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HYDROLOGICAL EVALUATION IN DOHUK-SEMEL AREA

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ABSTRACT

The study area located on the east of Duhok city, it is divided into three sub-basins: Hishkero in the east, Semel in the middle, and Gregewr in the west, it covers about 487 km^2. The historical record of rainfall data in Duhok-Semel area from Seismology Directorate and Duhok Meteorological Stations were used to calculate the water balance parameters for the period 2005-2006 to 2020-2021. It receives 559.6 mm of rain during rainy months. This occurs across 58 days in the eight wet months of the year. The amount of rain in January, which averages 124.8 mm, is the most. The amount of runoff is calculated using the curve number approach and the Soil Conservation Service method (SCS), where the soil type is the most important variable. Since all of the soil in the study area belongs to the D group, that the calculated value of runoff is (259mm/Year) or (45.9%) from annual average of rainfall (563.6mm/year). From the total annual rainfall, there is a water surplus of 31.2% and a water deficit of 68.8%. According to overall calculations of the water balance components, the groundwater recharge is (-175.5 mm/year) or (0.1%) of the study area from surplus water. From rainfall prediction value according to Log person III during return period (95.2%) as probability in first two years appear that the rainfall amount will be little, but inversely rain falling will start with probability (80%).

KEYWORDS: water surplus, water deficit, Hydrology and Return period.

1. INTRODUCTION

The Rain, snow, sleet, ... other precipitation, storage evaporation, and interception depression are the main components of the hydrological cycle. Any area can't be developed without water. Water is in extremely high demand right now because of the growing population, making it difficult to use it for agriculture and other uses (Subedi and Chavez, 2015). A water balance of study area is defined and illustrated as the interaction of variables like precipitation (P), return (R), evaporation (E), reserve, and consumption in a certain location or over the entire world. The science of water-hydrology is based on how each of the numerous components of the hydrological system interacts with one another. In how much water does the hydrological cycle involve? This significant question has been studied by the study of water for more than a century. The terms "water balance" and "outflow" refer to the inflow and outflow, respectively, of any water system. The inflow (snow melt, precipitation), the outflow (transpiration, evaporation, surface and subsurface runoff), and the balance of these processes in a given area are then stored and gathered for irrigation or general agricultural purposes (Ivezic.,2017). The calculation of water balance will speed up and save time and money hydrological studies of lakes, river basins, and ground water basins. Meteorological data were used in numerous earlier studies to estimate water balance parameters. (2019, Al-Sudani).

The study area covers an area about 482Km2 of Duhok-Semel area- Iraq Kurdistan Region. Semel town become a center of our study area with population average near to 67498 peoples in 2014 Urban population estimate by CSO (KRI, 2018). And the study area in the north is bounded by Bexair anticline, Tigres rivers in the south, Duhok city in the east and Duban Plain in the west. It is bounded by Latitude (N 36º 45′ and N 37º 00′) and Longitude (E 42º 43′ and E 43º 00′), show in Fig (1). It is divided into three sub-basins: Gregewr in the west, Mseruk in the middle, and Hishkero in the east. Semel, which is 466.88 meters above sea level.

It is one of the most often used systems for categorizing the global climate is the Koeppen classification (Kottek, et al., 2006). Based on the annual and monthly averages of temperature and precipitation, where temperature is expressed in (C°) and precipitation is expressed in (cm/month), it recognizes five main climate types. As illustrated in (https://koeppen-geiger.vu-wien.ac.at/present.htm), Hydro-meteorologically, according to the study area has a Mediterranean climate with hot summer as a main climate, steppe precipitation.

The aims of this study are:

1. To research the hydro-meteorological features of the local catchments by analyzing climatic parameters and the climatic conditions to be used in the water balance technique applied.

2. To research the connections between the rainfall and runoff processes.

3. To be familiar with water balance parameters.

4. To advance sustainable development, aid in the revitalization of ongoing initiatives, and motivate action to fulfill the future agenda.

Finally: Numerous agro-hydrological studies have been conducted in the subject area, including those by Parson Co. (1955), Taufiq and Domas (1977), Yaqo (1990), Hameed (2006), Fayadh (2010), and Abdulrahman (2020). Due to the world's changing environment, additional study was required to resolve agricultural issues.

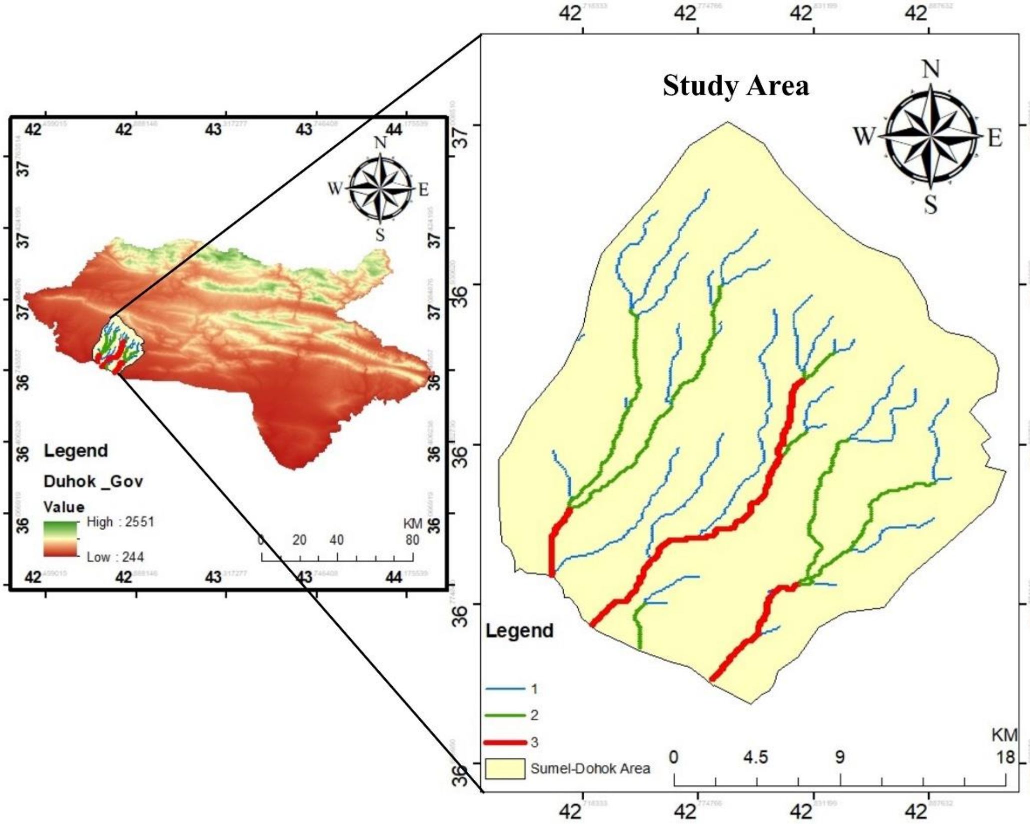

Fig (1):- Map of study area

2. MATERIALS AND METHODS

2.1. Data Acquisition

The average monthly rainfall, temperature, evaporation, and the average number of wet days per month were acquired from the Duhok meteorology and seismology station for the years 2005–2006 to 2020–2021 and are displayed in (Table 1, 2, 3 and 4).

Table (1):- the average monthly rainfall (mm) for the Duhok-Semel Area from the water years 2005-2006 to 2020-2021

Month	Oct	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	July	Aug.	Sep.	Sum
Rainfall mm	28.2	57.2	90.6	124.8	81.3	87	61.5	26.3	0	0	0	0	**559.6**

Table (2) :-the number of wet days per month for the Duhok-Semel Area from the water years 2005–2006 to 2020–2021

Month	Oct	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	July	Aug.	Sep.	Sum
Number of rainy day	4	6	8	10	8	11	7	4	0	0	0	0	**58**

Table (3) :-the average monthly temperature (C°) for the Duhok-Semel Area from the water years 2005–2006 to 2020–2021

Month	Oct	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	July	Aug.	Sep.	Mean
Temp. C°	29.4	19.6	14.5	11.8	14.3	18.5	24.6	32.2	38.8	42.1	42.2	37.3	**27.1**

Table (4) the average monthly evapotranspiration (mm) for the Duhok-Semel Area from the water years 2005–2006 to 2020–2021

Month	Oct	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	July	Aug.	Sep.	Sum
ET° mm	126.9	78.5	44.0	34.6	52.4	77.8	137.6	256.1	423.0	488.1	474.6	356.1	**2549.7**

2.2. Climate Classification

2.2.1. Brown & Cocheme, 1973:

The humidity index (H.I) was classified by (Brown & Cocheme, 1973) as being dependent on the ratio of rainfall to potential evapotranspiration, which is represented by equation (1) in Table (5):

HI = Ri / PEi …………. (1)

Where:

H.I: Humidity index.

Ri: Annual rainfall (mm).

PEi: Potential evapotranspiration (mm).

HI = Ri / PEi = 559.6 / 2549 = 0.21

Given that H.I in equation (1) the results is equals (0.21) Ranged between **(0.1 < HI < 0.25)**, the researched region has a DRY Climate.

Table (5): Brown and Cocheme's classification of the world's climates (1973)

Climate Type	Description	Range HI
Wet	Humid	HI > 1
Moist	Not Humid	0.5 < HI < 1
Moist to Dry		0.25 < HI < 0.5
Dry		0.1 < HI < 0.25
V. Dry		HI < 0.1

2.2.2. Mather, 1974:

There are numerous classifications of climatic conditions, to locate and ascertain the type of climate. Iraq's wet season is only present from October to May, as determined by rainfall (Ketanah, and Gangopadhyaya, 1974). According to the climate index of (Mather, 1974), which was based on the connection between rainfall and evapotranspiration, climate was divided into three classes:

Im = [(Ri / ETi) -1] ∗ 100 ………….(2)

Where:

Im = Climate index.

Ri = Rainfall.

ETi = Potential evapotranspiration

***Im = [(559.6 / 2549) -1]* ∗ **100 = - 78.04 %**

They depict a dry climate when (Im) is negative, and a humid climate when (Im) is positive ranged from (0.0 to -33.3), the semi-arid ranged between (-33.3 to -66.6) and the arid climate ranged from (-66.6 to -100). The climatic index (Im) for the research area for Decade (2005-2006 to 2020-2021) is (-78), and the climate type is **Arid**, eq. (2).

2.2.3. Al-Kubaisi (2004):

Al-Kubaisi (2004) proposed a categorization system to identify the type of climate based on mean annual rainfall and temperature using the annual dryness treatment (AI), according to the following equation:

$$AI - 1 = 1.0 \times P / (11.525 \times t) \ldots\ldots\ldots\ldots (3)$$

$$AI\text{-} 2 = \sqrt{p / t} \ldots\ldots\ldots\ldots (4)$$

Where:

AI: Annual dryness index.
P: Mean annual rainfall (mm).
t: Mean annual temperature (C°).

As illustrated in Table (6), the value of (AI-1) indicates the classification of the dominating climate, whereas (AI-2) represents a change of that classification.

AI- 1 = (1.0 * 559.6) / (11.525 * 27.1) = **1.7**

This result suggests that the area's predominant climate is Moist to sub-arid to arid when compared to the climatic category in Table (6).

AI- 2 = 2* √ (559.6 / 27.1) = **1.7**

Additionally, when comparing this result to the values in Table 6, it is clear that the area falls under the classification of Humid to moist Climate in AI.2 and the moist to sub-arid in AI.1.

Table (6): -Al-2004 Kubaisi's classification of climate

Type 1	Evaluation	Type2	Evaluation
AI. 1 > 1.0	Humid to moist	**AI. 2 > 4.5**	Humid
		2.5 < AI. 2 < 4.0	Humid to moist
		1.85 < AI. 2 < 2.5	Moist
		1.5 < AI. 2 < 1.85	Moist to sub-arid
AI. 1 < 1.0	Sub arid to arid	**1.0 ≤ AI. 2 ≤ 1.5**	Sub-arid
		AI. 2 < 1.0	Arid

2.3. The number of rainy days per month (n/month):

The number of rainy days is important to know effect of rainfall on the lacking of evapotranspiration for each yaer during decade. The number of rainy days each month in the research area fluctuates from month to month for a single year based on the pattern of rainfall. They were calculated from the hydrographic years (2005–2006) mean monthly precipitation distribution to (2020-2021). The yearly mean of 58 days per eight months, or a mean of 556.9 mm of annual rainfall, ranged from 4 to 11 days in the mean number of wet days per month (Tables 1 and 2). With 26.3 mm, The May had the fewest rainy days, while January had the most, with roughly 124.8 mm. According to the seasonal distribution of the annual rainfall average, there is no rain in the summer while the fall months of October, November, and December presented near 31%, while the winter months of January, February, and March and the spring months of April and May provided 53% and 16%, respectively.

2.4. Runoff:

Surface runoff is calculated using the soil conservation system (SCS) method and the available rainfall data (Hammer and Mackichan, 1981; Showap, et al., 1984 ; Jawad and Washeed, 1986). The relationship between rainfall and runoff is:

$$Q = (P - 0.2S)2 / P + 0.8 S \ldots\ldots\ldots\ldots (5)$$

Where Q is runoff (mm) of depth; P is monthly rainfall (mm); S is retention including the initial abstraction [S = 1000/CN – 10]; CN is Curve number. When precise information on the soil and vegetation cover is available, this method is used. The technique was created using a large number of rainfall and runoff records, as well as many combinations of soil and covers (Fig.2). With four soil classifications (hydrologic soil groups), the Soil Conservation Service (SCS) technique was used. Table (7).

Table (7). Groups of soils depending on infiltration rates for hydrology (Maidment, 1993)

Group Type	Infiltration rate MM/HR	Runoff rate	Soil description
A	**≥ 0.76**	**Low**	**Sands or gravels**
B	**0.38 - 0.76**	**Moderate-Fine**	**Silt loam and loam**
C	**0.13 – 0.38**	**Fine-High**	**Sandy clay loam**
D	**0.0 – 0.13**	**High**	**Clay loam, silty clay loam, sandy clay, silty clay and clay.**

The study area soils are of mixed type, consists of grain size ranges from fine clay to coarse sand (Khasback, 1973; Jassim and Sisakian, 1978). In addition, according to (Abdulrahman et al, 2020) the accuracy types of study area is represented group D and the vegetation cover during rainy season consists of wheat, and straight row cultivation is used for soil treatment, therefore according to this specifications, the soil is of class A type (according to the classification proposed by this method). Soils in Group D have strong runoff potential and a relatively slow infiltration rate. This category consists of soils with a high water table, a clay pan or layer at the surface, shallow soils over largely impervious material, and clays with a high shrink-swell potential. additionally, cause runoff to develop.

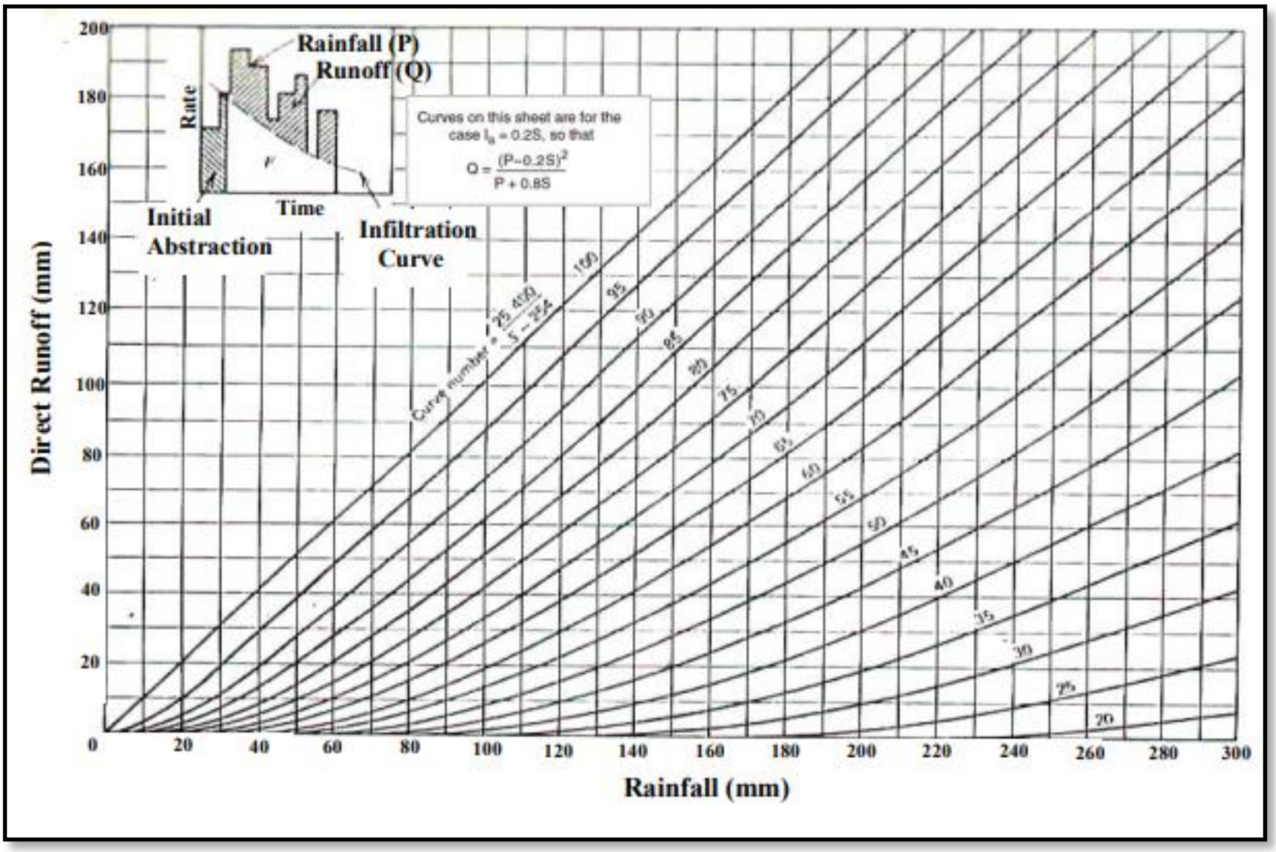

Fig (2): Nomograph for the relationship of rainfall-surface runoff (after Soil conservation, 1971, in Hammer and Mackiehan, 1981)

2.5. Evapotranspiration

A water loss is categorized as an EPAN "A" evaporation type, which includes soil moisture as a component of evaporation, according to Jamil et al. (1999), Hassan and Zeki, (1982). In dry places without access to data needed to use the PMF-56 method, the Blany-Cridle equation calibrated in this study is proposed as a workable way for predicting ET (Hossein Tabari. 2013). The Blany-Cridle equation originated in dry continental regions, such as Iraq. The formula for the equation is:

$$PE = K\,P\,(0.4\,t + 8.13) \;\ldots\ldots\ldots\ldots.\; (6)$$

Where:

PE = Potential evapotranspiration (mm).
K= Correction factor = (0.0311 t + 0.24).
P = The percent of sum of sunshine hours in each month to the sunshine hours of one year.
t = Monthly mean temperature (C°).

2.6. Water Balance Model:

We may have approximated using the following formula for estimation ground water recharge:

$$GWi = (Ri) - (SRi + ETi) \;\ldots\ldots\ldots\ldots\ldots.\; (7)$$

3. RESULTS & DISCUSSION

3.1. Rainfall Characteristics Over Decade

Available historical data of rainfall is the mean number of Water year per Decade (n/Decade) according to International Hydrological Decade (IHD), in this study the one decade consist from 15 years. The average number of wet years per decade in the research area changes depending on the rainfall pattern, so is the (556.9 mm) as average for decades (2005-2006 to 2020-2021), in the same order, as seen in the table (1), fig (3).

3.2. Water balance parameters

3.2.1. Precipitation

In the most recent time (2018-2019), the average annual precipitation increased in a substantial way. However, the greatest decrease in precipitation for the (2020–2021) decade was conversely (approximately 49.8%). As well as the rainfall-runoff process was significantly due to lacking of infiltration especially during rainfall when soil saturated by water, show in fig (4). According to that statement, precipitation has varied annually and there is a water shortage, but during the cropping cycle period, the reduction is large and could result in a decrease in crop yield in the research field if irrigation practice is neglected, show in Table (1), fig (3).

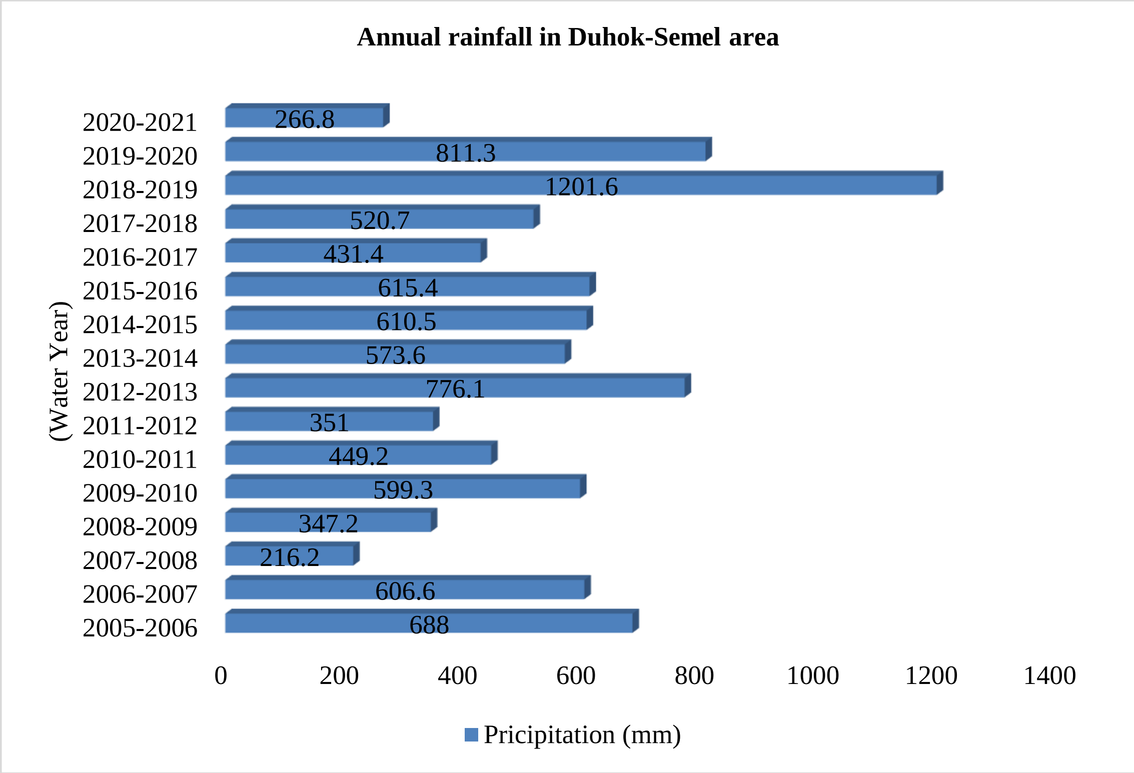

Fig.:- (3) Annual Average Precipitation of Duhok – Semel area during period of (2005-2006 to 2020-2021)

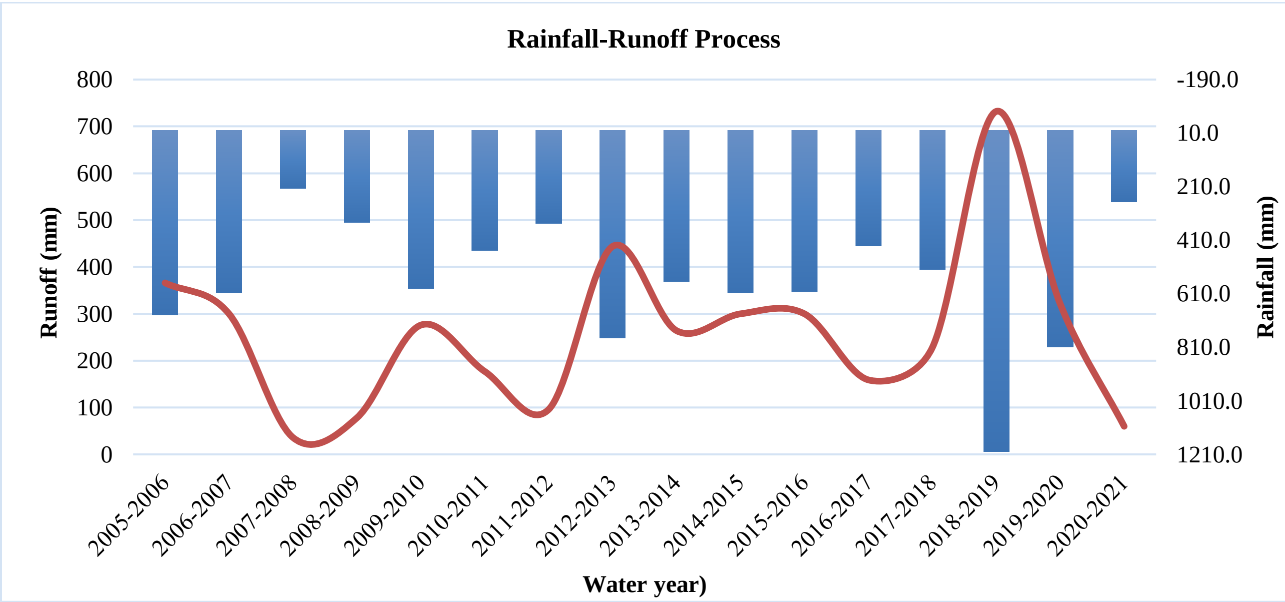

Fig (4):- Hydrograph for the Rainfall-Runoff Process of Duhok – Semel area during period of (2005-2006 to 2020-2021)

3.2.2. Calculation of water surplus using monthly data:

Comparing the mean annual rainfall and evapotranspiration may not increase water surplus since rain falls on a relatively small number of days throughout the year yet potential evapotranspiration occurs all year round. The comparison is therefore useless because rainfall really results in evaporation rather than an abundance of water (Jamil et al., 1999).

To calculate the mean monthly water surplus, the potential evapotranspiration (PETi) and mean monthly of both (Ri) were compared. The results are shown in (Table 8) as follows:

$$WSi = Ri - PETi \quad \ldots\ldots\ldots\ldots\ldots (8)$$

$$WSI\% = \frac{\Sigma WSi}{\Sigma WRi} * 100 \quad \ldots\ldots\ldots\ldots\ldots (9)$$

$$WDI\ \% = 100 - WSI\ \% \quad \ldots\ldots\ldots\ \ldots.. (10)$$

When:
Ri > PETi and AEi = PET
Where:
AEi = actual evapotranspiration
WSi = water surplus = 0
When Ri <= PETi and AEi = Ri
Therefore,

$$WSI\% = \frac{\Sigma WSi}{\Sigma WRi} * 100 \quad \rhd \quad \frac{174.9}{560} * 100 = 31.2\%$$

Without taking into account soil moisture, this portion of the water surplus represents surface runoff and groundwater recharge.

WDI % = 100 – WSI % ⊳ *WDI% = 100 – 31.2 % = 68.8 %*

The water deficit is approximately 68.8% of the annual rainfall, while the water surplus is approximately 31.2% of the annual rainfall, so study area need to -37.6% rain falling over an area to be increased the water resources, shown in table (8).

Table (8):- mean monthly surplus or deficit from comparison between mean monthly of Ri and PETi

Para-meter	Oct	Nov.	Dec.	Jan.	Feb.	mar.	Apr.	May	Jun.	July	Aug.	Sep.	Sum
Ri	28.2	57.2	90.6	124.8	81.3	87	61.5	26.3	0.0	0.0	0.0	0.0	**559.6**
PETi	126.9	78.5	44	34.6	52.4	77.8	137.6	256.1	423	488.1	474.6	356.1	**2552.9**
AEi	95.2	58.9	33	25.9	39.3	58.4	103.2	192.1	317.3	366.1	355.9	267.1	**1912.3**
WSi	0.0	0.0	46.7	90.2	28.9	9.1	0.0	0.0	0.0	0.0	0.0	0.0	**174.9**
WDi	-98.7	-21.3	0.0	0.0	0.0	0.0	-76.1	-229.8	-423	-488.1	-474.6	-356.1	**-2167.9**
WSI%													**31.2%**
WDI%													**68.8%**

3.2.3. Calculation of water surplus using daily data:

The following techniques were used to determine water excess using the number of rainy days (Hassan et al., 1999). Because potential evapotranspiration is typically only assessed on a monthly basis, evaporation is used instead (Hassan and Al kubaisi, 1998). Water losses with an equal chance for (n/year) event:

$$En = no\ of\ rainy\ days * \frac{\Sigma EPAN''A''}{\Sigma di} \ldots\ldots\ldots\ldots\ldots\ldots (11)$$

$$WSi\% = \frac{\Sigma EPAN''A'' - En}{\Sigma EPAN''A''} * 100 \ldots\ldots\ldots\ldots\ldots\ldots (12)$$

$$En = no\ of\ rainy\ days * \frac{\Sigma EPAN''A''}{\Sigma di} \quad \rhd \quad 58 * \frac{807.9}{243} = 192.83\ mm$$

$$WSi\% = \frac{\Sigma EPAN''A'' - En}{\Sigma EPAN''A''} * 100 \quad \rhd \quad \frac{807.9 - 192.83}{807.9} * 100 = 76.13\%$$

∴ WDi%= 100% - WSi% = 100 – 76.13 = 23.87%

Where:
Σ EPAN ″A″ = Total of evapotranspiration during rainy month = 807.9
Σdi = Total of days during rainy month = 243.
En = Mean total of evapotranspiration (mm) occurs in number of rainy days per year.
n = Mean total of rainy days per year = 58.
WSI= Water surplus.

WDI= water deficit.

This approach is dependent on the number of rainy days each year as well as the total amount of evapotranspiration that falls on these days. As a result, the following formula (Table 8) can be used to determine the mean evapotranspiration corresponding to the mean number of wet days.

3.2.4. Variable probability of water losses for (n/month) Event:

The evapotranspiration from EPAN ″A″ that takes place during the average number of rainy days each month is what this method relies on. The daily average evapotranspiration from EPAN ″A″ for a given month is multiplied by the number of rainy days in that month to determine the quantity of evapotranspiration during the mean wet days per month. It appears that sorting the annual water surplus in descending order can be used to estimate the return period for the water surplus, as stated in (Kosslar and Read, 1974). For every given month, water surplus (Table 8) is computed by deducting the evapotranspiration of the wet days from the related rainfall as indicated below:

$$Edi = EPAN\ ''A'' / di \quad \text{………….. (13)}$$

$$Ei = Ni * Edi \quad \text{………………… (14)}$$

$$WSi = Ri - Ei \quad \text{……………….. (15)}$$

Where:

Edi = daily average evaporation in a given month (mm).

EPAN ″A″ = monthly evaporation (mm).

di = number of days per month.

Ei = sum of evaporation for rainy days during month (mm).

Ni = sum of rainy days.

WSi = monthly water surplus (mm).

Ri = monthly rainfall (mm).

Table (9): -Mean monthly water surplus (WSi) of variable probability n/month for study area

Month	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	July	Aug.	Sep.
Ri	28.2	57.2	90.6	124.8	81.3	87.0	61.5	26.3	0.0	0.0	0.0	0.0
PETi	126.9	78.5	44.0	34.6	52.4	77.8	137.6	256.1	423.0	488.1	474.6	356.1
di	31.0	30.0	31.0	31.0	29.0	31.0	30.0	30.0	30.0	31.0	29.0	30.0
Edi	4.1	2.6	1.4	1.1	1.8	2.5	4.6	8.5	14.1	15.7	16.4	11.9
ni	4.0	6.0	8.0	10.0	8.0	11.0	7.0	4.0	0.0	0.0	0.0	0.0
Ei	16.4	15.7	11.3	11.1	14.4	27.6	32.1	34.2	0.0	0.0	0.0	0.0
Wsi	11.8	41.5	79.3	113.6	66.8	59.4	29.4	-7.8	0.0	0.0	0.0	0.0

3.2.5. Groundwater Recharge

The water balance model was validated using input rainfall from the study area's water year (2020–2021). Model validation begins with the theoretical output model (WSi), where WSi = Ri - ETi. The next step is to estimate the (SRi) and the (GWi) (Fetter,1980). One of the hardest parts of the hydrological cycle to quantify is groundwater recharging. The groundwater recharge projected in the research region according to surface runoff and water excess is typically negative, which indicates a scarcity of water in the area, particularly since (2020-2021), shown in fig (5), table (8).

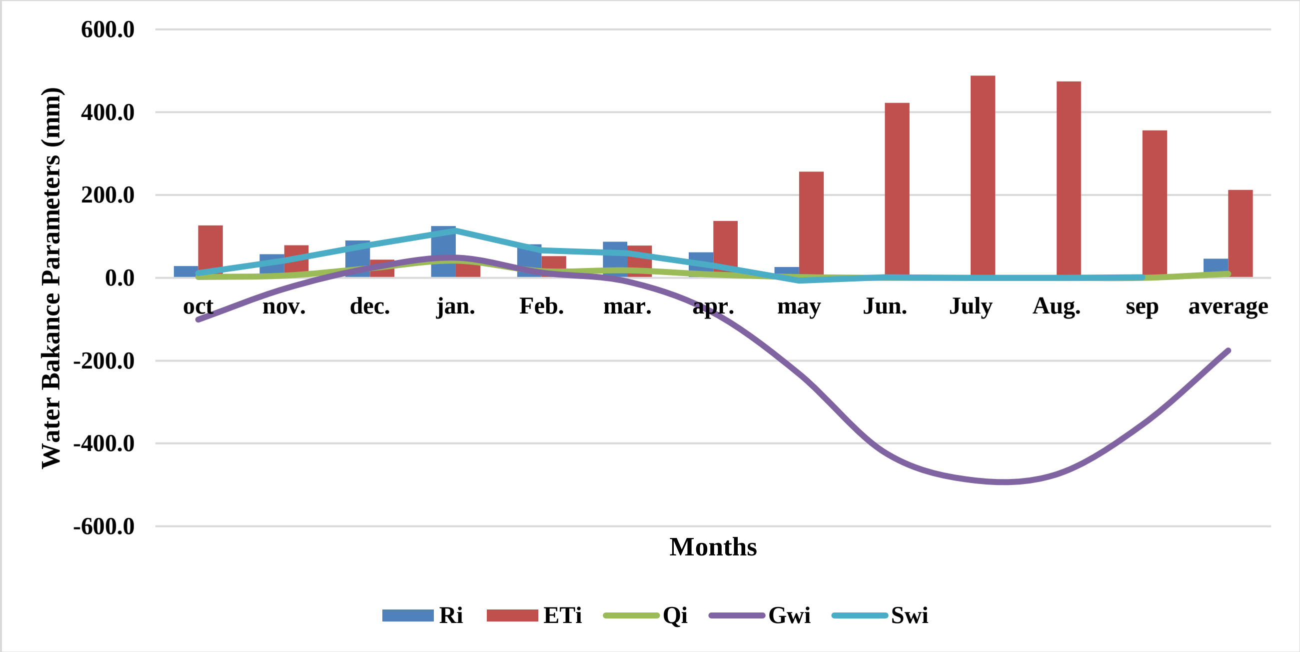

Fig (5):- Ground water recharge of Duhok – Semel area during period of (2005-2006 to 2020-2021).

3.3. Return period of Rainfall-Water deficit

The probability that an event, such as a flood, a windstorm occur is frequently stated as a return period by the Log Pearson III technique (Veronica L. Webster & Jery Stedinger. 2007). **Formulas as follow:**

y = log (Ri)* …………………… *(16)

y = yave + Ksy* …………………*(17)

K = f (T,Csy)* ………………….. *(18)

Ri = log-1 (y)* ………………….. *(19)

- **skew coefficient [of the logarithms] Cs = -1.026**

The predicted time interval between events of comparable size or intensity is given by the inverse of probability, which is typically stated in percentages. A rainfall flood's return period, which is represented as its probability of occurring being 1/100, or 1% in any given year, might be 100 years. according to results of this study the first two years in the future will be have little rainfall, instead of it after two years will increased by (18mm) with probability (50%) and when the five year starting the amount of rainfall accumulation increased to (106mm) by (20%) as a prediction to future, shown in table (10).

Table (10): -Return period for the research area's average rainfall-water deficit from 2005–2006 to 2020–2021.

Return Period T (Yr)	Probability P (Percent)	Frequency Factor K	Y = Log (Ri)	Rainfall Amount (mm)
1.05	95.2	-1.874	-1.01	**0**
1.11	90.1	-1.34	-0.415	**0**
1.25	80	-0.76	0.231	2
2	50	0.161	1.257	**18**
5	20	0.852	2.027	**106**
10	10	1.131	2.338	218
25	4	1.373	2.608	405
50	2	1.502	2.752	564
100	1	1.601	2.862	727
200	0.5	1.68	2.949	889

CONCLUSIONS

1. Due to climatic change, land damage, and poor exploitation of agricultural land for varied human activities, according to more approaches, the climate is classified as semi-arid or desert.
2. Due to the existence of suitable places, water that is surface runoff can be held in depressions or behind tiny dams that can be used for agricultural purposes.
3. During the last decade, there was a 68.8% water deficit and a 31.2% water excess, and it is currently believed that there is not enough rainfall.
4. There is a bad sign regarding groundwater recharging! is approximately (-175.5 mm) every year due to annual rainfall or water excess.
5. It appears that the rainfall-water deficit is happening two years in the future after the rain falling started, but with it the frequency factor value raised and lead to rising rainfall amount but the probability reduced by 80% during five years! The probability of the rainfall returning, based upon the annual average during all water years (2005-2006) to (2020-2021).

Recommendations:

1. Water surpluses during the dry season cannot be used because of high summer evapotranspiration; thus, it is necessary to build small mud dams parallel to the Tiger River's margins so that they can be used to irrigate nearby farms and crops, particularly during years with little rainfall.
2. Providing tools in the research area for maintaining vegetation cover and preventing soil erosion, which would provide the area a nice appearance and view and possibly draw tourists (especially Qeshefre Village).
3. To get precise data and measurements regarding the watershed's water discharge. We advise installing an automatic measuring system at the catchment's exit.
4. Building a rain gauge station to measure rainfall intensity and determine when a flash flood will occur in the research area.
5. Building discharge measurements V-notch and a par-shall flume in order to calculate the quantity of both surface water and infiltration and create an appropriate water balance for the area, weir the runoff water in valleys (outlet culverts) during the rainy season.

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