc = \frac{l^{0.8}(S+1)^{0.7}}{1140\, y^{0.5}}$$

Tc: Time of concentration (hours)	L: Flow path (ft)
Y: Average water shed land slope %	S: Maximum potential retention (in).
S = (1000/CN)-10	Lag time = 0.6 Tc

Where the characteristics of the basins were converted to the units included in the equation, and the delay time equation was applied, as the results were as shown in Table (2). It was noticed that the time to reach the maximum discharge is noted at the same time for each scenario, while the concentration time and the delay time differ from one basin to another due to the taking into account the longest path for each basin.

Table (2): Concentration time and delay for each basin.

Subbasin	Latitude	Longitude	Time of concentration (hr)	Delay time (hr)
Subbasin 1	33.066	47.064	11.16	6.70
Subbasin 2	32.911	47.433	3.84	2.31
Subbasin 3	32.59	47.225	12.14	7.28
Subbasin 4	32.568	47.588	9.98	5.99
Subbasin 5	32.283	47.385	10.51	6.31
Subbasin 6	32.206	47.717	11.84	7.10
Subbasin 7	32.058	47.323	16.64	9.98

3.3 Loss results

The Curve number method was adopted to calculate the leaching losses in the basins, depending on the type of soil and its vegetation cover. The Curve number rate for the basins of the study area, as shown below. The type of vegetation affects the watershed, and the quality or density of this cover has a significant impact on the infiltration of a particular soil, where the infiltration is proportional to the inverse relationship with the curve number. Most of the soils within the catchment of the Iranian and Iraqi sides were classified as D-type soils, which are characterized by their low percolation rate, which increases the rate of runoff in these types of soils.

Subbasin	1	2	3	4	5	6	7
Mean CN	87.26871	87.55968409	87.53899	87.76796	87.96903	87.76659	86.81687

3.4 Suggested Scenarios for Rainfall

The first scenario: Actual rainfall data of Ali Al-Gharbi and Al-Amarah stations was used which were brought from the Meteorology and Seismic Monitoring Authority of the Ministry of Transport and for the period (2012-2022), where the Thiessen polygon method was applied for the purpose of knowing the effect of the rain stations on the used basins. The method according to Figure (8E) proved that the Ali Al-Gharbi rain station in yellow colour effects on a part of the area of the fifth basin, estimated at about 103 km2 out of 748 km2, and part of the area of the third basin equal to 957 km2 out of 1660 km2, and part of the area of the seventh basin with about 121 km2 out of 511 km2, while for Al-Amarah station which affects on the seventh basin with black colour with an area estimated at about 99 km2 out of 511 km2, while there are no actual rainfall stations on the Iranian side, which affects the following basins: the first, the second , fourth, sixth, and part of the third, fifth, and seventh basins. In this case, the inverse distance method (IDM) was used, according to Figure (8B) to extract rainfall data for Dehloran station on the Iranian side depending on the stations of Ali Al-Gharbi, Al-Amarah, Al-Kut, where this method was also used in the strategic study at the ministry of water resources in Iraq to find rainfall station in the centre Al-Teeb basin and another station in the centre of Dwerege basin. The results of using actual rainfall data for peak discharge of strategy study and HEC-HMS model are shown in Table (3).

Table (3): Peak discharge of study area.

	Strategy study		**HEC-HMS Model**			
	Value (M3/s)	**Date**	**Value (M3/s) at 2013**	**Date**	**Value (M3/s) at 2019**	**Date**
Assanaf Marsh	Not Mentioned	Not Mentioned	2969.7	3/3/2013	1526.6	13/3/2019
Al-Teeb River	Not Mentioned	Not Mentioned	735.7	3/5/2013	337.7	13/3/2019
Dwerege River	1600	Not Mentioned	1909	19/11/2013	985.5	13/3/2019

The second scenario: NASA's rainfall data for the period (2012-2022) was used for the purpose of comparison with actual data, because as mentioned previously, there is a problem in the process of finding the required data for the study area in Iraq as shown in Figure (10), and we note that there is a big difference between actual and NASA's discharges. The value of the maximum discharge coming to the Assanaf Marsh from Al-Teeb and Dwerege rivers is 4398.9 m3/s and differs greatly from the maximum discharge following the real data, also as shown in Figure (11) for the difference of rainfall data between actual and NASA, so only real rain data was relied upon in this study.

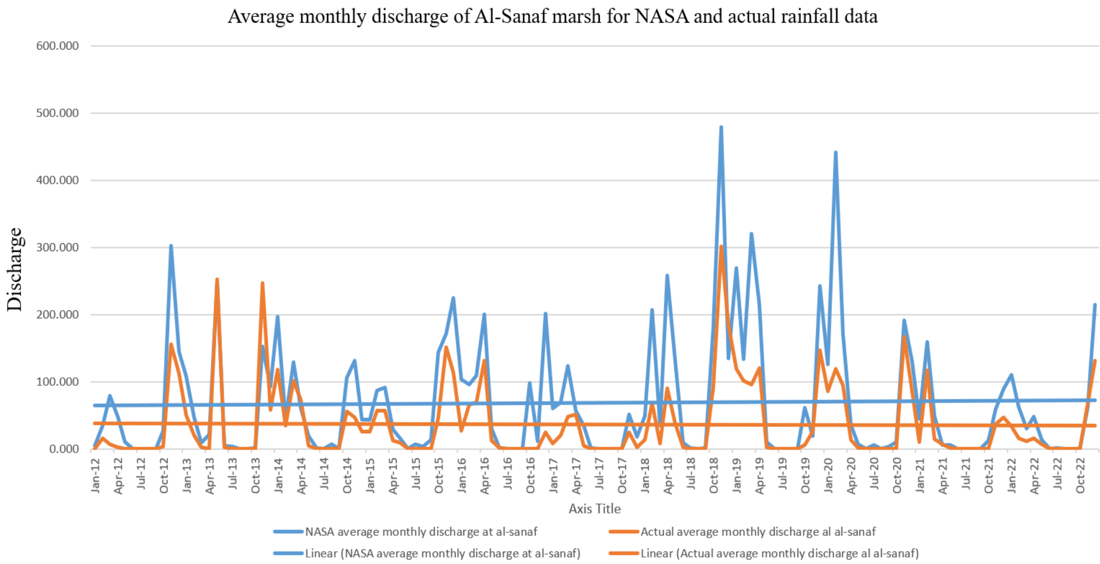
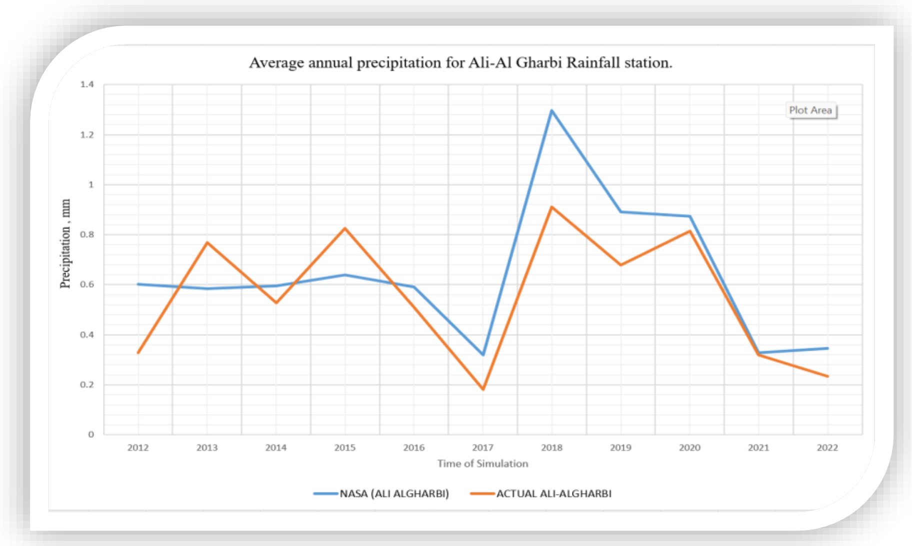
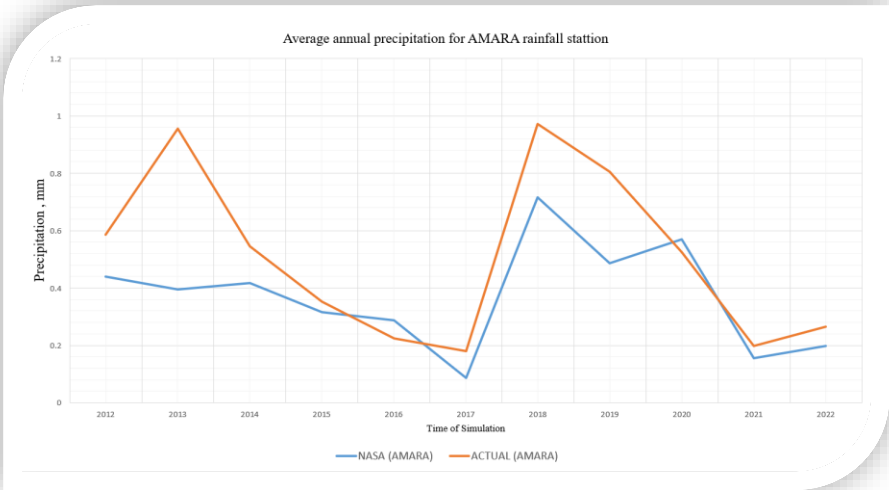


Figure (10): Average monthly discharge of Assanaf Marsh for NASA and actual rainfall data.





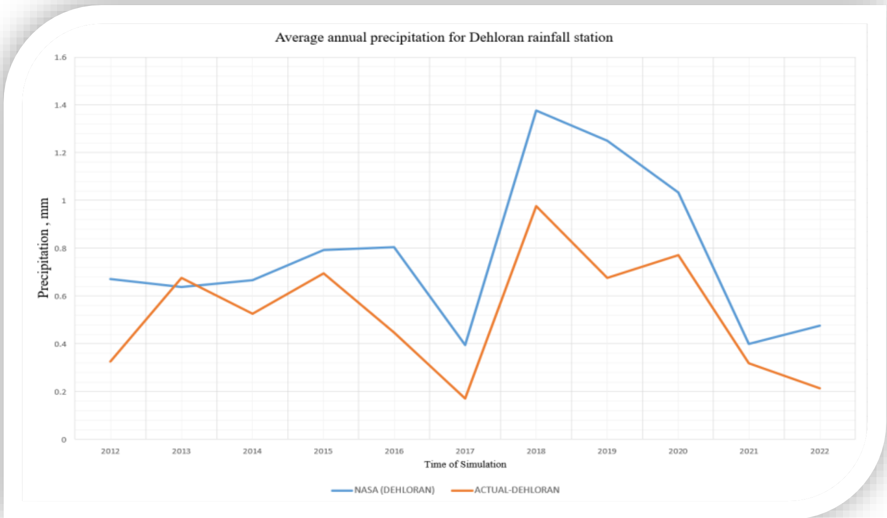


Figure (11): Difference between Actual and NASA for average annual precipitation Data of three stations.

3.5 Average and Peak discharges

Table (4) shows the maximum discharge of the basins and rivers belonging to each basin and the period of this drainage. Table (5) shows the average annual discharges of Al-Teeb, Dwerege and Al-Sannaf Marsh during the simulation period. Table (6) shows the average monthly discharge into the Assanaf Marsh. Table (7) shows the average monthly discharge for Al-Teeb River. Table (8) shows the average monthly discharge for Dwerege River. Figure (11) shows the average annual discharge of actual data for Al-Teeb, Dwerege rivers and Assanaf Marsh and Figure (12) shows average annual discharge of NASA data for Al-Teeb and Dwerege rivers and Assanaf Marsh.

Table (4): Maximum discharge of HEC-HMS model.

Subbasin, Reach	Maximum discharge at 2013		Discharges at 2019	
	Value m^3/sec	Date	Value m^3/sec	Date
Reach-10	735.7	03May2013, 00:00	337.7	31/3/2019
Reach-11	1256.8	19Nov2013, 00:00	650.9	31/3/2019
Reach-12	732.2	03May2013, 00:00	351.8	31/3/2019
Reach-13	1298.5	19Nov2013, 00:00	663.3	31/3/2019
Reach-14	447.1	19Nov2013, 00:00	227.1	31/3/2019
Reach-15	727.5	03May2013, 00:00	364.6	31/3/2019
Reach-16	841.2	03May2013, 00:00	477.5	31/3/2019
Reach-18	2637.2	03May2013, 00:00	1250.4	31/3/2019
Reach-2	722.3	19Nov2013, 00:00	376.1	31/3/2019
Reach-3	746.8	19Nov2013, 00:00	386.1	31/3/2019
Reach-4	771.3	19Nov2013, 00:00	391.9	31/3/2019
Reach-8	1885.3	03May2013, 00:00	958.8	31/3/2019
Reach-9	1909.9	19Nov2013, 00:00	985.5	31/3/2019
Sink-1	2969.7	03May2013, 00:00	1526.6	31/3/2019
Subbasin-1-	794.7	19Nov2013, 00:00	388.5	31/3/2019
Subbasin-2-	460.7	19Nov2013, 00:00	225.1	31/3/2019
Subbasin-3-	853.2	19Nov2013, 00:00	591.3	31/3/2019
Subbasin-4-	891.8	19Nov2013, 00:00	435.6	31/3/2019
Subbasin-5-	430.9	19Nov2013, 00:00	202.3	31/3/2019
Subbasin-6-	715.6	19Nov2013, 00:00	349.6	31/3/2019
Subbasin-7-	433.4	19Nov2013, 00:00	276.2	31/3/2019

It was concluded that the maximum values of discharge are for the year 2013 compared to the year 2019. This interpretation is attributed to the actual rainfall data from the years 2012-2022 provided by the Meteorology and Seismic Monitoring Authority, but when taking the annual and monthly average, it was found that the year 2019 is the highest, according to Figure (11) Whereas, the river (9), which represents the end of the Dwerege river before confluence with the seventh basin, has a maximum discharge of 1909.9 m^3/sec for actual data, while the river (10), which represents Al-Teeb river before entering the seventh basin, has a maximum discharge of 735.7 m^3/sec.

Table (5): Annual average discharges (m^3/sec) for Al-Teeb, Dwerege rivers and Assanaf Marsh During simulation period.

Year	Al-Teeb river	Dwerege river	Seventh Subbasin	Assanaf Marsh
2012	6.346249537	15.45461346	2.928643555	24.93746478
2013	13.61114887	34.0836988	5.608346774	52.79666283
2014	10.14049027	24.5321979	3.215967742	38.57964734
2015	10.73268817	26.80672043	2.046119432	39.34626216
2016	7.591959276	18.96152237	1.371913855	27.9197491
2017	3.69703341	8.79327509	1.023740399	13.40795507
2018	17.31093702	42.97994368	5.806059908	66.777436
2019	13.38314324	32.79401562	4.803347414	51.61023425
2020	12.74821777	31.13778519	3.111376838	47.41214312
2021	5.405770609	13.26743472	1.144518049	19.40260241
2022	6.265662442	15.34776306	1.691984127	23.71772657

Table (6): Average monthly inflow discharge (m^3/sec) for Assanaf Marsh of HEC-HMS model.

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
1	0.02	50.08	118.32	25.73	27.44	8.11	13.35	118.79	85.89	9.84	33.09
2	16.40	20.04	34.41	56.86	66.00	20.85	68.21	101.14	119.16	116.81	16.17
3	6.71	2.12	101.25	56.71	69.61	48.06	8.03	96.45	95.23	14.30	11.85
4	2.39	0.27	74.06	12.38	131.78	51.64	90.27	120.48	13.72	6.63	15.89
5	0.61	252.34	4.93	9.09	12.74	4.62	38.43	2.47	1.44	1.46	7.21
6	0.02	2.71	0.55	0.51	1.80	0.49	2.44	0.39	0.11	0.20	0.53
7	0.00	0.55	0.16	0.19	0.67	0.20	0.45	0.13	0.04	0.06	0.14
8	0.00	0.19	0.06	0.15	0.26	0.07	0.16	0.03	0.00	0.03	0.05
9	0.00	0.07	0.01	0.35	0.06	0.01	0.07	0.00	0.00	0.00	0.01
10	4.15	0.01	56.13	45.62	0.00	0.00	93.13	6.07	0.00	0.00	0.00
11	156.42	247.58	46.68	151.28	0.00	24.38	301.78	26.03	167.17	36.71	68.56
12	112.53	57.60	26.40	113.28	24.67	2.46	184.99	147.36	86.18	46.80	131.12

Table (7): Average monthly inflow discharge (m^3/sec) for Al-Teeb River of HEC-HMS model.

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
1	0.248	13.652	29.042	7.413	6.826	2.242	2.555	31.826	23.135	3.071	7.123
2	3.772	4.754	10.079	14.800	17.383	5.682	18.193	26.196	31.055	31.200	4.532
3	2.010	0.661	27.013	15.835	19.100	16.690	2.687	34.390	26.265	3.752	3.174
4	0.620	0.103	18.533	3.713	36.473	9.823	23.543	18.970	3.407	1.927	4.487
5	0.177	63.658	1.510	2.571	4.148	1.555	9.832	0.855	0.371	0.455	1.387
6	0.013	1.067	0.200	0.250	0.850	0.210	0.937	0.197	0.053	0.063	0.253
7	0.000	0.265	0.068	0.068	0.274	0.081	0.190	0.055	0.000	0.000	0.061
8	0.000	0.087	0.000	0.074	0.087	0.035	0.065	0.013	0.000	0.000	0.010
9	0.000	0.020	0.000	0.080	0.027	0.000	0.023	0.000	0.000	0.000	0.000
10	1.035	0.145	15.571	11.571	0.000	0.000	24.155	1.690	0.000	0.000	0.000
11	37.833	62.297	12.493	41.217	0.593	6.317	75.187	6.173	43.467	10.357	19.590
12	30.452	16.626	7.177	31.200	5.342	1.729	50.365	40.232	25.226	14.045	34.571

Table (8): Average monthly inflow discharge (m^3/sec) for Dwerege river of HEC-HMS model.

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
1	0.781	33.642	70.403	17.745	16.348	5.519	6.213	78.555	56.519	5.858	16.806
2	9.593	11.496	22.921	36.700	43.845	13.675	46.129	64.336	77.041	80.029	10.989
3	4.797	1.271	68.668	39.555	49.523	42.887	5.123	89.987	65.384	7.765	7.665
4	1.407	0.133	43.173	7.350	94.517	21.357	57.530	41.750	7.617	4.380	10.890
5	0.365	163.639	2.410	6.016	6.287	2.629	24.671	1.303	0.548	0.942	2.926
6	0.007	1.027	0.310	0.387	1.097	0.350	1.147	0.253	0.100	0.083	0.210
7	0.000	0.310	0.135	0.116	0.484	0.132	0.261	0.055	0.000	0.032	0.071
8	0.000	0.139	0.019	0.119	0.132	0.016	0.126	0.000	0.000	0.000	0.016
9	0.000	0.020	0.000	0.197	0.003	0.000	0.007	0.000	0.000	0.000	0.000
10	2.674	0.432	39.448	30.023	0.000	0.000	57.781	4.313	0.000	0.000	0.000
11	96.717	162.267	29.930	104.967	1.780	15.567	190.970	15.063	110.357	26.737	47.700
12	69.116	34.629	16.968	78.506	13.523	3.387	125.803	97.913	56.087	33.384	86.900

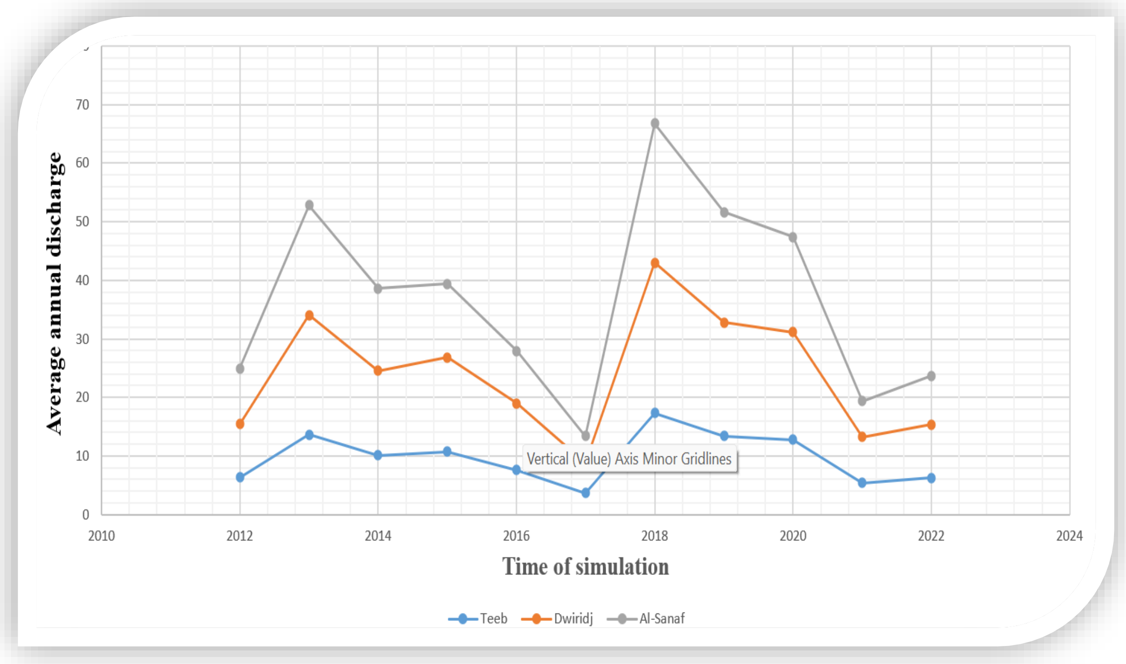


Figure (12): Average annual discharge of actual data for Al-Teeb and Dwerege rivers and Assanaf Marsh.

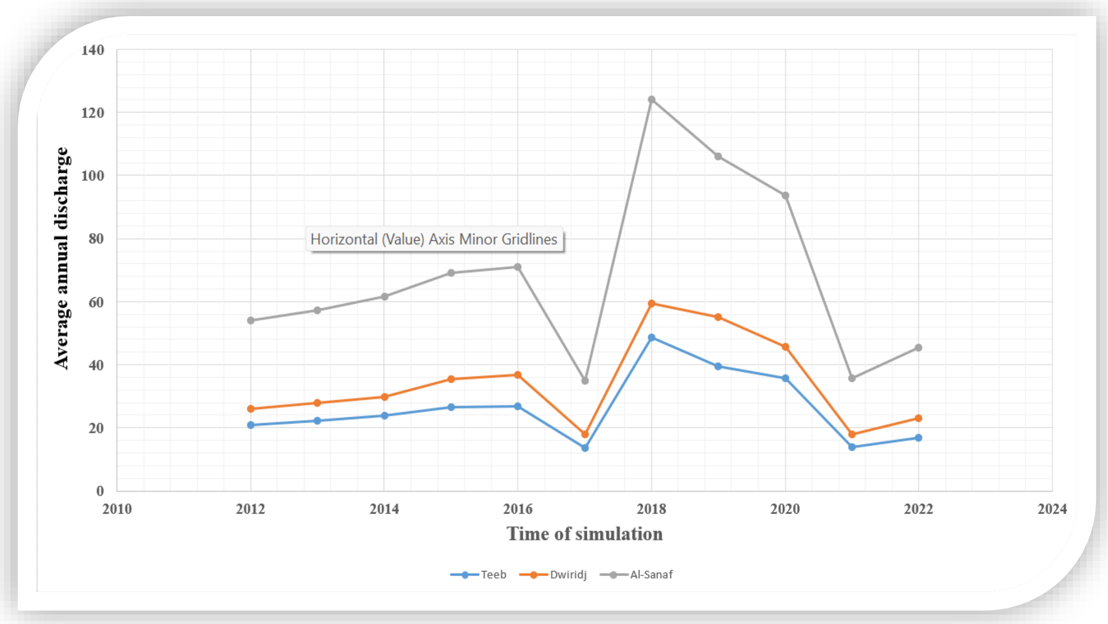


Figure (13): Average annual discharge of NASA data for Al-Teeb and Dwerege rivers and Assanaf Marsh.

From the Figures (12) and (13), it was noticed that there is a great difference in rainfall data for all years, and for the years (2012-2016) there is a difference in value of the rain and the pattern. From here it is concluding the significant difference between NASA and actual data.

4. Conclusions

1) HEC-HMS Software was used for the simulation and ArcGIS Software used for map analysis.

2) It was Concluded that Al-Teeb and Dwerege area were 7891 km^2, which 4850.7 $km^2$for Dwerege basin and 3040.9 km^2 for Al-Teeb basin.

3) It was used ten years for rainfall data for the period (2012-2022) which contains the flood years 2013 and 2019 according to data from the Iraqi Ministry of Water Resources.

4) Peak discharge entering Assanaf Marsh was 2969.7 m^3/sec at 3/3/2013 including 735.7 m^3/sec for Al-Teeb basin and 1909 m^3/sec for Dwerege basin according to actual rainfall data.

5) It was concluded that the data from NASA website for rainfall prediction was so far from the actual rainfall data.

6) The simulation results of the HEC-HMS Software were not calibrated with the actual data of the discharges of Al-Teeb and Dwerege rivers due to the lack of sufficient observations of these data, especially at the dams of these rivers.

7) Inverse distance method (IDM) was used to estimate addition rainfall station in Iran because of the lack of data in this country.

8) The types of soil of the study area were loam for the Iranian side, clay loam for the Iraqi side and sand for a region between previous countries.

9) Thiessen polygon method was used for the purpose of showing the effect of actual rainfall stations used in the simulation (Al-Amarah, Ali Al-Gharbi) on the basin of the study area.

5. Recommendations

1) The simulation period is preferably more than 10 years to obtain accurate results.

2) Correction of rainfall data taken from internet sources before using it in the modelling.

3) In periods of flooding, it is preferable to have data measured by the person who conducted a study due to the lack of the data, especially on Al-Teeb and Dwerege dams.

4) Attempting to apply another method for losses is different from curve number.

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