

RAINFALL IN THE GREAT ZAB BASIN RIVER IN IRAQ FOR THE PERIOD OF (1984- 2013)

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ABSTRACT

Rainfall is regarded as one of the most important climatic factors that affects the region in time and space and analyzing the amount of precipitation in the study Area by analyzing the climatic factors in (Salah al- Din, Erbil, Zakhu, and Dohuk) stations as well as the range of influence of other climatic factors on the monthly, seasonal and annual rainfall and analyzing coefficient of Fluctuation, coefficient of deviation of rainfall in addition to the number of rainfall days for the period of (1984-2013). Moreover, the study aims to analyze the climatic classification of measuring the number of dry years Besides, the study deals with the impact of precipitation element on the surface runoff together with soil conservation from erosion, and building dams, water reservoirs, maintenance of drainage system, decreasing Drought in summer which help in land development process, and planning of building agricultural, industrial and urban projects.

INTRODUCTION:-

Rainfall is considered one of the most important aspects of water vapors condensation in the air and precipitation of clouds -charged with water droplets and ice crystals to the earth's surface. one of the key forms of Rainfall is "Rain" However, the climate type determines type of rainfall, therefore, it affects the amount of river runoff because river discharge relies basically on climate especially rainfall together with its type, period of perception, amount of precipitation and Average of river vapor.

Rainfall is deemed to be the basic tributary of the Great Zab basin. Yet, water levels increase in concurrence with ice melting and rise of temperature in April and May, due to the fact that the amount of water drainage is associated with the type of precipitation together with its temporal and spatial distribution, when heavy rain occurs, there is an increase in river drainage and there is a peak run off coincided with the rise of temperature and ice melting in spring and summer. The

nature of formulations in terms of permeability and storability have a direct impact on the amount what rivers provide during Rainfall and icefall stoppage according to the year features whether it is humid, Average or dry as well as the influential factors including (circles of latitude and height above mean sea level and the impact of closeness and distance of sea level.

Access of mean depressions and high altitude into the great Zab basin in which rains are marled by oscillation from one year to another so it is probable to precipitate high a mount of rain in these areas which overrode the general average while in certain years, low a mount of rain may precipitate in the same regions. Foe this reason, estimation of rain a mount is very necessary in many applied fields. mover over, It should betaken into consideration the a mount of perticipated rains which is considered one of the environmental variables notwithstanding, ignoring these factors resulted in failure of these projects- Accordingly, It is advisable to take great care of forests and farming and

agriculture as well as protecting them from rain erosion in mountain areas. Furthermore, It is necessary to store water in winter to take full advantage of it in summer.

It is beneficial to activate tourism by taking great care of the most marvelous views, tributaries, streams, fountains and springs for touristic purposes.

Firstly: Statement of the problem

The problem of the current study revolves around the following questions:

- 1- What are the effective factors that affect rainfall in Iraq, and what are the natural features in time and space variance of Rainfall ?
- 2- What are the effective meteorological factors of the study Area ?
- 3- How could rainfall vary in time and space and what are the factors of rain fluctuation in the study Area ?

Secondly: Hypothesis

It is hypothesized that:

- 1- The effective factors that affect the features of rainfall including stable and variable factors which affect the study area through its influence upon the Natural features of mountain area of the study area.
- 2-The meteorological elements (temperatures, atmospheric depressions, winds, relative humidity and evaporation).
- 3- Changes of meteorological elements in variance of temporal and spatial rainfall accompanied with rainfall oscillation and Annual and monthly deviation and quantitative assessment of rainfall by using suitable statistical means or methods.

Thirdly, Aims of the study

The paper aims at:

- 1-Demonstrating the geographical and meteorological factors affecting rainfall variance temporally and spatially among stations of the study area and determining its amount of Fluctuation.
- 2- Studying the amount of monthly, quarterly and annually rainfall.
- 3-Calculating the amount of monthly and annual rainfall, coefficient of seasonal Fluctuation of rainfall of the study area and Analyzing the climatological elements in the stations of the great zab river basin region in the tables, figures and climatological changes during the period between. (1984 and 2013).

Fourthly: Justifications of the Study

Studying the impact of rainfall on runoff system in the great zab basin in order to state the amount of participating level of rainfall in the drainage system because rains are considered the key source of river feed in which all human activities rely on especially agriculture.

Fifthly: Limits of Study AREA

The limits of the study area represented in:

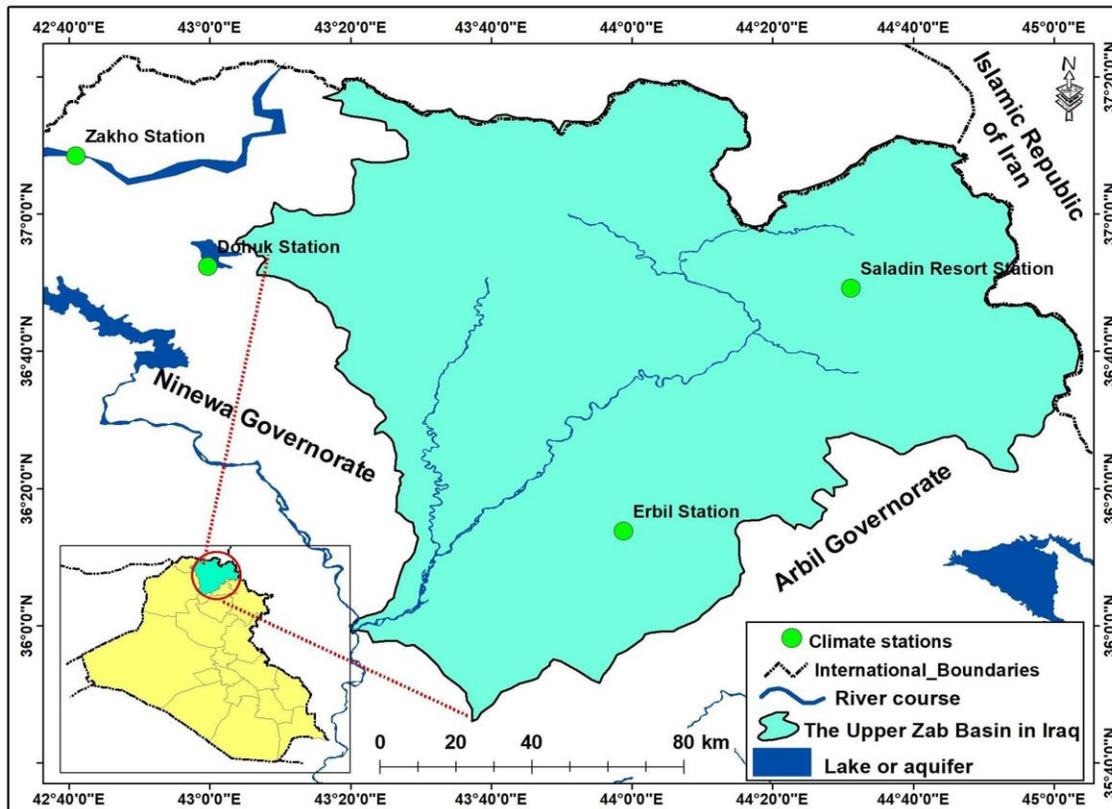
- 1- The spatial limits: The Great zab River Basin is locted in Iraq-Erbil and Duhuk Governorates in the North Area of Iraq. The stations include (SALAH AL-Din Summer resort, Erbil, Dohuk and ZAKHO) As shown in Table (1) and Map (1).
- 2-The Temporal Limits: The study is restricted to the period between (1984 and 2013).

Table (1)The Climatological Stations in the Study Area

Serial No.	Stations	Circles of Latitude	Longitude	Height of Station above sea levelPer meter
1	SALAH al- Din	36° 23'	40° 20'	1088
2	Erbil	36° 09'	44° 03'	420
3	ZAKHO	33° 25'	43° 18'	442
4	DOHUK	34° 17'	42° 37'	860

Source: The General Directorate of Iraqi Meteorology -Baghdad - Ministry of Transportation and Communication.

Map (1) The Climatological Stations in the Study Area



Source: The General Directorate of Iraqi Meteorology -Baghdad- Ministry of Transportation and Communication.

THE NATURAL FEATURES OF THE GREAT ZAB RIVER BASIN IN IRAQ:-

The Great Zab River Basin is regarded as the most important basins in Iraq. It was one of the largest tributaries of the Tigris river. This area occupies the Northern and Northeastern parts of Iraq in Erbil and Dohuk governorates. The Area of the Basin amounts to (16600) km² with percentage of (64%)⁽¹⁾ and it forms (33.4%) out of the Tigris river water. As for the great Zab river basin boundaries to the North, the Great Zab basin borders on the Zagros Mountains, which adjoins

the Iraqi, Turkish and Irawan border line, To the west, It borders with a line divides waters between them and the khabur. As for Iraq, it borders with Natural characteristics, to the Eastern part, there is a line that divides waters between the great Zab river basin a the lesser Zab river basin following the mountains chains in Rawandooz mountains, shaqlawa, Slah ad- Din mountains, Makhmour High lands⁽²⁾, It appeared that the tributaries of the great Zab basin run in extreme rough areas surrounded by gorges (Narrow Vallies) straits with sloping banks including, The great Zab river tributaries: Al- Sabina tributary, Shamdinan tributary,

(1) High council of Agricultur, Burean of coordination and Agricultural Research, **Soil maintenance and river basin management**, 1978, Al- Arshad Publishing House, Baghdad, P.20.

(2) Mohammed Saeed Kitana, (1972), **Tigris basins North downstream of the great Zab importance of Aski Kalak, Mousl and Bekhma project for Iraq**, Al- Mosul Journal issue (11), P.15.

Rizan tributary, Rawandooz tributaries, Bastora tributary and Khazir river, As for the soil of the Great Zab river basin, it differs from one place to another according to the diversity of climate, surface features and natural plants according to its type, sources of deposits, kind of soil, its permeability which differs due to the difference in the height, slope level and erosion factors, As for the Natural plants, they differ from one place to another according to the amount of precipitation and the density of forests differs from one area to another so the Northern and Northeastern foothills are marked by low density due to the fact that.

They are located in the rain shadow whereas the southern and south western foothills facing wet winds are surrounded by forests which is influenced on rainwater drainage system and its runoff in rivers, Forests also act as shelterbelts and forests can retain excess rainwater, prevent extreme run-offs and reduce the damage from flooding, They can also help mitigate the effects of droughts. The Natural plants of the great Zab basin are transferring among forests and Mountain plants on one hand and desert herbs on the other hand. Besides, most of these plants are annual and the amount of rainfall led to grow these plants and these plants appear in the form of trees, and grass.

THE CLIMATIC FACTORS AFFECTING THE STUDY AREA:-

The climatic factors are considered the most most natural influential controls affecting the study Area due to the fact that climate plays a big role in the river drainage which affects directly on the basin waters, For this reason, Hydrology of the basin is a reflection of the prevailing climatic conditions in the study Area and the climatic impact varies from one place to another. The most influential factors are as follows.

1: The Ordinary Temperature:-

The Ordinary temperature varies among stations and it increases the more we move from North to south- the Area climate is characterized by extremity among the year's seasons owing to the fact that there are mountain high lands in the Northern Area and the temperature difference affects the amount of run-off and thus temperature is one of the most important climatic factors since it affects directly on other factors. Table (2) and figure (1) show that the Area climate falls

within Mediterranean region (i.e, increase in temperature is summer and decrease in winter). There is also a difference among averages monthly temperature in stations for the period extending from (1984 to 2013), Where temperature recorded in January in Dohuk station of about (4C^o) Celsius and it highly recorded in Erbil station of about (8.6 C^o) celsius. During summer, temperature increases in July and it reaches (35.8 C^o) celsius due to approaching sunlight beams from vertical or semi-vertical, an increase of length daylight, the sky is devoid of clouds, and cessation of rainfall. It shows that the Lowest rest temperature that is recorded in Dohuk station amounts to (26 C^o) celsius. Table (2) shows that the Averages of temperature in July is higher than August for the whole climatic stations.

This feature makes the climate of the study Area continental where the continental climates of ten have a significant annual variation in temperature (hot summers and cold winters) in that July is the hottest month in mainland areas and August is the hotter month in areas influenced by seas due to the fact that the variation of acquiring main lands and water of temperature⁽³⁾, The length of daylight differs according to latitude circles in the restricted Areas among sunbeams alignment or perpendicularity- daylight becomes longer than any Area and starts to be shortened North ward and south ward alignment Angel⁽⁴⁾, As shown Map (2).

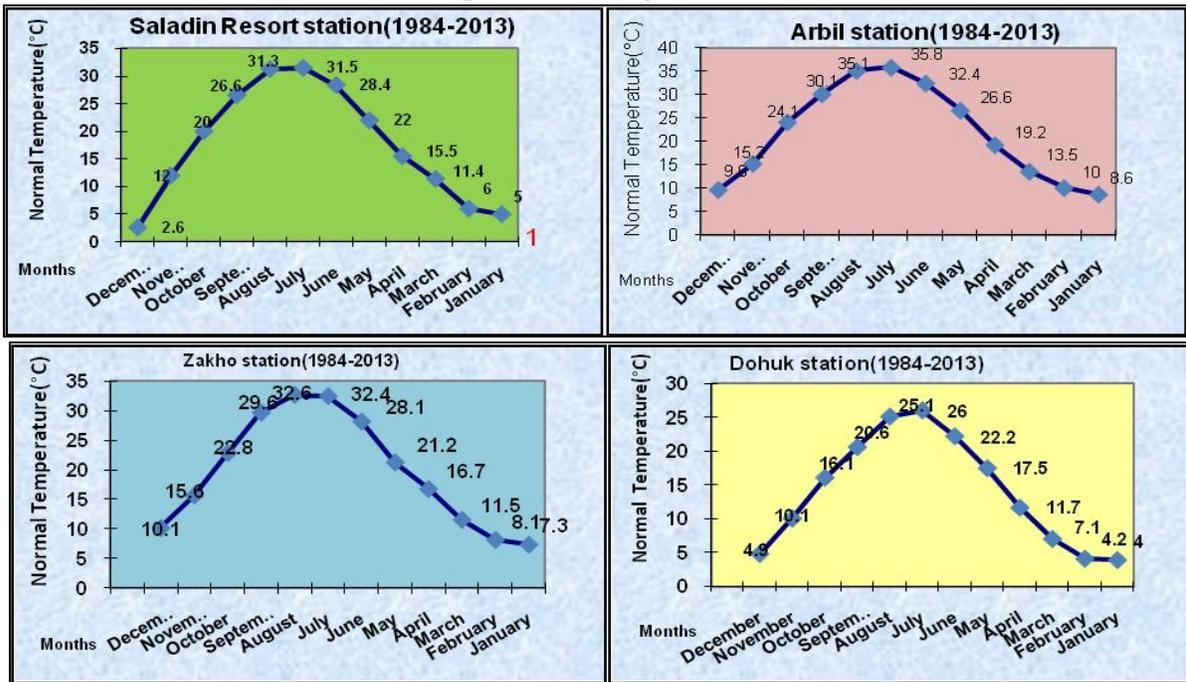
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- (3) Ismael, Saeed Ismael, **Characteristics of drainages of the Great Zab river in province of Kurdistan in Iraq**, college of Arts. University of Salah al-Din. Unpublished Master thesis, Baghdad, 2006, P.47.
 - (4) Mohammed Jaefor Al- Samaray: **The Spatial variation of the climatic factors in Iraq and determining water territory**. The geographical Association Journal, Issue (42), 1999, P.198.

Table (2) shows monthly and annual averages of temperatures (C°) in stations of the study Area for the period extending from (1984 to 2013)

Stations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Annual Average
Salah al-Din Summer Resort	5	6	11.4	15.5	22	28.4	31.5	31.3	26.6	20	12	2.6	18.1
Erbil	8.6	10	13.5	19.2	26.6	32.4	35.8	35.1	30.1	24.1	15.2	9.6	21.7
Zakhu	7.3	8.1	11.5	16.7	21.2	28.1	32.4	32.6	29.6	22.8	15.6	10.1	19.7
Dohuk	4.2	4.2	7.1	11.7	17.5	22.2	26	25.1	20.6	16.1	10.1	4.9	14.1

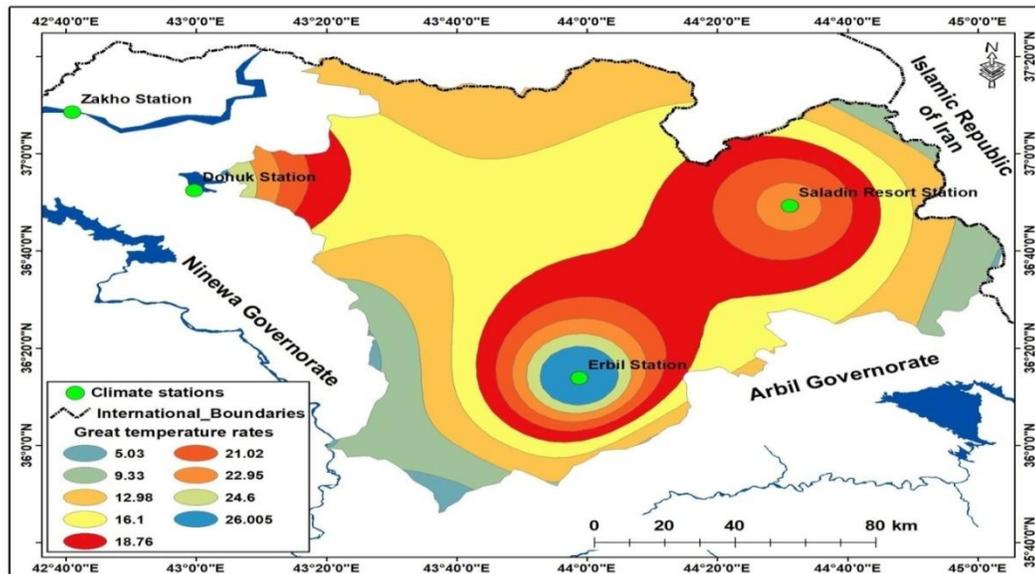
Source: The Iraqi General Directorate of Meteorology and Seismology of the Kurdistan region- unpublished data.

Figure (1) shows monthly averages of temperatures (C°) in stations of the study Area for the period extending from (1984 to 2013)



source: Figure (1) is the researcher’s own adaptation by relying on table (2).

Map (2) shows the lines of ordinary temperature (C°) in the study area



source: Map (2) is the researcher’s own adaptation by relying on table (2)(ARC Map 10.4 programme)

2- Maximum Temperature :-

The Analysis of Table (3) and Figure (2) shows the fact that there is a variation among monthly Average of Maximum Temperature in the Four stations due to the exposure of the study Area to different air masses as well as Height above mean sea level for the period extending from (1984 to 2013), Temperature is recorded, in station of Salah Al-Din summer resort, (8.2 C°) due to the Height of the station above sea level and decrease in value of incidence angle of solar radiation. The maximum temperature in station of Erbil is recorded (12.6 C°) and in summer, where the sun is perpendicular in Tropic of cancer, and the maximum temperature in July is recorded in stations of Erbil and

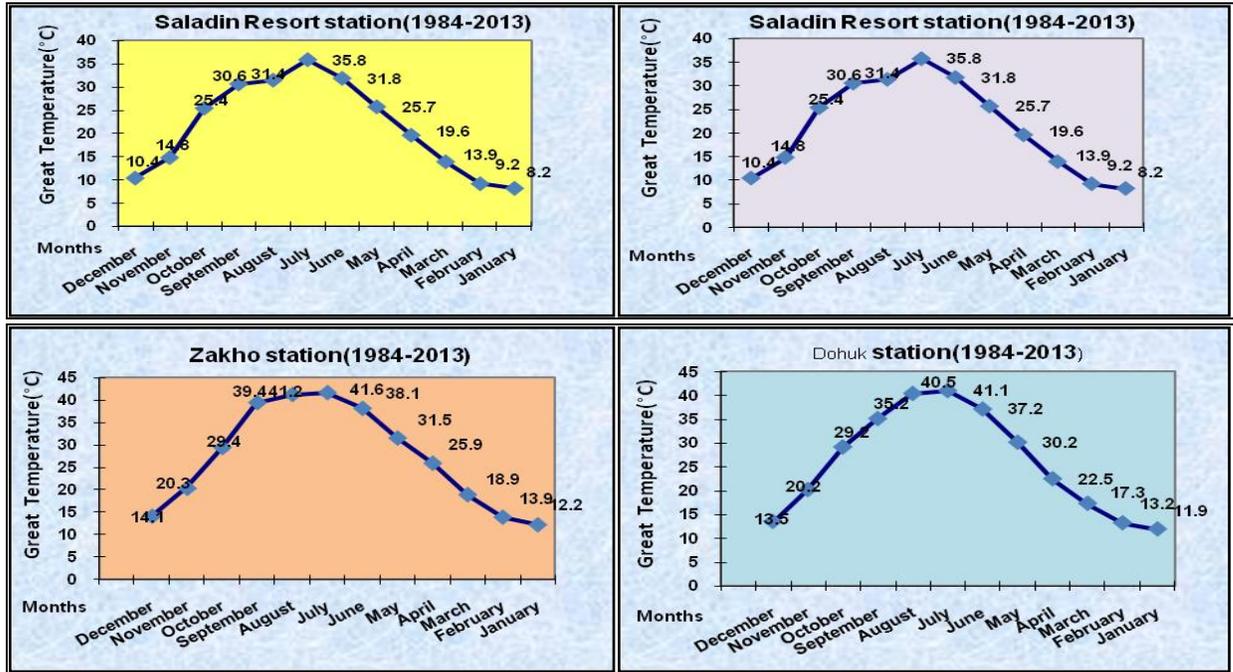
ZAKHU amounts to (41.6C°) due to the clear atmosphere and the minimum temperature Salah al-din station amounts to (35.8C°),The surface features also play an important role in modifying temperatures. It appeared that there is clear variation in monthly Averages of Maximum temperatures in the four given stations and the minimum annual temperature in station of Salah al-Din which amounts to (21.9C°) and the maximum annual temperature in stations of Erbil and Zalkhu which amounts to (27.2C°). The Annual Average decrees the move we move from the North to the south western as a result of the variation of circles of altitude and surface features and other local features as shown in Map (3).

Table (3)Shows the monthly and annual Averages of Maximum temperature (C°) in the stations of the study Area for the period extending from (1984 to 2013)

Stations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Annual Average
Salah al-Din Summer Resort	8.2	9.2	13.9	19.6	25.7	31.8	35.8	31.4	31.6	25.4	14.8	10.4	21.9
Erbil	12.6	14.3	18.7	24.4	34	38.4	41.6	41.4	36.9	30.5	20.4	14.5	27.2
Zakhu	12.2	13.9	18.9	25.9	31.5	38.1	41.6	41.6	39.4	29.4	20.3	14.1	27.2
Dohuk	11.9	13.2	17.3	22.5	30.2	37.2	41.1	40.5	35.2	29.2	20.2	13.5	26

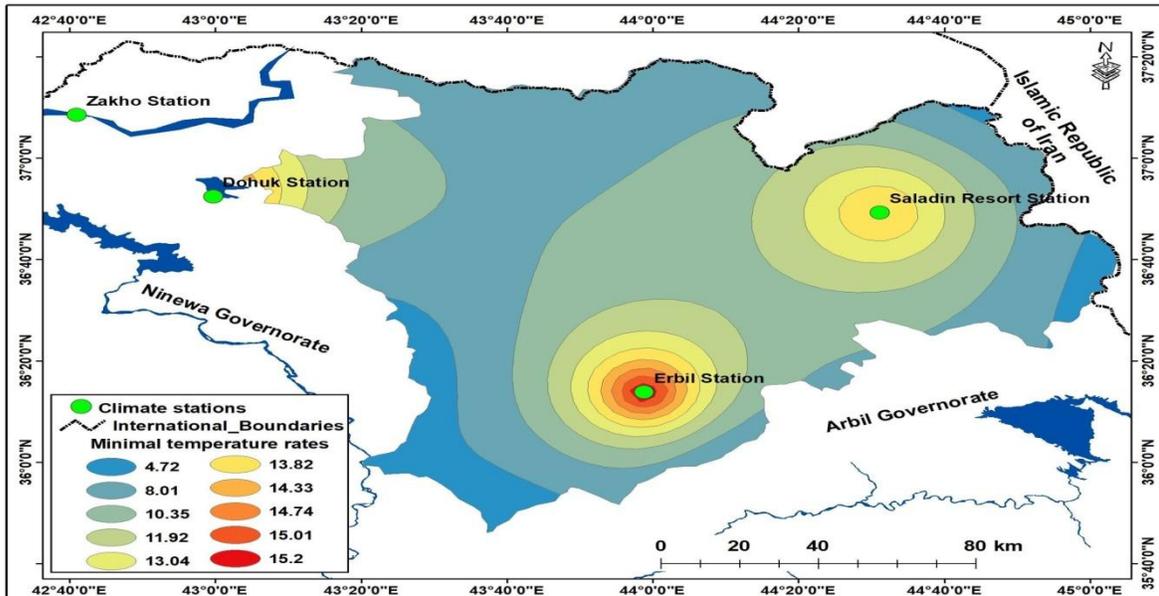
Source: The Iraqi General Directorate of Meteorology and Seismology of the Kurdistan region- unpublished data.

Figure (2) Shows the monthly and annual Averages of Maximum temperature (C^o) in the stations of the study Area for the period extending from (1984 to 2013)



source: Figure (2) is the researcher's own adaptation by relying on table (3).

Map (3) Shows the lines of Maximum temperature (C^o) in the study Area for the period extending from (1984 to 2013)



Source :Map (3) is the researcher's own adaptation by relying on table (3)ARC Map 10.4 programme)

3- Minimum Temperature :-

The Analysis of Table (4) and Figure (3) shows that there is a variation among monthly Average of Maximum Temperature in the Four stations for the period extending from (1984 to 2013) and in January, the temperature is recorded in Salah al-Din station (2.1C^o) and the Maximum temperature in Zakhu as (26.8C^o) due to the clear atmosphere and daylight length and air drought as well as them are ??? air

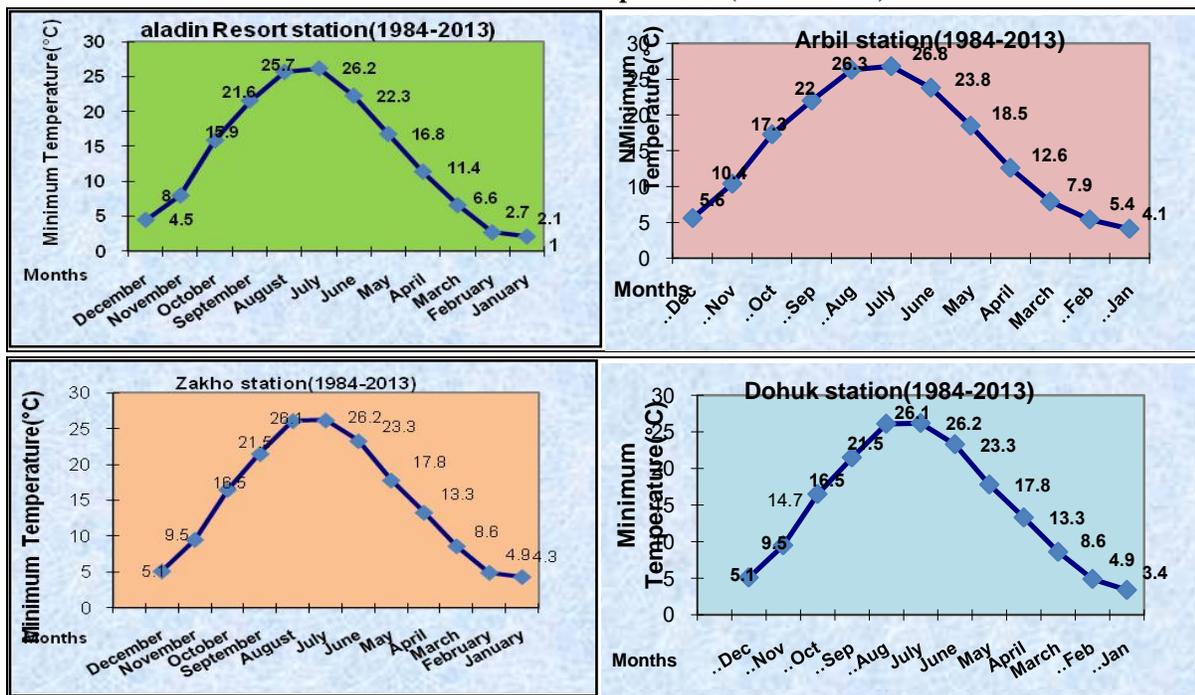
masses and there is a variation in monthly Averages of temperature and the minimum annual Averages is recorded in Salah al-Din station amounting to (13.7C^o) due to a decrease in temperatures as a result of the exposure to cold air masses as well as there are high mountains which afflict the wind movement and Area falls within the Mediterranean climate and the Maximum annual Average in Erbil station amount to (15.2C^o) as shown in Map (4).

Table (4)Shows the monthly and Annual Averages of minimum temperature (C^o) in the stations of the study Area for the period of (1984 to 2013)

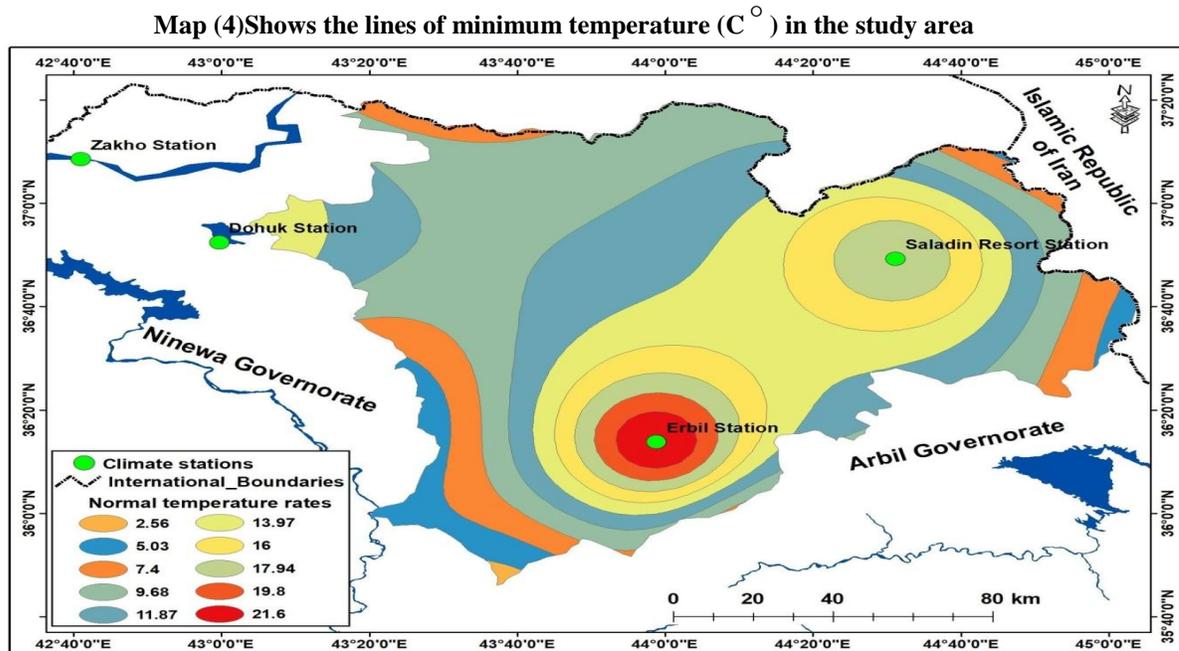
Stations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Annual Average
Salah al-Din	2.1	2.7	6.6	11.4	16.8	22.3	26.2	25.7	21.6	15.9	8	4.5	13.7
Erbil	4.1	5.4	7.9	12.6	18.5	23.8	26.8	26.3	22	17.3	10.4	5.6	15.2
Zakhu	4.3	6.2	7.8	13	17.5	23.3	26.8	26.4	21.7	16	9.7	4.9	14.8
Dohuk	3.4	4.9	8.6	13.3	17.8	23.3	26.2	26.1	21.5	16.5	9.5	5.1	14.7

Source: The Iraqi General Directorate of Meteorology and Seismology of the Kurdistan Region-unpublished data.

Figure (3)Shows the monthly and Annual Averages of minimum temperature (C^o) in the stations of the study Area for the period of (1984 to 2013)



source: Figure (3) is the researcher’s own adaptation by relying on table (4).



4- Winds:-

Winds are considered the most important climatic factors. Winds can be defined as air currents or moving mass of air from high pressure areas to low pressure areas. Typically, air under high pressure normally moves towards areas under low pressure. Thus, the greater the pressure difference, the faster the flow of air which creates moving air with considerably strong force⁽⁵⁾. Wind speed on the open earth surface is larger than restricted land surface such as plants. The minimum wind speed is measured during Night and early morning due to the clear and stable weather. Besides there is a decrease of temperature at night and early morning⁽⁶⁾.

The Analysis of Table (5) and Figure (4) shows that there is a variation Average of wind speed and the Maximum wind speed is recorded in January in Erbil station which amounts to (3) meter per second (3 m/s)

and monthly Averages varied in summers and the maximum wind speed is recorded in July in Erbil station which comes to (3.1 m/s), The increase of wind speed stems from the fact that the area is open from the west side as well as the surface flatness. The minimum wind speed is recorded in Dohuk station which comes to (1.1 m/s) and Zakhu is recorded as (1.1 m/s) and the maximum wind speed is recorded in Erbil which comes to (2.7 m/s) due to its basin position and surface features of the Northern Area impeded wind movement and wind speed increases in the southern Area as a result and wind speed increases in the southern Area as a result of surface regression^o) as shown in Map (5).

(5) Danita Martin. **Climates of the world.** pawn- polish scientific publishers wars wawa, 1992, P.3-4.

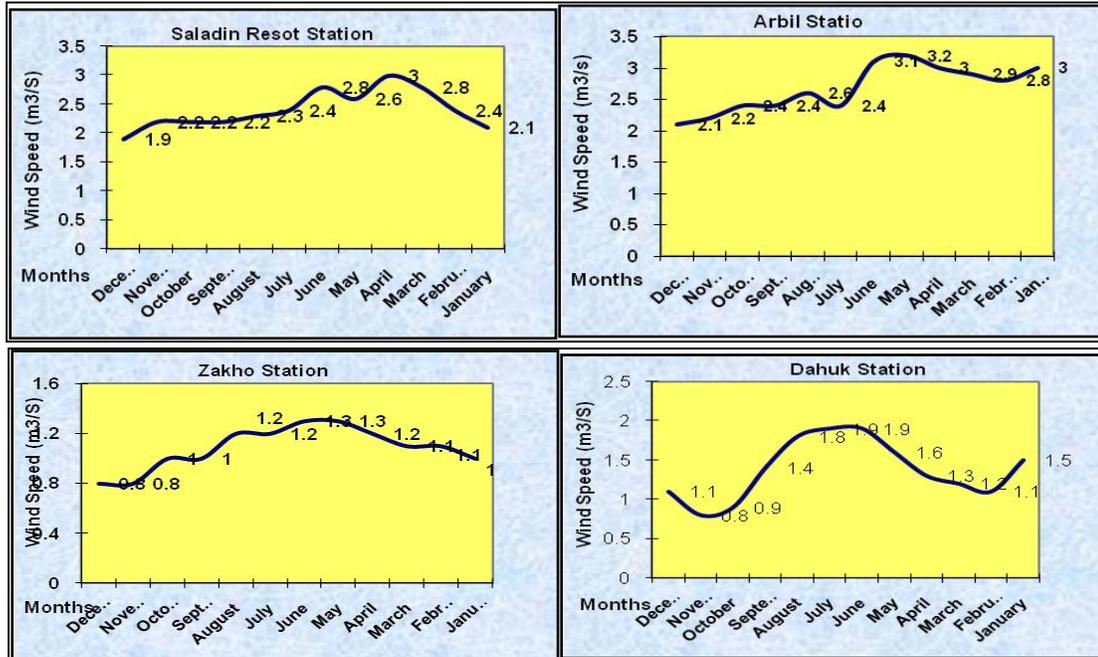
(6) Ali Abdulzahra, Al- Eaeli. **Bases and principles of Meteorology and climatology,** Ibid, P.72 .

Table (5) Shows the monthly and Annual Averages of wind speed (m/s) in the stations of the study Area for the period of (1984 to 2013)

Stations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Annual Average
Salah al-Din Summer Resort	2.1	2.4	2.8	3	2.6	2.8	2.4	2.3	2.2	2.2	2.2	1.9	2.4
Erbil	3	2.8	2.9	3	3.2	3.1	2.4	2.6	2.4	2.4	2.2	2.1	2.7
Zakhu	1	1.1	1.1	1.2	1.3	1.3	1.2	1.2	1.1	1	0.8	0.8	1.1
Dohuk	1.5	1.1	1.2	1.3	1.6	1.1	1.9	1.8	1.4	0.9	1.8	1.1	1.4

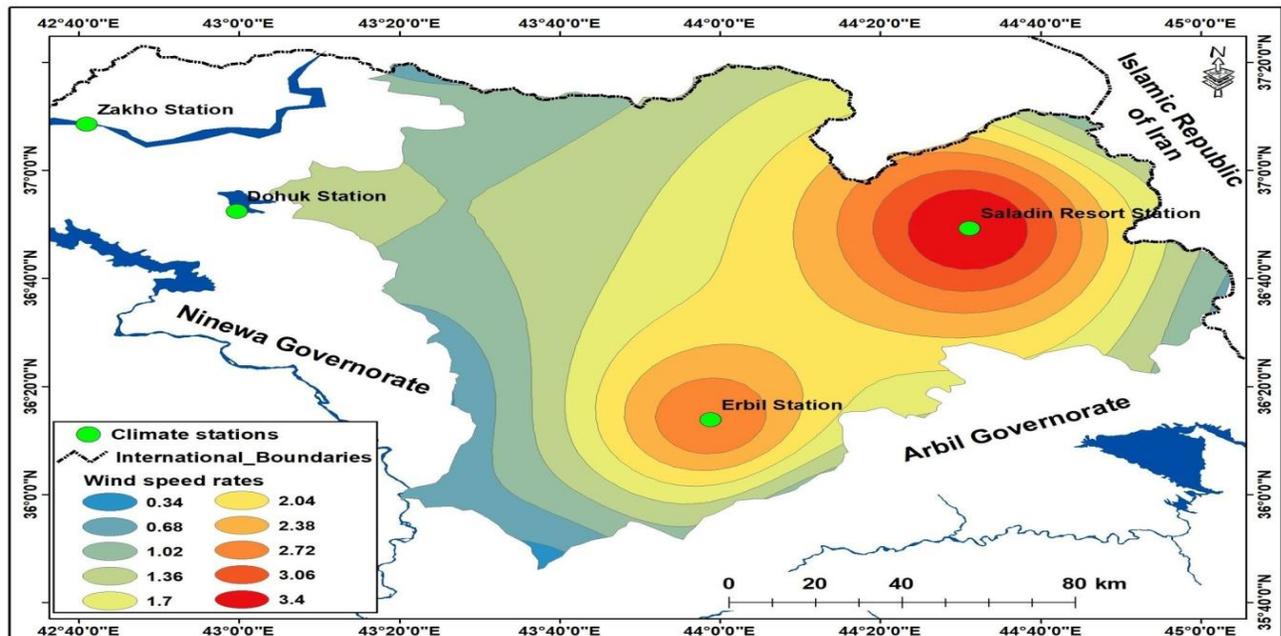
Source: The Iraqi General Directorate of Meteorology and Seismology of the Kurdistan region- unpublished data.

Figure (4) Shows the monthly and Annual Averages of wind speed (m/s) in the stations of the study Area for the period of (1984 to 2013)



source: Figure (4) is the researcher's own adaptation by relying on table (5).

Map (5) Shows speed of wind (m/s) in the stations of the study Area for the period of (1984 to 2013)



source: Map (5) is the researcher's own adaptation by relying on table (5)ARC Map(10.4) programme.

5- Relative Humidity:-

The Relative Humidity is affected by the local factors and Height above mean sea level. Thus, the relative humidity varies in the study Area and the relative humidity is influenced by temperatures since an increase in temperatures led to shortage of the relative humidity in the air and then an increase of water losses due to the process of evaporation.

The Analysis of table (6) and Figure (4) shows that a variation in the monthly Averages of the relative humidity among the stations of the study Area from one month to another, the relative humidity increases in winter and the relative humidity increases in January due to a decrease in temperatures and an increase in clouds Appearance as well as the impact of humid air masses and repetition of air depression which resulted in rainfall, the maximum on relative humidity is

recorded in January in Dohuk station which comes to (77%) and the minimum relative humidity is recorded in ZAKHU which comes to (60.6%). The monthly Averages also varied in Summers. Where the relative humidity decreases to a large scale due to an increase of temperatures and cessation of rainfall and an increase of falling of solar radiation Angle and Length of daylight, The Maximum relative humidity is recorded in July in Salah al-Din station (35%) and the minimum of the relative humidity is recorded in Zaku (19.5%).

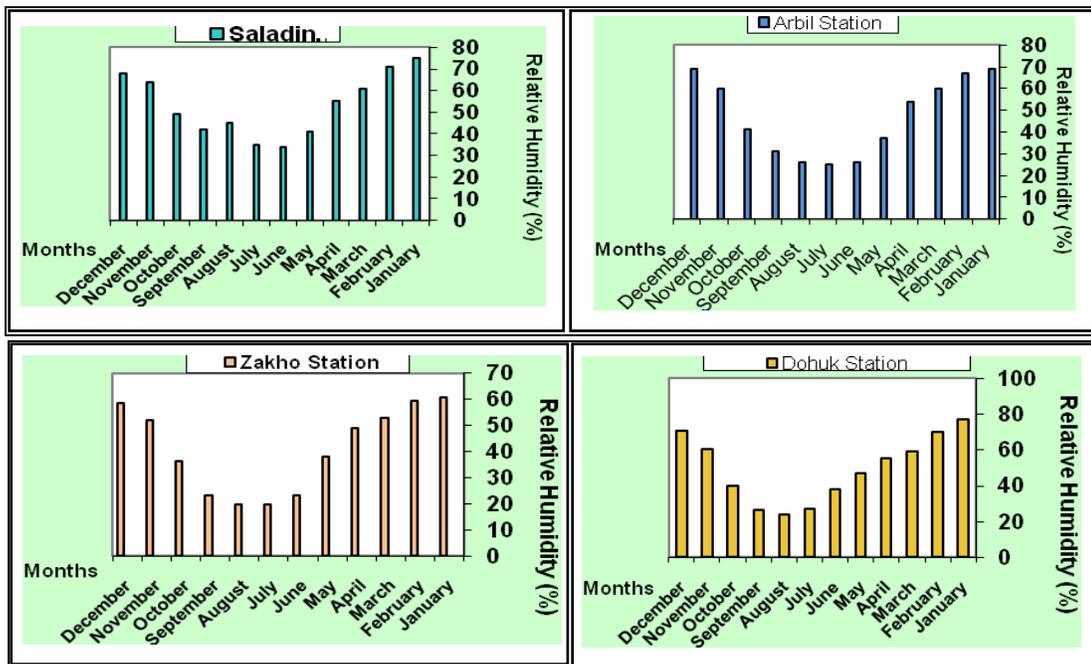
The Analysis of table (6) states the annual average of the relative humidity in the study Area stations. The Maxim relative humidity is recorded in Salah al-Din station of abut (53.3%) and the minimum relative humidly is recoded in ZAKHU of about (41.1%) due to the high pressure indirectly as shown in Map (6).

Table (6) Shows the monthly and Annual Averages of the relative humidity (%) in the stations of the study Area for the period of (1984 to 2013)

Stations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Annual Average
Salah al-Din Summer Resort	75	71	61	55	41	34	35	45	42	49	64	68	53.3
Erbil	69	67	60	54	37	26	25	26.2	31	41.4	60	69	47.1
Zakhu	60.6	59.5	53.1	49	38.2	23.2	19.5	19.8	23.1	36.5	51.9	58.7	41.1
Dohuk	77	69.8	58.8	55.2	46.7	38.1	26.7	23.9	26.1	39.9	60.2	70.3	49.3

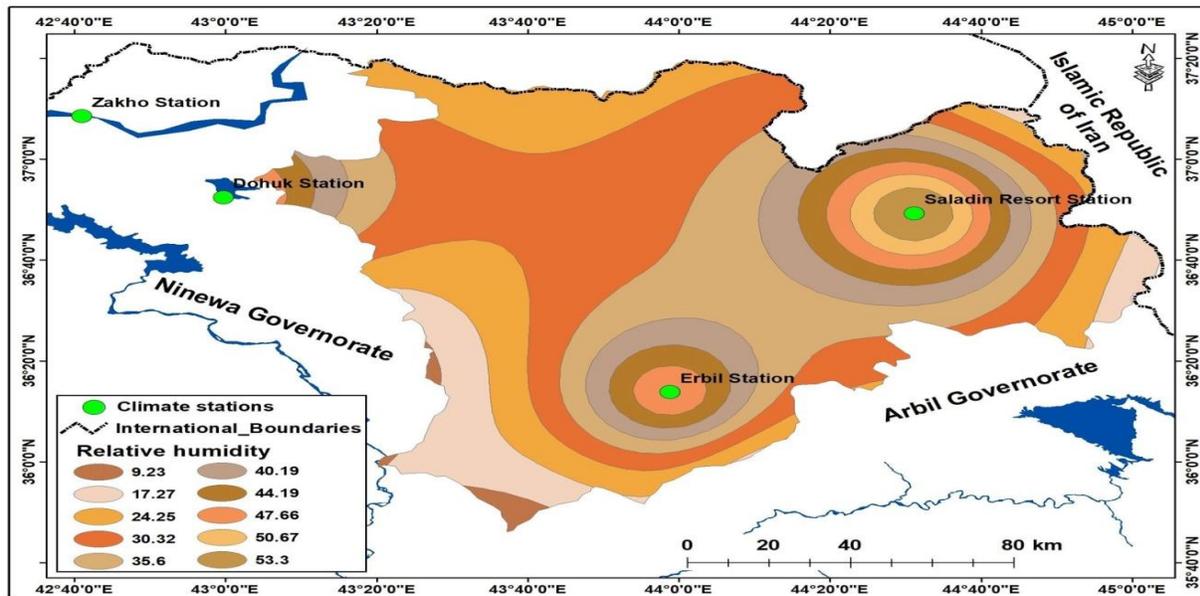
Source: The Iraqi General Directorate of Meteorology and Seismology of the Kurdistan region- unpublished data.

Figure(5) Shows the monthly and Annual Averages of the relative humidity (%) in the stations of the study Area for the period of (1984 to 2013)



Source: Figure (5) is the researcher's own adaptation by relying on table (6)

Map (6) Shows the relative humidity (%) in the stations of the study Area for the period of (1984 to 2013)



source: Map (6) is the researcher's own adaptation by relying on table (6) ARC Map (10.4) program.

6- Evaporation

Evaporation is regarded as one of most important climatic factors which delimit the amount of run - off waters in rivers and water features. Evaporation is affected by many factors such as length of solar radiation hours, temperature, winds speed and the relative humidity as well as the Nature of surface Area through which evaporation occurs, the other factors include depth of water features, level of underground water and plant cover. Accordingly, there is a total climatic evaporation⁽⁷⁾, which is the maximum evaporation that ever happened and it is affected by climatic factor, There is an inverse relation between the amount of precipitation and the amount of evaporation by adopting the amount of temperature and the amount of precipitation because they are interrelated processes⁽⁸⁾.

The Analysis of Table(7) and figure (6) shows that the amount of evaporation varies from one month to another and from season to another. The minimum amount of evaporation is recorded in January in Salah al-Din station of about (39 mm) and the maximum amount of evaporation in Erbil amounts to (49.5 mm). Evaporation in creases in summers. The maximum amount of evaporation is recorded in July in Dohuk station of about (362.5 mm) and the minimum amount of evaporation in Salah - al- Din station of about (327.9 mm). Table (6) shows that there is a variation in the annual amount of evaporation among stations from one year to another. The maximum amount of exaporation is recorded in Erbil station of about (2422.5 mm) and the minimum amount of evaporation in Salah al- Din station of about (1749.7 mm), as shown in Map (7).

(7) Noman Shehaden, **Climatology**, Edition (1), Dar Al- Safaa for publishing and Distribution, Amman, 2009, P.127.

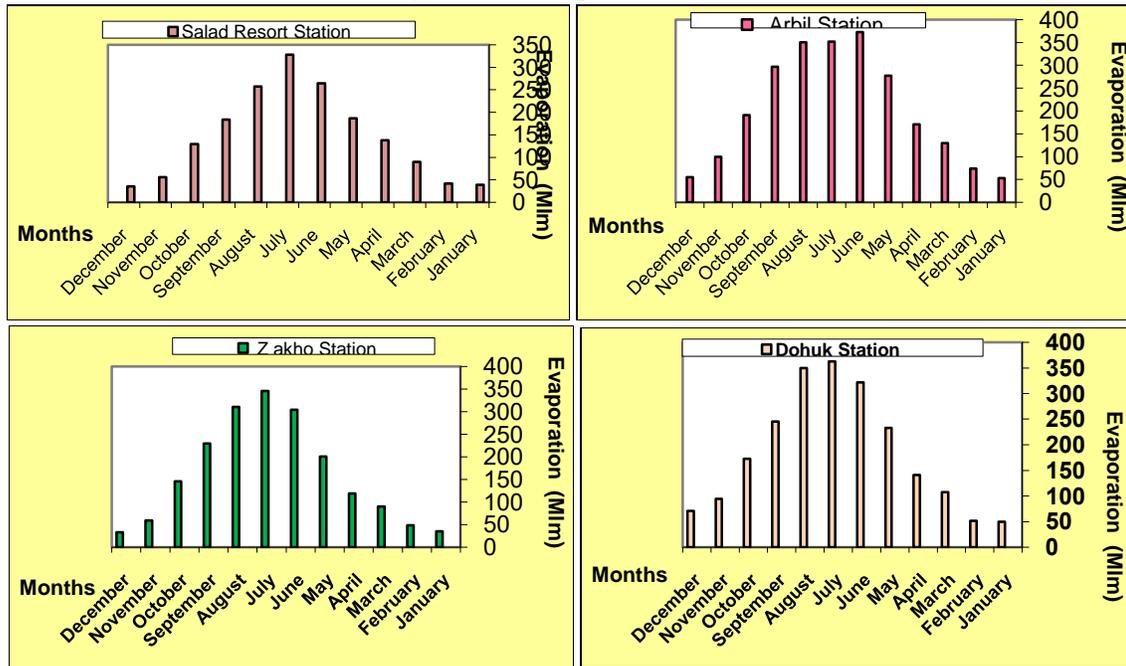
(8) Adel Saeed Al- Rawy, Qusay Abdul Majeed Al- Samaray. **The Applied Climatology**, DAR- Al- Hikma for publishing, Mosul, 1990, P.99.

Table (7) Shows the amount of monthly and annual evaporation (m m) in the stations of the study Area for the period of (1984 to 2013)

Stations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Annual Average
Salah al-Din Summer Resort	39	41.7	89.9	137.8	186.7	264.1	327.9	257.7	184.1	129.6	55.8	35.4	1749.7
Erbil	52.7	74.2	129.8	170.5	277.4	372.9	352.1	350.3	296.6	191.1	99.6	55.3	2422.5
Zakhu	35.2	48.5	90.2	119	200.8	304.3	345.9	310.5	229.4	145.9	59.5	33.3	1922.5
Dohuk	49.5	51.4	107.3	140.9	233.2	321.7	362.5	349.8	245.3	172.8	94.6	71.1	2200

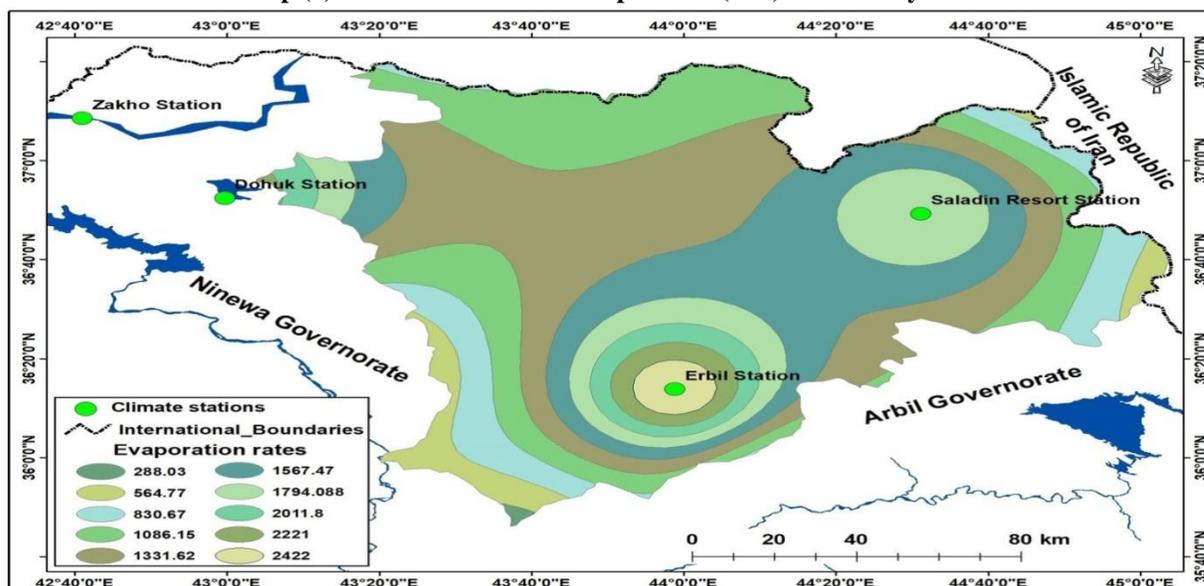
Source: The Iraqi General Directorate of Meteorology and Seismology of the Kurdistan region- unpublished data.

Figure(6) Shows the amount of monthly evaporation (m m) in the stations of the study Area for the period of (1984 to 2013)



Source: Figure (6) is the researcher’s own adaptation by relying on table (7)

Map (7) shows the amount of evaporation (mm) in the study area



source: Map (7) is the researcher's own adaptation by relying on table (7)ARC Map (10.4) programm.

Seventhly: Precipitation

1- Rainfall:-

Rainfall is considered one of the climatic factors in the study Area that affects the amount of water level in the geat Zab basin the amount of rainfall affects to a large scale in the Nature of river drainage, the more rainfall increases, the more the amount of drainage increases. Thus, most of rainfall of the study Area falls within the Midetterean climate and this type of rainfall is regarded as hurricane and or graphic precipitation due to the highlands- precipitation varies according to the height of sea level and a number of mean and merged or graphic depressions⁽⁹⁾ as well as closness and distance from water features and cloud distributor factor which affect the spatial and temporal variation of the amount of rainfall in Iraq⁽¹⁰⁾, Rainfall occurs in the cold alp of the year in winter as well as the two transitional seasons (Autumn and Spring) and ceased in

summer,Rainfall may last many hours if the hurricane speed system is slow⁽¹¹⁾, Monthly rainfall distributors are affected by a cluster of climatic factors including percentage cloudiness and type of air musses (continental, sea) and the prevailing thermal system in the study Area. More one and the astronomical position of the station and land features.

The Analysis of the amount of rainfall in table (8) and figure (7) shows that there is a variation in the amount of rainfall in the stations of the study Area in that it varies spatially and temporarily. The maximum rainfall is recorded in January in Zohuk station of about (104.2 mm) and the minimum rainfall is recorded in Erbil station of about (75.7 mm) due to the approaching of cold air masses, atmospheric depressions and humid cold fronts. Rainfall increases in February and the maximum rainfall is recorded in Zakhu station of about (104.4 mm) and the minimum rainfall in Erbil station of about (75.9 mm).

In Spring, rainfall varies from one month to another, the maximum rainfall is recorded in March in Salah al-Din station of about (100.0 mm) and the minimum rainfall is recorded in Erbil station amounting to (69.2

(9) Mohammed Jafer Al- Samaray. **The Spatial Variation of the climatic factors in Iraq and determing water territory**, P.201.

(10) Noman Shehadha, **Seasonal of rainfall in the eastern Area of Mediterranean Sea**, Studies Journal, Vol (12), Issue (7), 1985, P.104.

(11) Fadhel Baqer Al- Hasany, Ahmed Saeed Haded, **Climatology**, University of Baghdad, 1984.

mm) due to a decrease in mean atmospheric depressions and an increase of temperatures. In Autumn, rainfall stats in September but in little amount, and in January

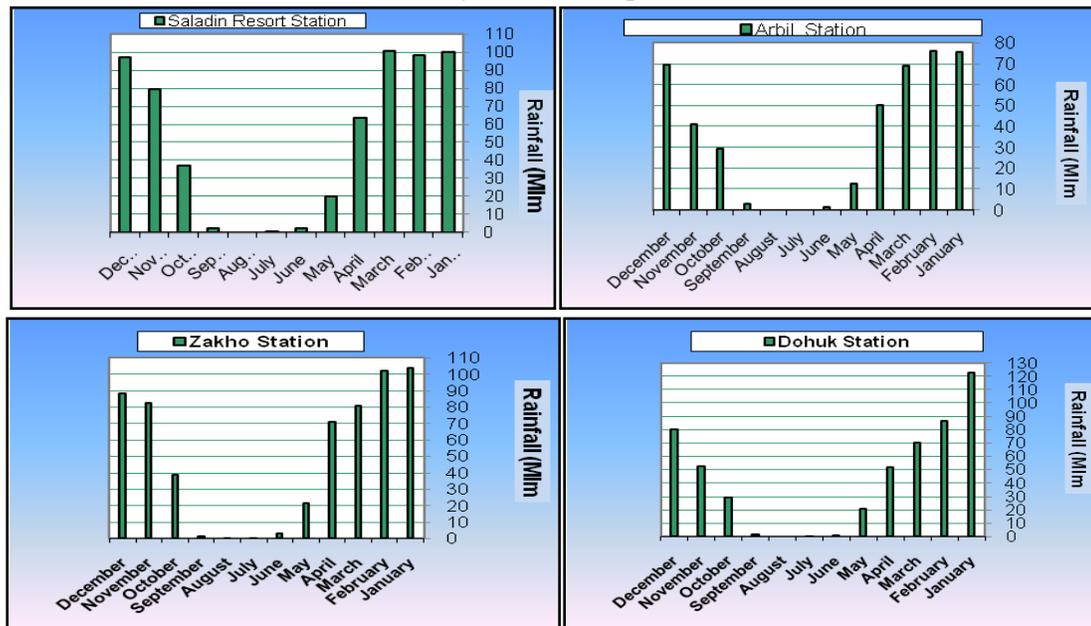
comes to high level accompanied by spatial and temporal oscillation according to the height of sea level and atmospheric depressions.

Table (8) Shows the amount of monthly and Annual rainfall (m m) in stations of the study Area for the period of (1984 to 2013)

Stations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Annual Average
Salah al-Din Summer Resort	99.9	98.1	100.6	63.5	19.7	2.2	0.7	0	2	36.9	79.3	97	599.9
Erbil	75.7	75.9	69.2	50	12.7	1.5	0.1	0.1	3	29.5	41.1	69.7	428.5
Zakhu	102	104	84.8	70.6	19.7	2.2	0.1	0.2	1	38.4	82.3	96.4	602.1
Dohuk	104.2	98.7	81.6	62.2	24	0.3	0	0	0.5	19.6	58.3	79.1	528.5

Source: The Iraqi General Directorate of Meteorology and Seismology of the Kurdistan region- unpublished data.

Figure (7) Shows the amount of monthly and Annual rainfall (m m) in stations of the study Area for the period of (1984 to 2013)



source: Figure (7) is the researcher’s own adaptation by relying on table (8).

The Analysis of the amount of rainfall during the four seasons of the year shows that the Average of the seasonal rainfall varies from one season to another and from one place to another. Table (8) illustrates winter is regarded as the main season of rainfall in the stations of the study Area due to the Activity of Frontal atmospheric depression movement during this season. Thus, the maximum amount of rainfall is recorded in Zakhu station of about (104.2 mm) with percentage of about (50,257%) and the minimum amount of rainfall is recorded in Erbil station of about (221.3 mm) with percentage of about (51.645%).

In Spring, even though it is considered transitional season, yet it witnessed activity of atmospheric depressions movement where a number of atmospheric depressions decrease yet, they are still active, and high pressure doesn't come to the study Area as well as the thermal depressions are very active⁽¹²⁾ Accordingly, spring occupies the second rank in the amount of rainfall in the stations of the study Area. The maximum amount of rainfall is recorder Salah al-Din station of about (183.8mm) and the minimum amount of rainfall in Erbil station is recorded of about (131.9mm) with a percentage of about (30.781%). As for summer, it is marked by absence of rainfall in some of these station. As for Autumn, being transitional season, it witnessed atmospheric depressions passage relatively⁽¹³⁾.

The maximum amount of rainfall is recorded in Salah al- Din station which amounts to (118.2 mm) with a percentage of (19.703%) and the minimum amount of rainfall is recorded in Erbil station which amounts to (73.6 mm) with a percentage of (17.176%).

Table (9) Illustrates the percentage of the seasonal rainfall amount (mm) in stations of the study Area for the period of (1984 to 2013)

Stations	Percentage of seasonal Rainfall Amount	Seasonal Precipitation				Annual Average
		Winter	Spring	Summer	Automu	
Salah al-Din Summer Resort	Rain fall Amount	295	183.8	2.9	118.2	599.9
	Percentage	49.174%	30.638%	0	19.703%	100%
Erbil	Rainfall Amount	221.3	131.9	1.7	73.6	428.5
	Percentage	51.645%	30.781%	0.396%	17.176%	100%
Zakhu	Rain fall amount	302.4	175.1	2.5	121.7	601.7
	Percentage	50.257%	29.100%	0.415%	20.226%	100%
Dohuk	Rain fall amount	282	167.8	0.3	78.4	528.5
	Percentage	53.358%	31.750%	0.056%	14.834%	100%

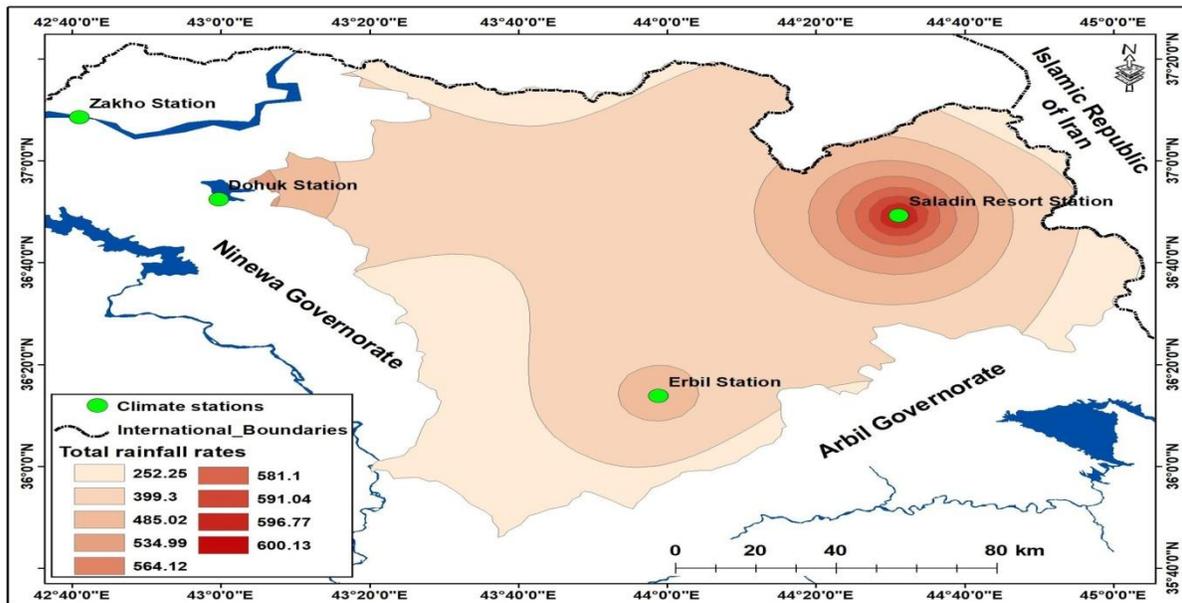
Source: The Iraqi General Directorate of Meteorology and Seismology of the Kurdistan region- unpublished data

As for the annual rainfall in the stations, the maximum amount of rainfall is recorded in Zakhu station of about (601.7 mm) and the minimum of rainfall is recorded in Erbil station of a bout (428.5 mm). Thus, the amount of rainfall decreases from south to North and it affects by local conditions and atmospheric depressions as shown in Map (8).

(12) H.H, Lamp. Climate: Present, Past and future, Vol (1), Fundamental and Climate Noe&co LTD, London, 1972, P.365.

(13) Laith Mahood Mohammed ZANGANAM position of jet stream and its impact on atmospheric depressions and rainfall in Iraq. Center of Kurdistan of strategic studies Al-Sulaimanyahm 2007, P.137.

Map (8) Shows the amount of monthly and Annual rainfall (m m)
in stations of the study Area for the period of (1984 to 2013)



Source: Map (8) is the researcher's own adaptation by relying on table (8)ARC Map(10.4) programme)

2- Rainfall Days

The study of rain fall days has a great importance since it gives a general of the type of rainfall, its mean daily intensity and frequency of occurrence and they give some indication of rainfall days, whether daily, monthly, seasonal, and annual, the rain days study can provide information regarding frequency and intensity of rain events during different weather conditions in time and space⁽¹⁴⁾,The intensity of rain fall varies from period to another and from place to another and the intensity becomes high in case of short rain fall such as thunderstorm and long rain fall such as stratus clouds⁽¹⁵⁾.

Table (10) illustrates the monthly distribution of rainfall. The maximum monthly average of rainfall is

(14) SALAR Ali Al- DAZY, Bushra Ahmed Jawad, Summer rainfall in Iraq, Al-Ustadh Journal. College of Education, Ibn Rhusd, Issue (61), 2007, P.570, 577, 578.

(15) Hassan Fadel Abed Al- Shably, The Spatial and temporal distribution of patterns of precipitation in Iraq, unpublished Doctorate of Education, 2006, P.56.

recorded in February in Salah al- Din station of about (14) days and the minimum monthly average in Erbil and Zakhu station is recorded of about (11) days, and the minimum monthly average in May is recorded in Salah al- Din of about (9) days and the minimum average in Duhok is recorded of about (5) days.

As for the seasonal distributions of rainfall in the stations, Table (10) illustrates that winter is recorded as the maximum seasonal Average of about (39) days un Salah al- Din station and in Erabil Zokhu and Duhok, the maximum seasonal Average is reconded of about (31-34) days.

As for the Annual distribution of rainfall, Table (10) shows that the maximum Annual Average of rainfall days is recorded in Salah al- Din station of about (87) days ,due to its position and height of above sea level and highlands and the minimum Annual average of rainfall day is recorded in Duhok station of about (70) days. Therefore ,it can be said that the maximum monthly averages of rainfall days are in the months of Winter and the lack of rainfall days is in Summer.

Table (10) shows that the monthly, seasonal and annual averages of rainfall days in the stations of the study Area for the period of (1984 to 2013)

Stations	Dec	Jan	Feb	winter	Mar	April	May	spring	
Salah al-Din Summer Resort	12	13	14	39	13	11	9	33	
Erbil	11	12	11	34	11	10	6	27	
Zakhu	10	10	11	31	11	9	6	26	
Dohuk	9	11	12	32	12	10	5	27	
Stations	Jun	Jul	Aug	Summer	Sept	Oct	Nov	Autumn	Annual Average
Salah al-Din Summer Resort	0	0	0	0	0	7	8	15	87
Erbil	0	0	0	0	0	6	8	14	75
Zakhu	0	0	0	0	0	7	8	15	72
Dohuk	0	0	0	0	0	5	6	11	70

Source: Table (10) is the researcher's own adaptation relying on table (8).

3- Fluctuation of Rainfall Amount:-

Fluctuation of Rainfall is considered one of the characteristics that the rainfall of Mediterrean basin has marled with due to the Nature of the general cycle of atmosphere, zonal cycles. Fluctuation is basically a natural phenomenon which means any increase or decrease in the amount of rainfall of its monthly and annual Averages and this phenomenon is considered a major feature of rainfall in the Northern Areas in Iraq. Which are characterized by erratic rainfall that can mean both an increase and decrease of precipitation amount⁽¹⁶⁾, The coefficient of Fluctuation has been calculated in the following Formula:

$$\text{Coefficient of Fluctuation} = \frac{\text{Standard deviation}}{\text{Mean rainfall}} \times 100^{(17)}$$

The analysis of table (11) shows the monthly deviations of the stations of the study Area and standard deviation increase in October due to the increase of the atmospheric depressions, The maximum standard deviation is recorded in Salah al- Din station in January of about (54.63 mm) and in Erbil station in February of about (47.56 mm) and in ZAKHU station in February of a bout (51.971 mm) and in DOHUK station in January of about (55.80 mm).

As for percentage of Fluctuation (coefficient of variation). The monthly amount of rainfall. The maximum percentage of fluctuation is recorded in Salah al- Din station in October of about (88.48%) ,The minimum percentage of fluctuation is recorded in march of about (53.82%) and the minimum percentage of fluctuation is recorded in Erbil in May (78.08%) and the minimum percentage in September of about (21.3%) and in ZAKHU station in October (82.14%)

(16) Ahmed Abdul Ghafour Khatab Al- Sumoeday, **Modelling of rainfall in the mountain province in Iraq by using data of Remote sensing**, unpublished Master thesis, Tikrit University, college of Education, 2004, P.24

(17) Mohammed Bahjet Al-Mursy, **Rainfall and Agriculture in coastal plains of North Sinai**, Unpublished Master thesis, Al-Menoufia University, Egypt, 2010, P.157.

and the minimum percentage in February, of about (49.97%) and In DOHUK station in September of about (75.34%) and in January of about (53.55%).

Table (11) Shows that the standard deviation and the percentage of monthly Fluctuation of rainfall amount (mm) in the stations of the study Area for the period of (1984 to 2013)

Stations		Months of the year											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Salah al-Din Summer Resort	Rainfall Amount	99.9	98.1	100.6	63.5	19.7	0	0	0	2	36.9	79.3	97
	Standard Deviation	54.63	54.14	54.14	43.59	24.28	0	0	0	7.43	32.65	48.57	53.83
	Percentage of Fluctuation	54.6	55.19	53.82	68.64	123.2	0	0	0	371	88.48	61.25	55.5
Erbil	Rainfall Amount	75.7	75.9	69.2	50	12.7	0	0	0	3	29.5	41.1	69.7
	Standard Deviation	47.56	47.64	44.72	38.03	19.14	0	0	0	9.34	29.22	35.08	45.63
	Percentage of Fluctuation	32.11	31.67	33.37	39.28	78.08	0	0	0	160	51.12	44.02	21.3
Zakhu	Rainfall Amount	102	104	84.8	70.6	19.7	0	0	0	1	38.4	82.3	96.4
	Standard Deviation	51.39	51.971	46.86	42.75	22.59	0	0	0	4.98	31.54	46.16	49.953
	Percentage of Fluctuation	50.38	49.97	55.27	60.56	114.6	0	0	0	498.8	82.14	56.09	51.82
Dohuk	Rainfall Amount	104.2	98.7	81.6	62.2	24	0	0	0	0.5	19.6	58.3	79.1
	Standard Deviation	55.80	54.29	49.38	43.14	26.8	0	0	0	3.77	24.22	41.72	48.62
	Percentage of Fluctuation	53.55	55.01	60.52	69.36	179.6	0	0	0	753.4	123.6	71.6	61.5

Source: Table (11) is the researcher's own adaptation relying on table (8).

The maximum percentage of fluctuation is recorded in Salah al-Din station in October of about (88.48%) and the minimum percentage of fluctuation in March of about (53.82%). The maximum percentage of fluctuation is recorded in Erbil station in May of about (78.8%) and the minimum percentage of fluctuation in December of about (21.3%) and the maximum percentage of fluctuation is recorded in Zakhu in October of about (82.14%) and the minimum percentage of

fluctuation is recorded in February of about (49.94%). The maximum percentage of fluctuation is recorded in Dohuk station in September of about (353.4%) and the minimum percentage of fluctuation is recorded in Dohuk station in January of about (53.55%).

The Analysis of Table (12) shows that the amount of annual rainfall varies from are year to another and from one place to another and the standard deviation varies in the study Area, The maximum standard deviation is recorded in Salah al Din station of about (48.60) and the minimum standard deviation is recorded in Erbil station of about (32.479).The Analysis of Table (12) shows that the maximum percentage of annual fluctuation is recorded in Erbil station of about (90.91%) and the minimum percentage of annual fluctuation in Salah al- Din station of about (64.41%),The more the percentage decreases, the more the amount of rainfall increases, The number of seasons that incense amounting to (16) years and the number of seasons that decreases amounting to (14) years in Salah al- Din and Erbil stations, As for Zakhu station, the number of seasons that increase of the average amon ? to (12) years and the number of seasons that dances of the average a mounting (18) years, As for Dohuk station, the number of seasons that exceed the Average amounting to (11) years, whereas the number of seasons that denseness the average amount to (19) years.

Table (12)Shows the standard deviation and the percentage of annual fluctuation of rainfall amount (mm) in the stations of the study Area for the period of (1984 to 2013)

Stations	Rainfall Amount	Rainfall Amount Mean	Standard deviation	Percentage of fluctuation the Average	Number of seasons that exceed the Average	Number of seasons that decreed the Average
Salah al-Din Summer Resort	599.9	50	48.605	64.41	16	14
Erbil	428.5	35.7	32.479	90.91	16	14
Zakhu	602.1	50.1	36.092	71.98	12	18
Dohuk	528.5	44	36.298	68.36	11	19

Source: Table (12) is the researcher's own adaptation by relying on table (8)

To sum up, the coefficient of variation varies among the stations of the study area, due to the fact that the intensity of the atmospheric depressions and its directions and it appeared that the move the rainfall amount increases, the move the percentage of fluctuation decreases and vice versa.

THE IMPACT OF RAINFALL ON THE DRAINAGE OF THE GREAT ZAB BASIN IN IRAQ

1- Characteristics of monthly Drainage: -

The importance of the monthly run-off emerges in Aski Kalak station in the great Zab basin through determining the a monthly amount of drainage and its relation to monthly rainfall distribution on the great Zab basin for the sake of utilizing of it in projects of storage, water control and for agricultural and developmental planning utilization⁽¹⁸⁾.

Table (13) and figure (9) shows that the monthly amount of drainage is recorded in Aski Kalak for the period of (1984-2013) and the maximum amount of drainage is about (884.3 m³/s) due to the increase of rainfall amount in (January - February- March and April) and reliance on winter and spring rainfall together with ice melting. The minimum amount of drainage is recorded September of about (98.07 m³/s).

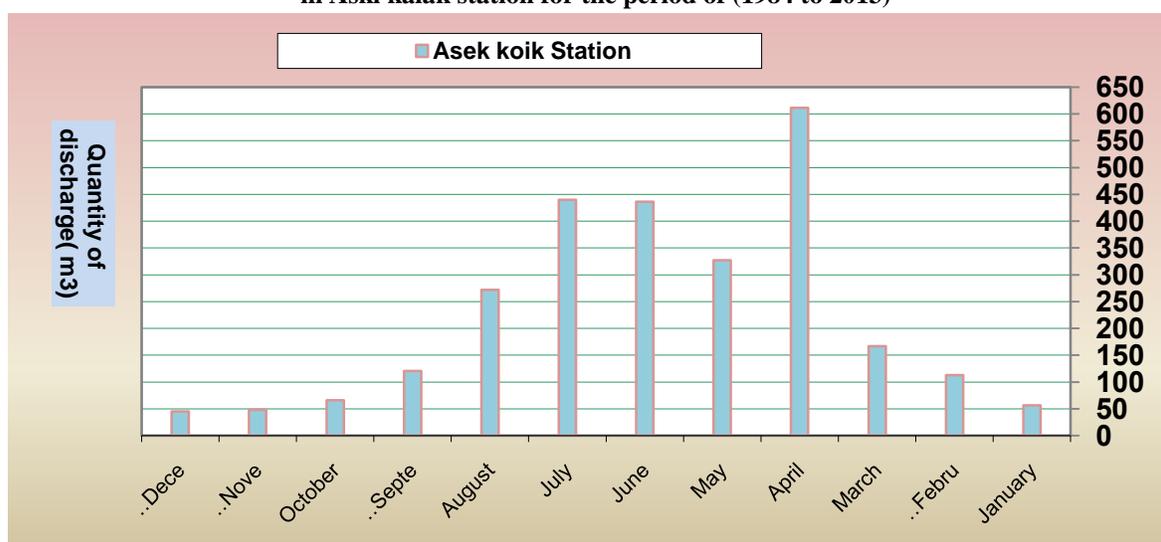
(18) Ali, Mosa, **Climate and Meteorology**, University of Damascus, 2003, P.459.

Table (13) Shows the average monthly drainage (m^3/s) in the Great Zab basin in Aski kalak station for the period of (1984 to 2013)

Stations	Months of the year												Annual Average
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	
Aski KALAK	299.7	436.4	567.8	884.3	800.8	486.3	232.5	125.4	98.07	107.7	165	247.4	4451

Source: The Iraqi General Directorate of Meteorology and Seismology of the Kurdistan region- unpublished data

Figure (8) Shows the Average of Annual drainage (m^3/s) in the Great Zab basin in Aski kalak station for the period of (1984 to 2013)



source: Figure (8) is the researcher's own adaptation by relying on table (13).

2- Characteristics of the Annual Drainage of the great Zab Basin:-

Through studying the characteristics of the annual Drainage of the great zab basin, The Annual mean of drainage means what the river passes of water measured by meter cubic in second during a long period of time⁽¹⁹⁾. Table (14) shows the amount of annual drainage of the great zab basin for the period extending from (1984 to 2013) in Aski Kalak station and thus the amount of drainage comes to (4451 m^3/s), The amount of drainage relies on the environmental rocky structure, climatic conditions, variations in the plant cover, as well as land features- thus, the increase in Run-off resulted from Rainfall and rise of temperature which led to ice melting.

The analysis of Table (14) shows the difference in distributing drainages by delimiting the amount of run-off. The maximum amount of drainage is recorded in Aski Kalak of about (304 m^3/s) in 1996 and the minimum amount of

(19) Yousef Mohammed Al- Hathal, **Fluctuation and direction in Factors in Factors and phenomena of climate in Iraq**, college of Education / Ibn Rhused (Baghdad), 1999, P.78-79.

drainage is recorded ($133.75\text{m}^3/\text{s}$) and the amount of run-off comes to (5.752) due to the rainfall and Icefall to gether with the variation in land features and geological configuration of the study Area⁽²⁰⁾.

Table (14) Shows the amount of Annual drainage (m^3/s) of the Great Zab Basin in the stations for the period of (1984 to 2013)

Stations	Average of drainage	Maximum Drainage		Minimum drainage		Amount of run off
		year	Drainage Mean	year	Drainage Mean	
Aski KALAK	381.15	1996	769.33	2011	133,75	5.752

Source: Table (14) is the researcher's own adaptation by relying on Ministry of Water Resources-Baghdad /Department of Water control/ Records of Zab river drainage

3- Fluctuation and the standard Deviation of Drainage Basin:

The percentage of fluctuation of the means of the amount of drainage and the monthly standard deviation in Aski Kalak station in the great zab basin according to the geographical distribution and monthly and annual distribution. Table (15) illustrates the percentage of fluctuation and the monthly standard deviation of the amount of drainage. The maximum standard deviation in April is recorded of about (161.80). Whereas the minimum standard deviation in September is recorded of about (54.13), The maximum amount of fluctuation in September comes to (55.19%) whereas the minimum fluctuation in March comes to (2.29%).

Table (15) Shows the percentage of fluctuation and standard deviation of the monthly drainage in Aski Kalak station for the period of (1984 to 2013)

Stations	Months of the year											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Mean of Drainage Amount	299.7	436.4	567.8	884.3	800.8	486.3	232.5	125.4	98.07	107.7	165	247.4
Standard Deviation	94.48	113.9	129.86	161.86	154.0	120.2	83.26	61.20	54.13	56.73	70.17	85.87
Percentage of fluctuation	31.53	26.11	2.29	18.3	19.24	24.27	45.81	48.8	55.19	52.67	42.53	34.71

Source: Table (15) is the researcher's own adaptation by relying on Ministry of Water Resources-Baghdad /Department of Water control/ Records of Zab river drainage

The analysis of table (16) illustrates the annual deviation in the Aski Kalak station and the variance of the amount of the drainage which relies on the amount of rainfall from one year to another and from one place to another. Thus the standard deviation amounted to (360,3) and the rate of fluctuation amounted to (23,3%) as well as the number of seasons that exceed the average amounted to (9)years while the number of seasons that decrease of the average amounted (21) years.

(20) Nihzd Khudair Kadlum Al-Kinany, **Time and space analysis of characteristics of Rainfall and chronological order in Iraq for predicting years of drought**, Al- Kufa University, college of Education for Women, 2009, P.68.

Table (16) Shows the percentage of fluctuation and standard deviation of the Annual drainage in Aski KALAK stations for the period of (1984-2013)

Stations	Amount of Drainage	Mean of Drainage	Standard deviation	Percentage of Fluctuation	No of seasons that exceed of the Average	No of seasons that تقل the Average
Aski KALAK	4451	449.7	360.3	23.3	9	21

Source: table (16) is the researcher's own adaptation by relying on table (8)

4- Climatic classifications of measuring drought in the Great Zab basin in Iraq

The climatic characteristics differ from one area to another and from one year to another due to the factors that govern the climatic features including, A location's position along of a circle of latitude, and features and Applying equations to determine the type of drought in the stations of the study Area. These equations include the following:

1- Thornthwaite equation:-

Is applied to classify the type of climate in the stations of the study Area and the Analysis of table (9) shows the amount of drought in (Salah al- Din, Zakhu and DOHUK) stations which are marked humid climate whereas in Erbil station which is marked by dry climate. Application of Thornthwaite equation as follows⁽²¹⁾:

$$12 \sum 1.65 (r/t + 12.2)^{10/9}$$

where:

(r) = means the Annual Average of rainfall (mm).

(t) = means the Annual Average of temperature.

(C^o) = 12.2 = Constant Value.

2-Lange equation:-

Is applied to classify the type of climate in the stations of the study Area by analyzing table (17) which shows that climatic results in (Salah al- Din, Zakhu, Erbil and DOHUK) stations which are marked by dry climate according to Lange Equation⁽²²⁾: -

$$F = N/T$$

where:- (F) = means coefficient of rainfall.

(N) = means the Annual Average of precipitation.

(T) = means the Annual Average of Temperature.

In conclusion through the climatic classification of the study Area, Thornth waite equation is very suitable equation that can be applied in the study Area due to the Approaching of the equation Results from the climate of the study area.

Table (17) Determines the type of drought in the stations of the study Area for the period of (1984 to 2013)

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- (1) Gchzpmn, Mc Grew, Charles, B. Monroe, Introduction to statistical problem solving in Geography, Mc Grow- Hill, Co, U.S.A., 1993p.48.
 - (1) Sana Abdul Baqi Bskar, resources of Natural fortunes in Docan basin and ways of Maintenance unpublished master thesis. College of Arts, University of Salah al - Din, 2003, P.85.

Stations	Amount Average of temperature	Amount Average of Rainfall	Thornthwaite Equation	Class	Lange Equation	Class
Salah al-Din Summer Resort	18.1	599.9	88.38	Humid	33.14	Dry
Erbil	21.7	428.5	48.58	Semi-Humid	19.7	Dry
Zakhu	19.7	602.1	82.92	Humid	30.5	Dry
Dohuk	14.1	528.5	89.92	Humid	37.4	Dry

Source: Table (17) is the researcher's own adaptation by relying on table (2) which shows the annual temperatures and table (8) which shows the averages of annual rainfall.

CONCLUSION

The current paper has come up with the following findings:

- 1- Rainfall is concentrated in the study Area in winter and Spring due to its correlation with the passage of air depressions coming out of the Mediterranean and they increase in winter and decrease in spring.
- 2- The monthly and Annual temperatures vary among the stations of the study Area and the maximum temperature in Erbil stations amounts to (21.7 C^o) and the minimum temperature in DOHUK station amounts to (14.1 C^o).
- 3- Averages of wind speed vary in the stations of the study Area. The maximum Annual wind speed is recorded in Erbil of about winter (2.7 m/s) in due to the impact of cold air mass and decrease of temperatures and increase of cloudiness. Where as the minimum Annual wind speed is recorded in Zakhu station of about (1/1 m/s).
- 4- The Averages of the relative Humidity vary in the stations of the study Area. Thus, the maximum Annual relative humidity is recorded in Salah al- Din station which amounts to (53.3%) due to the decrease of temperatures in winter whereas the minimum annual relative humidity is recorded in Zakhu station which comes to (41.1%).
- 5- The amount of evaporation varies in the study Area from one place to another. Thus, the maximum annual amount of evaporation is recorded in DOHUK station which amounts to (2200 mm) where as the minimum annual of evaporation is recorded in Salah al-Din station which comes to (1749.7 mm).
- 6- The atmospheric depressions, which are centered above Turkey, are characterized by a decline in its temperatures and intensity of rainfall as well as icefall in the study Area.
- 7- The amount of rainfall, together with its distribution in time and space, varies. In the study Area. Thus, the atmospheric depressions, humid air masses and an increase of the amount of cloudiness in precipitation in winter and spring and differs from one year to another. Moreover, the Annual precipitation differs from one season to another where it starts in Autumn and sometimes in winter.
- 8- The phenomenon of the fluctuation of monthly amount in the stations of the study Area where it increases in early October due to the increase of Frequency of atmospheric depressions in Salah al-Din station. Thus, the maximum standard deviation reaches (48.60) and the minimum standard deviation comes to (32.479).
- 9- The surface run-off in Basin lasts a long period time to drain rainfall water and reaching its downstream and this helps feed the ground storage. The maximum drainage in Aski Kalak reaches (304 m³/s) in 1996 due to rainfall and icefall as well as the variation in Geographical Area and land features.
- 10- The climatic classification of the study Area according to Thornthwaite Equation (humid-semi-humit) and Lange Equation which classifies the dry climate.

RECOMMENDATION:

The current paper has come up with the following findings:

- 1- Taking a great interest in plants and Farming in slopes of mountains to protecting it from rainfall erosion.
- 2- Taking a great interest in Geomorphological features in the study Area and making use of them for touristic grounds.
- 3- Expanding in using contour cultivation to reduce soil ersion due to rainfall.
- 4- Taking a great interest in storing rain water in winter and making use of it by storing them in dams and generate electricity.
- 5- Activating the touristic movement in view of the fact that the gab basin possess spectacular and marvelous view as well as it has many fountains and springs.
- 6- Making use of the amount of rainfall in producing some agricultural products.
- 7- Making use of abundance of water resources out of tributaries, streams, and Mineral springs for touristic reasons.

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