CLIMATIC ANALYSIS FOR PIRMAM AREA, KURDISTAN REGION, IRAQ

¹Shevan Jirjees*, ²Shwan Seeyan and ³Kaiwan K. Fatah

¹Geology Department, Science College, Salahaddin University, Erbil, Iraq

²Soil and Water Department, Agriculture Engineering Science College, Salahaddin University, Erbil, Iraq

³Geology Department, Science College, Salahaddin University, Erbil, Iraq

*E-mail: shevan.jirjees@su.edu.krd

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ABSTRACT

Techniques for water balance are methods of solving major theoretical and practical hydrological problems. The main objectives of this research are analyzing climatic parameters and the climatic conditions to be used in the water balance technique applied in Pirmam area, northern Iraq. The meteorological data of the Pirmam meteorological station during the period 1992–2017 were used to assess the climatic conditions of the study area. The average annual rainfall is 689.2 mm and the evaporation is 1665.9 mm, mean monthly relative humidity, temperature, wind speed, and sunshine were 52.25%, 21.36 °C, 2.26 m/sec, and 8.28 hr/day, respectively. Thornthwait method was used to determine potential evapotranspiration, water surplus and deficit, soil conservation method was used to determine surface runoff, and groundwater recharge based on water balance method. The results indicate that total potential evapotranspiration, water surplus and deficit are 1451.5 mm, 389.84 mm, and 1152.23 mm respectively, and annual runoff equal to 209.6 mm/year. The standardized precipitation index was calculated to characterize meteorological drought on a range of timescales, the average value of is -0.012. Groundwater recharge of the area equal to 209.6 mm/year and groundwater budget is 2.34×10^5 m³/year. Different methods were like Mather, Unep, and Al-Kubaisi, the results of these classifications show that climate is dry-sub humid according to the first classification, semi-arid according to the second classification, and humid to moist according to the third classification.

Keyword: Water balance; Groundwater recharge; Climatic classification; Kurdistan region

INTRODUCTION

Climate change leads to severe droughts, increased flood risk, increased soil salinity, lower groundwater levels, etc. Climate is an important component of the ecosystem because it plays

an important role in affecting other environmental components such as water quality, weathering and erosion, transportation, sedimentation and the relationship between geochemical variables and then living organisms (Faure, 1998). Climate change is directly affecting the hydrological cycle. Techniques for water balance are methods of solving significant theoretical and practical hydrological problems. The relationship between precipitation and evapotranspiration represents climate conditions across the state that can influence water availability. For storage and surface runoff, seasons that have more precipitation than evapotranspiration may have sufficient water. Whereas a season that tends to have deficit in water will have less water for storage and runoff in both above and below ground. Several variables influence the relationship between rainfall and evapotranspiration, such as soil water ability, canopy density, leaf area, intensity and amount of precipitation, solar energy gain, and latitude. The rate of evapotranspiration will also change with the changing conditions of soil moisture (Chapin et al., 2002). The water balance hydro-meteorological approach is commonly used when the development of a small basin is considered to occupy a part of urbanization.

Mostly, such output is not always available, so analytical approaches were taken into consideration. The input parameters for water balance are thus used to explain future water surplus and deficit cycles. These parameters consist mainly of two groups; the first group represents the water availability elements, while the second group includes water depletion elements (Hassan, 1998). Precipitation plays a key role in distributing the vegetation type and quantity. Increased precipitation results in increased vegetation mass; while increases in moisture levels result in changes in vegetation type (Leopold et al., 1964). This can generate input that influences evapotranspiration, annual runoff, and water levels in streams and lakes as vegetation changes. (Awadh and Ahmed, 2012) mentioned that the rainfall in Mosul and Baghdad decreased by about 70 mm/ 48 years with a slight decrease in evaporation. The scope of this study is to investigate climate parameters due to the effects of the global climate change which is expected to change the hydro meteorological processes also, to analyze hydro meteorological information to evaluate the analysis of the rainfall variation, determine surface runoff, groundwater recharge, and classified the climate in the study area.

STUDY AREA

The study area is located in the north of Iraq, about 36 km northeastern of Erbil City. The area extends between $44^{\circ} 8' - 44^{\circ} 21'$ longitude and $36^{\circ} 20' - 36^{\circ} 29'$ latitude (Fig. 1), the elevation ranges between 492–1971 m above sea level, and it covers an area of about 130 km². The area

is bounded by Pirmam Mountain in the southeastern part, the Safin anticline in the northeast, and Sartka anticline in the southwestern part. Tectonically, the area is located within the high folded zone of the Zagros mountain range in the Unstable shelf (Buday et al., 1973; Buday and Jassim, 1987). Aspect values of the study area indicate the directions the physical slopes face, aspect directions classify based on slope angle with a descriptive direction. The output aspect raster will typically result in several slope direction classes (Figs. 2 and 3).

Fig. 1. Location map with stream orders and digital terrain model of Pirmam watershed

Fig. 2. Aspect map of the study area

Fig. 3. Slope map of the study area

GEOLOGICAL SETTINGS

The exposed geological units are characterized by different formations from Early Cretaceous to Pliocene and Quaternary deposits, which are represented by Holocene Era alluvial deposits and Pleistocene period river terraces. The oldest unit of the Lower Cretaceous age is the formation of Qamchuqa, which is consisted mainly of carbonate rocks and forms the center of most of the anticlines in the region. Carbonate rocks of the Bekhme and the Shiranish formations represent the Upper Cretaceous age. The Kolosh Formation represents Paleocene Age which is including shale, limestone, marl and mudstone. The Gercus Formation represents early Eocene includes red mudstone, sandstone and shale, with few conglomerates. The Pila Spi Formation represents middle-late Eocene consists of limestone overlain by recrystallized and chalky limestone. The Fatha and Injana formations represent Miocene age. The Bai-Hassan and Muqdadiya formations which consist mainly of sandstone and conglomerate belong to Pliocene and a recent alluvial deposit represents Holocene age.

AQUIFER SYSTEM

The study area contains a variety of aquifer types including porous, fissure- karstic, and karstic aquifers (Stevanovic and Markovic, 2004) (Fig. 4). Porous aquifer represented by Pliocene deposits (Bai Hassan and Muqdadiya formations) including conglomerate and gravel

of varied grain size, sand, silt, partly clayed or interstratified by clay or clay lens. The characteristics of this aquifer are the inter-bedded layers of fine, medium and coarse-grained textures and permeability variations within the same aquifer horizon from one location to another. The middle and upper Miocene deposits (Fatha and Injana formations) represent mainly semi and impermeable rocks or small groundwater reservoir aquifer, the impermeable layers like claystone or marls partly alternate with permeable rocks, such as fractured limestone, resulting in low permeability and limited groundwater presence. This rock complex reflects either aquitards, or aquiclude which is fully impermeable groundwater flow barrier. Fissured-karstic aquifer represented by Paleocene and Eocene deposits (Kolosh, Khurmala, Gercus, and Pila Spi formations) including well-karstified and bedded limestone (partly bituminous and crystalline), except the Kolosh and Gercus formations which include impervious clastic rocks. The karstic aquifer represented by the Cretaceous deposits (Bekhme, Aqra, Shiranish formations) including massive and bedded well-karstified limestones, this aquifer is characterized by its very high permeability and transmissivity and by its turbulent water-flow regime (Stevanovic and Markovic, 2004).

**Fig. 4. Type of the aquifers within Pirmam watershed
(after Stevanovic and Markovic, 2004)**

MATERIALS AND METHODS

Climatic Elements

Water availability elements

The most important parameters influencing water availability are rainfall and relative humidity. Analysis of rainfall is critical in various fields such as agricultural planning, water resources planning, runoff prediction, climate studies, environmental studies, stream flow estimation and human life activities (Subramaya, 1984; Hatzzian et al., 2007).

Meteorological data are obtained from the Pirmam ground meteorological station during the years 1992–2017 indicates to the mean of rainfall in the study area around 689.2 mm per year, while maximum and minimum mean monthly relative humidity were 73.9% and 34.6% in January and August respectively. The meteorological data are used to determine the mean monthly, annual, and the seasonal variation, the standard deviation and the coefficient of variation of the studied area according to the following formulas:

$$X' = \Sigma x / n \quad (\text{Mean Equation}) \dots\dots\dots (1)$$

Where: X' is mean monthly rainfall for giving periods; Σx is the summation of each mean monthly rainfall for giving periods of one season; n is number of years for giving season.

$$SD = [\Sigma (X - X')^2 / N]^{0.5} \quad (\text{Standard Deviation Equation}) \dots\dots\dots (2)$$

Where: SD is standard deviation; X is monthly rainfall for giving periods of one month; X' is mean monthly rainfall for giving periods, and N is number of years for giving periods.

$$C.V \% = (SD / \text{Mean}) * 100 \quad (\text{Coefficient of Variation Equation}) \dots\dots\dots (3)$$

The average monthly rainfall of 26 years is utilized for preparing rainfall variation. The increasing trend in the rainfall from January to May, and declining trend from May to August are noticed. The maximum and minimum mean monthly rainfall are 129.3 mm and 0.1 mm in January and August, respectively. The total annual rainfall was 689.2 mm. The dry season represents four-month (summer months) which includes June, July, and August, in addition to the month of September of the autumn. While the wet season lasts from to the end of May depending on the climate year in Kurdistan region, which are four seasons; each season represents three months.

Coefficient of variation is used to recognize the consistency of the data which means the uniformity in the values of the data/distribution of the arithmetic mean of the data/distribution. A distribution with smaller C.V than the other is taken as more reliable than the other (Helsel and Hirsch, 2002). Relative humidity controls the rate of evaporation from water surfaces, soil and transpiration of plant leaves, where the larger the relative humidity,

the less evaporation and transpiration (Wilson, 1971). The maximum and minimum mean monthly relative humidity is 73.9% and 34.6% in January and August respectively (Table 1 and Fig. 5), and the mean annual is 52.3 %.

Water losses elements

The water loss elements are represented by temperature, wind speed, sunshine and evaporation. Temperature is an important factor influencing both evaporation and evapotranspiration. There is an important link between plant growth and temperature, where plants respond to certain temperature limits through which their activities can be accomplished (Thornthwaite, 1948). The maximum and minimum mean monthly temperature in the study area are 36.8 °C and 7.7 °C in August and January respectively, while the mean annual of temperature is 21.4 C°. The maximum mean monthly of wind speed was recorded in April while the minimum mean monthly was recorded in months August, December and January. The mean annual wind speed is 2.3 m/sec. Sunshine is an important component of the climate, as it affects relative humidity, evapotranspiration and temperature. The number of hours of daylight considered functions as solar impact on temperature and relative humidity, and then it is effect on actual evapotranspiration (Chow, 1964). The maximum mean monthly sunshine in the study area is 12 h/day in July and the minimum mean monthly is 4.6 h/day in January, whereas the mean annual sunshine is 8.3 h/day. Evaporation is influenced by numerous factors such as: sunshine, air temperature, saturation deficit, wind speed, atmospheric pressure, and surface evaporation nature (Thornthwaite, 1948). The maximum mean monthly evaporation is 267 mm in July but the minimum mean monthly is 33.2 mm in January, while the total annual evaporation is 1665.9 mm (Table 1 and Fig. 5).

Table 1. Values of mean monthly of climatic parameters in Pirmam station during the years 1992–2017

Months	Rainfall (mm)	Relative Humidity (%)	Temperature (°C)	Wind speed (m/sec)	Sunshine (hr/day)	Evaporation (mm)
Oct.	62.3	51.2	23.6	2.0	7.7	125.3
Nov.	76.9	62.6	14.5	2.2	6.3	54.4
Dec.	107.5	65.6	9.8	1.7	7.8	44.5
Jan.	129.3	73.9	7.7	1.9	4.6	33.2
Feb.	114.2	69.4	8.8	2.3	5.3	40.1
Mar.	111.5	61.4	13.1	2.6	6.3	97.6
Apr.	62.2	55.6	18.5	2.7	7.1	122.9
May	18.2	42.8	24.9	2.5	9.2	191.2
Jun.	2.0	35.0	32.3	2.5	11.8	256.5
Jul.	0.6	35.2	36.5	2.4	12.0	267.0
Aug.	0.1	34.6	36.8	2.1	11.1	254.4
Sep.	4.3	39.7	29.8	2.2	10.2	178.7
Total	689.2					1665.9
Mean	57.43	52.25	21.36	2.26	8.28	138.82

There are the diverse relationships between climatic variables; Sunshine is the basis on raising the temperature values, the temperature value causes an increase in wind speed and evaporation. The curves of each of rainfall and relative humidity have Parallel motion. Also, the temperature curve has a parallel motion with the sunshine duration curve, and both have an opposite relation with the first group.

Fig. 5. Relations between the climatic parameters during months for the period 1992–2017 in Pirmam area

Evapotranspiration

Evapotranspiration was calculated by Thornthwait method through making a number of tests on diverse types of climate based on temperature only. (Thornthwaite and Wilm, 1944) expected that the amount of water absent by evapotranspiration from the vegetation-covered soil is controlled by climatic factors. According to this method, the potential evapotranspiration for a given month is based on the mean monthly air temperature of that month and on the annual air temperature (Serrano, 1997) as follows:

$$PET_{12} = La \cdot 16 \cdot (10t / J)^a \quad \text{mm/month} \quad \dots\dots\dots (4)$$

$$J = \sum_{j=1}^{12} j$$

$$j = (t / 5)^{1.154}$$

$$a = (675 \times 10^{-9}) J^3 - (771 \times 10^{-7}) J^2 + (179 \times 10^{-4}) J + 0.492$$

Where: PET is potential evapotranspiration in mm; La is monthly correction constant function of latitude; j is monthly temperature parameter; J is Annual heat index (°C); and t is mean monthly temperature (°C)

Water deficit (WD) and water surplus (WS)

Water surplus means that rainfall values increase the values of corrected evapotranspiration through the given months of the year ($WS = P > PET$), while the water deficit is the decrease in rainfall values associated with the values of corrected evapotranspiration through the same year's residual months ($WS = P < PET$). Actual potential evapotranspiration (PE) can be derived as following (Lerner, et al., 1990). The values of monthly averages PE, WD and WS are illustrated in Table 5.

$$WS = P - PET; P > PET \quad \dots\dots\dots (5)$$

$$WD = PET - P; P < PET \quad \dots\dots\dots (6)$$

$P > PET$ then $PET = AET$; while $P < PET$ then $P = AET$

Where: WS is water surplus; WD is water deficit; P is rainfall; PET is potential evapotranspiration; and AET is actual evapotranspiration.

Surface runoff

Soil conservation system (SCS) method is used to determine surface runoff from available rainfall data (Hammer and Mackichan, 1981; Showap, et al., 1984 ; Jawad and Washeed, 1986). The empirical rainfall-runoff relation is:

$$Q = (P - 0.2S)^2 / P + 0.8 S \quad \dots\dots\dots (7)$$

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. This method uses when detailed data on soil and vegetation cover are available. The method developed from many records of rainfall and runoff and numerous combinations of soil and covers (Fig. 6). The SCS approach was implemented with four soil classes (hydrologic soil groups) (Table 2).

Table 2. Hydrologic soil groups based on infiltration rates (Maidment, 1993)

Group type	Infiltration rate cm/h	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

Pirmam area soils are of mixed type, consists of grain size ranges from fine clay to coarse sand (Khasback, 1973; Jassim and Sisakian, 1978) and the vegetation cover during rainy season consist of wheat, and straight row cultivation are used for soil treatment, therefore according to this specifications, the soil is of class A type (according to the classification proposed by this method), so the curve number for this soil condition is equal to 65.

Fig. 6. Nomograph for the relationship of rainfall-surface runoff (after Soil conservation, 1971, in Hammer and Mackiehan, 1981)

Groundwater recharge

Groundwater recharge estimated by employing water balance method based on climatic data, the recharge values were calculated by the relation bellow:

$$Re = WS - Rs \quad \dots\dots\dots (8)$$

Groundwater budget calculated according to the annual water budget formula which is equal to:

$$\text{Water budget} = \text{Groundwater recharge} * \text{Area} \quad \dots\dots\dots (9)$$

Climate Classification

Different methods are used for climate classification including climatic variance elements. Three classifications will be used to determine the kind of climate in Pirmam watershed as following:

Mather

The climate type is based on the climate index value to find three classes which associated with the rainfall and evapotranspiration as shown in the following equation (Mather, 1974):

$$CI = \{(P/PET) - 1\} * 100 \quad \dots\dots\dots (10)$$

Where: CI is climate index; P is rainfall; PE is potential evapotranspiration. The positive value of the (C.I) is representing to humid climate while the negative value indicates to dry climate.

Unep

Unep (1992) has adopted an index of aridity which is defined the aridity index as follow:

$$AI = P / PET \quad \dots\dots\dots (11)$$

where PET is potential evapotranspiration, and P is Average annual precipitation.

Al-Kubaisi

Al-Kubaisi (2004) suggests the annual dryness treatment based on temperature and rainfall quantities to determine the climate type using the following equations:

$$AI-1 = (1 \cdot P) / (11.525 \cdot t) \quad (t \text{ is not equal to zero}) \quad \dots\dots\dots (12)$$

$$AI-2 = 2 \sqrt{P} / t \quad \dots\dots\dots (13)$$

Where: AI is aridity index; P is annual rainfall (mm); t is temperature (C°).

RESULTS AND DISCUSSION

Rainfall Analysis

The seasonal coefficient of variance shows that the values of autumn months and season were the highest among all others; the value of C.V for the autumn season is 45.90%, while the values for the winter season is 22.20% and for the spring season is 29% (Table 2 and Fig. 7). All these values of C.V indicate that the rainfall of winter and spring seasons were nearly uniform and consistent and of less variable in their values. The rainfall of winter and spring is the most effective for creation of discharge in the area. The Standardized Precipitation Index (SPI) is a widely used index to characterize meteorological drought on a range of timescales (Table 3 and Fig. 8).

Table 2. Mean, standard deviation and coefficient of seasonal rainfall variation (in mm) of Pirmam meteorological station in different seasons for the period 1992-2017

Autumn Season				
Years	Months	Mean	Standard Deviation	Coefficient of variation %
1992 – 2017	Sep	144	66	46
	Oct			
	Nov			
	Spring Season			
	Mar	192	56	29
	Apr			
	May			
	Winter Season			
	Dec	351	78	22
	Jan			
	Feb

Fig. 7. Seasonal rainfall variation of Pirmam meteorological station during the years 1992-2017

Table 3. The standardized precipitation index (SPI) for annual rainfall (mm) in Pirmam station for the period 1992-2017 in the study area

Years	Annual Rainfall	SPI	Standard	Years	Annual Rainfall	SPI	Standard
1992	750	0.5	Near Normal	2005	605.7	-0.6	Near Normal
1993	828.1	1.1	Moderately Wet	2006	868.9	1.4	Moderately Wet
1994	927.7	1.9	Very Wet	2007	633.7	-0.4	Near Normal
1995	573.5	-0.9	Near Normal	2008	487.5	-1.5	Severely Dry
1996	677.1	-0.1	Near Normal	2009	587.6	-0.8	Near Normal
1997	573.5	-0.9	Near Normal	2010	557.5	-1.0	Moderately Dry
1998	708.9	0.2	Near Normal	2011	607	-0.6	Near Normal
1999	552.4	-1.0	Moderately Dry	2012	604.1	-0.6	Near Normal
2000	482.3	-1.6	Severely Dry	2013	827.3	1.1	Moderately Wet
2001	625.4	-0.5	Near Normal	2014	742.4	0.4	Near Normal
2002	801.4	0.9	Near Normal	2015	721.2	0.3	Near Normal
2003	680.6	0.0	Near Normal	2016	673.2	-0.1	Near Normal
2004	991.6	2.4	Extremely Wet	2017	700.15	0.1	Near Normal

Fig. 8. Relations between rainfall and SPI for the period 1992-2017 in the study area

Evapotranspiration

Potential Evapotranspiration is a group concept for both transpiration and evaporation and mean the aggregate absence of water from soil plants by transpiration and evaporation. The results of the evapotranspiration according to Thornthwait (1948) are shown in Table 4 and Fig. 9. The total evapotranspiration is 1451.49 mm/year.

Table 4. Calculation of potential evapotranspiration in Pirmam area for the period 1992-2017 according to Thornthwait (1948)

Month	Rainfall P (mm)	Evaporation (A pan) mm	Monthly Temp. j (°C)	Annual heat index J (°C)	Latitude corr. constant (La)	Potential Evapotrans. PET (mm)
Oct	62.30	125.30	5.99	65.47	0.95	107.14
Nov	76.90	54.40	3.42		0.80	42.97
Dec	107.50	44.50	2.17		0.76	22.48
Jan	129.30	33.20	1.65		0.81	16.59
Feb	114.20	40.10	1.92		0.82	20.58
Mar	111.50	97.60	3.04		1.02	46.93
Apr	62.20	122.90	4.53		1.13	87.96
May	18.20	191.20	6.38		1.27	155.42
Jun	2.00	256.50	8.61		1.29	234.63
Jul	0.60	267.00	9.91		1.30	284.84
Aug	0.10	254.40	10.01		1.20	266.23
Sep	4.30	178.70	7.85		1.03	165.71
Total	689.10	1665.88				1451.49
a = 1.523

Fig. 9. Monthly evaporation and potential evapotranspiration for the period 1992-2017 in Pirmam area
Water Deficit (WD) and Water Surplus (WS)

Water surplus means that the value of rainfall is greater than the potential evapotranspiration during a given period, while the water deficit means that potential evapotranspiration is greater than the rainfall. The results of the water surplus and water deficit are shown in Table 5 and Fig. 10.

Table 5. Calculation of water deficit and water surplus in Pirmam area for the period 1992–2017

Month	P	PET	APE	WS	WD
Oct	62.3	107.14	62.3		44.84
Nov	76.9	42.97	42.97	33.93	
Dec	107.5	22.48	22.48	85.02	
Jan	129.3	16.59	16.59	112.71	
Feb	114.2	20.58	20.58	93.62	
Mar	111.5	46.93	46.93	64.57	
Apr	62.2	87.96	62.2		25.76
May	18.2	155.42	18.2		137.22
Jun	2.0	234.63	2.0		232.63
Jul	0.6	284.84	0.6		284.24
Aug	0.1	266.23	0.1		266.13
Sep	4.3	165.71	4.3		161.41
Total	689.1			389.84	1152.23

The ratio of (WS) and (WD) are:

$$WS\% = WS/P \times 100$$

$$WS\% = 389.84/689.1 \times 100$$

$$WS\% = 56.57 \%$$

$$WD\% = 100 - WS\%$$

$$WD\% = 100 - 56.57$$

$$WD\% = 43.43 \%$$

Fig. 10. Water surplus and water deficit for the period 1992–2017 in Pirmam area surface Runoff

Surface runoff or overland flow is a rainfall discharge from a catchment that flows through its natural drainage system (Anderson, 2005). Surface runoff in the studied area is represented from October to May; the annual surface runoff is 209.6 mm/year (Table 6 and Fig. 11).

Table 6. Surface runoff values calculated by soil conservation (SCS) method

Months	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Rainfall	27.61	41.35	78.51	112.94	111.30	84.55	67.04	17.96	1.45	1.16	0.03	3.88
Runoff	11	19.5	35	55	40	38.5	10.6

Fig. 11. Relationship between mean monthly rainfall and runoff in (mm) which calculated by SCS method

Groundwater Recharge

Groundwater recharge is one of the most difficult to measure components of the hydrological cycle. The groundwater recharge estimated in the study area according to water surplus and surface runoff according the formula (Groundwater Recharge = Water surplus – Surface runoff) is equal to 180.24 mm/year.

Groundwater Budget

Groundwater budget in the study area is calculated based on an average groundwater recharge value (180.24 mm/year) and the area of the study (130 km²), the basin water recharge is equal to (2.34 x 10⁵ m³/year) according to the annual water budget formula.

Climate Classification

Climate was classified using different methods including Mather (1974), Unep (1992), and Al-Kubaisi (2004) to determine the kind of climate in Pirmam area. The climate type according to Mather classification is based on the value of climate index to find three classes which associated with the rainfall and evapotranspiration. The positive value of the CI represents humid climate while negative value indicates dry climate. This classification mentioned that the climate type is dry-sub humid due to the climate index value (CI) = -5.57, as showed in Table 7.

Table 7. Classification of the climate in the study area, according to (Mather, 1974) in Pirmam area for the period 1992-2017

Climate type	CI range	CI of the study area
Dry-Sub Humid	0.0 to -33.3	-5.57
Semi-Arid	-33.3 to -66.7	
Arid	-66.7 to -100	

The climate type of the Unep (1992) classification is depending on aridity index which is equal to the average annual precipitation over average annual potential evapotranspiration. The aridity index for the study area is 0.47 (AI = 57.43 / 120.96), accordingly, the climate is semi-arid due to the aridity index as shown in table 8.

Table 8. Classification of the climate in the study area, according to (Unep, 1992) in Pirmam area for the period 1992-2017

Climatic Type	Aridity Index Range	AI of the study area
Hyper-arid	< 0.05	0.47
Arid	0.05 – 0.2	
Semi-arid	0.2 – 0.5	
Dry to Sub-humid	0.5 – 0.65	

The type of climate by applying the treatment of annual dryness which based on temperature and quantities of rainfall according to Al-Kubaisi (2004) classification, the values of (AI-1) and (AI-2) are (2.79 and 2.45 respectively) which indicate that the type of climate is Humid to Moist (Table 9).

Table 9. Classification of the climate according to (Al-Kubaisi, 2004) in Pirmam area for the period 1992-2017

Climatic Type -1	Evaluation	Climatic Type -2	Evaluation
AI-1 > 1.0	Humid to Moist	AI-2 > 4.5	Humid
		$2.5 < \text{AI-2} < 4.0$	Humid to Moist
		$1.85 < \text{AI-2} < 2.5$	Moist
		$1.5 < \text{AI-2} < 1.85$	Moist to Sub-Arid
AI-1 < 1.0	Sub-Arid to Arid	$1.0 < \text{AI-2} < 1.5$	Sub-Arid
		AI < 1.0	Arid

CONCLUSIONS

The water balance equation is a useful concept, and can be employed successfully if the meteorological conditions and climatic elements of the basin are known. The coefficient of variance shows that the values of the rainfall of winter and spring are the most effective for creation of discharge in the area. Surface runoff is about % 30.4 of the rainfall and groundwater recharge of the area is about % 26.2 of the rainfall.

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