

Study of the Rainfall Rate in Iraq

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Received: 2024, 15, Sep
Accepted: 2024, 21, Sep
Published: 2024, 30, Oct

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Annotation: The research aims to shed light on the rates of rain falling on Iraq, as well as the amounts of rain between one region and another, and one direction and another. Our research targets the southern, central, and northern governorates, as the southern governorates suffer from a scarcity of rain during periods of drought and certain months of high temperatures and relative to moderate rain in Winter and the central governorates as well. As for the northern regions, they may flourish more than other regions in terms of rainfall rates, as they are the highest. Comparisons and numbers about rainfall rates were included in the research. They were extracted from a site and were studied in detail in the research. The research also reviewed the importance of rain and the devices used in measuring quantities. Falling rain: (Rain measuring devices Float rain recorder) We aim to study Arithmetic Method: One method is to calculate the arithmetic mean. To do this, add up all the values and divide the sum by the number of values.

1. Introduction

Precipitation is an important climate element, and rain is one of the most important forms of precipitation on the Earth's surface, and the most important manifestation of the condensation of water vapor present in the air. Its importance has increased in that it is the basic water element on which all human, animal and plant vital aspects depend and on heat. Rain is the main source of fresh water on Earth.

Due to the increased demand for water, there has become a scarcity that threatens our contemporary world after the global water crisis worsened as a result of the industrial revolution and its impact on the rise in population rates in the world. Due to the rise in the Earth's temperature, water scarcity has become a threat to existence, so people began to think seriously about this danger and innovative ways to confront water shortages in various ways, including what is called the process of water harvesting or water harvesting in the rainy season to confront the shortage during the period of interruption. The process of storing rainwater began in order to enhance water security, stability, and well-being for the population. The need arose since ancient times to construct terraces on highlands, create terraces and mountain lakes, build dams, and exploit river water. The need has prompted people in the arid and semi-arid regions to even benefit from rainwater falling on the roofs of houses, collect it, store it, and use it for various purposes. The rain that falls in the dry (desert) and semi-arid (steppe) regions similar to the climate of the semi-mountainous region in Iraq (such as the study region) is characterized by the fact that its rains are variable and fluctuate in quantity from year to year and have clear economic effects in those regions, and the resulting dangerous geographical phenomena. Such as desertification, so the need arose to collect rainwater and utilize it for agricultural and industrial purposes, and other complementary purposes.

This study came to determine the reality of rainfall in Iraq, analyze annual variations in the amount of rainfall and its fluctuation rate, and reveal the factors affecting the distribution of rainfall with the aim of identifying the main characteristics of rainfall (1).

2. First - the problem of the study:

The importance of the problem appears in that it represents the first step taken by the scientific researcher, which can be formulated as follows:

Rain is a natural phenomenon that varies in time and space. It falls on Iraq at different rates and in unequal quantities. It is affected by a group of variable and constant natural factors, which painted a picture of fluctuating rains varying in quantity from year to year and from one season to another, and the fluctuation of the rains of the same season from year to year in the study area, which is of an arid and semi-arid nature according to the coordinate and geographic location, meaning that this variation has different repercussions on All aspects of life (2)

3. Second - Objectives of the study:

The aim of the study is to analyze the general characteristics of rain in Iraq to diagnose the factors controlling the way its rain is distributed and to reveal the true character of its rain. The objectives of the study can be summarized as follows:

1. Geographical analysis of the factors affecting the distribution of rainfall in Iraq.
2. Statement of the actual value of rainfall and the effect of the evaporation/transpiration process on it to determine the amount of water deficit and surplus.
4. Identify the temporal and spatial variation of rainfall and the causes of this variation through statistical analysis of daily, monthly and annual rainfall rates.
5. Study the environmental effects of rainfall fluctuations through statistical analysis of rainfall rates at each station.

6. Determine the general trend of rainfall, whether it increases or decreases at stations in the region during the years of study.
7. Identify the correlation between the annual total rainfall and the factor of height above sea level and between the amount of rain and the number of rainy days.

4. Third: Study hypotheses:

Hypotheses are elementary facts that we impose and then they become true or we deny them. Therefore, rainfall assumptions will separate the temporal and spatial variation of rainfall. However, these variations are completely consistent with the period of passage of the weather depressions, each of which has its own hypotheses, as follows:

1. There is a temporal variation in the amount of rainfall in the study region at the level of day, month, season, and year, and it can be attributed to the distribution of permanent and seasonal pressure during each season during the rainy season. As a result, the following occurs:

A- Rainfall increases in years of high frequency of weather depressions.

B- Rainfall increases in months of high frequency of weather depressions.

The more frequent the passage of depressions in months and years, the greater the amount of rain

The rate of fluctuation decreased, and as the frequency of weather depressions decreased, the opposite occurred.

2. The spatial variation of rainfall is affected by the terrain variation between the regions of Iraq. The high areas near the mountainous region have an increase in the amount of annual rainfall due to their benefit from the altitude in increasing the air lift. Therefore, precipitation totals increase as we move from south to north, which indicates the existence of a correlation between the amount of rainfall falling and the factor of height above sea level.

3. The coordinate location is one of the most important fixed factors that have a significant impact on rainfall. The coordinate location of Iraq on the subtropical latitude makes it subject to the upper air elevation in the summer, and it also leads to a lack of rain in the summer.

4. Distance from bodies of water causes a lack of rain.

5. The actual value of winter rain increases despite its low amounts.

5. Fourth – The importance of the study:

In light of the justifications for the research and the temporal and spatial variation that occurs in rainfall, being the most fluctuating climate element, and the results it produces that affect the climate in general and the provision of fresh water in particular, so the study came to identify the reasons for this variation and the factors affecting the distribution of rainfall, its types and methods. Used to measure severity and effectiveness. Considering that rain is one of the most important manifestations of precipitation, in addition to its contribution to shaping the appearance of the Earth's surface over previous geological eras, and what is hidden is the role that rain has if it is predicted well in shaping the features of the economic life of the state, through the optimal use of rainwater, to achieve a number of economic goals. Improving agricultural production levels and increasing economic growth rates.

The importance of the study lies in identifying how to reduce the risk of torrents and floods, and preserve water from wastage and depletion, to achieve a strategic goal that includes enhancing water security in Iraq.

1. The second section: previous studies

This study was preceded by multiple studies inside and outside Iraq that dealt with climate elements, including rain, which receives great attention from researchers in the field of climate, due to its great impact on the natural and human aspects. A number of researchers have studied

the characteristics of rain and its relationship with other climate elements. Some of them studied the relationship between rain and water resources. A number of others also studied the relationship of rain to human aspects, the most important of which is agriculture, due to its direct impact on aspects of economic life. However, the process of counting all the studies that dealt with the subject of rain is not an easy matter. Therefore, giving an idea of the available studies, learning about their methodology, and the results they reached, and comparing them to the results that we will reach in our study, will contribute to determining the basic research goal. The following is a presentation of the most important of these studies according to the context of chronology:

- Karim Daragh Muhammad (1). He studied (recent trends in the climate of Iraq). His dissertation dealt with studying the modern trends of rainfall in Iraq during the period (1941-1980), and comparing them regionally and globally to determine whether the climatic path in Iraq keeps pace with the global climate regionally and climatically, or is linked to geographical conditions specific to Iraq, and has its impact on the occurrence of variation, as the researcher concluded that the recent trends of rainfall in the stations of the semi-arid region are moving in a non-uniform direction, while the two stations are trending.

Mosul and Sinjar are decreasing. We find that Kirkuk station is moving towards an increase in the amount of annual rainfall, and this is due to the geographical location of the station [1].

- Hassan Ahmed Hassan, and others (1). They studied the analysis of rain characteristics in the (Safwan-Zubair) region based on the analysis of rain data from the Basra Climatic Station for the period (1960-1986), using a type of statistical analysis, which is probability frequency analysis, to calculate the amount of daily, monthly, and annual rain for return periods between (2-100) years. Hassan and his colleagues reached results that show the existence of a special system in the monthly and daily relationships of rainfall that is proportional to the rainy period. It has been shown that the annual average rainfall occurs from the return period of 2 years[2].
- Harith Abdul-Jabbar Al-Dhahi (2). In his thesis (Rain in Iraq, a study in applied climate), he emphasized the role of the coordinate factor and fixed and dynamic geographic factors such as (coordinate and geographic location, terrain, and pressure distribution), using annual, monthly, and daily rainfall data, in addition to other climate elements and for (44) climate stations. Iraq was divided into three climatic regions based on the standard of the amount of rain falling in each region. He referred to the Mediterranean climate region with a criterion of more than (1000) mm, while the rains in the steppe region range between (200-400) mm, while the rains in the desert climate region decrease between (50-200) mm. Here it must be pointed out that the researcher neglected to specify the area whose rainfall ranges between (400-1000) mm, and (Al-Dhahi) concluded at the end of his study that the amount of rain in Iraq
- Basil Ihsan Al-Qashtini (1). In his research (The air masses that obstruct the Baghdad region in the rainy seasons), he touched on the diversity of sources of air masses that affect the Baghdad region in the rainy season. Al-Qashtini analyzed the (synoptic) weather maps for the years (1973-1978). The researcher showed that for the year Climatic phases: The first phase begins with the rainy season in the Baghdad region in mid-October, and the rainy season ends around the end of the first week of May, and this phase is negative. The second phase is positive and includes the last part of the spring, the summer, and the first part of the fall until the second week of October. The researcher emphasized the negative phase of the climatic year (the rainy season), as the Baghdad region can be likened in terms of atmospheric pressure to a pressure swamp, which Facilitates the passage of frontal depressions or cyclons from west to east (3).
- Kazem Abdul Wahab Al-Asadi (2). He studied the frequency of depressions and their impact on Iraq's weather and climate, referring to the depressions passing through the study area. His study begins from the season (1978-1979 to 1988-1989) and includes (15) climate stations. The researcher concluded that most of the cases of precipitation in the northern regions are due to the cold front from the depression. The increased frequency of depressions coming from the

Mediterranean Sea in the month of November is due to the weakening of the influence of the air depression, which allows the depression to advance northward.

Iraq suffers from severe drought, a characteristic inherent in its variable climatic conditions. Water shortages have a negative impact on agricultural lands and are linked to a high risk of desertification. Therefore, determining moisture conditions over a multi-year period is a challenging issue. In this research, monthly and annual precipitation figures from 20 meteorological stations in Iraq were analyzed to provide insight into the seasonal and annual variations of annual variations and temporal trends of precipitation during the period 1992-2010. The non-ranked Mann-Kendall test was applied to detect the trend in the annual series and the Kendall-Theil line was used to measure its magnitude. The results of the Mann-Kendall test show negative values for all stations, and this confirms the trend of climate change towards scarcity of rain. Most stations show a high level of significance of more than 95%, while a drying signal was observed in the Amara, Baghdad, and Salah al-Din stations only. The rate of change in Iraq is 3.5% of the average annual precipitation calculated for the years 1992-2010.

Rain maps constitute one of the cartographic methods that show geographical phenomena that fluctuate and flow from one place to another. Maps representing wind states, storms, anticyclones, etc. are very important. To be able to predict the weather. Weather maps are nothing more than graphic representations that help us know the values that some meteorological variables have a given geographic area. Of all the meteorologists, these maps make use of, as their use provides a lot of knowledge and an interesting picture about all the situations we can find in the atmosphere. Since the feature that is clearly evident in contemporary geographical research today is the use of modern technologies in applied geographical studies, especially in the field of weather and climate maps, which is a recent branch in geography. Geographical information systems (GIS) have been employed through the program (Arc Map 10. 8), which is one of the programs of this technology, which has the characteristics of spatial analysis and thematic mapping. Because the program has the tools for automatic mapping of linear, point and area symbols. The problem of the research is it possible to build maps of rainfall amounts based on the coordinate location of climatic stations showing the amounts and variations of rainfall for certain periods.

The results were in the mapping of precipitation with a high potential for perception, in addition to the design of databases for climatic stations that can be updated.

2. The Rain

Rain is the water droplets that fall from the clouds to the ground. Raindrops are formed through a group of stages, starting with the evaporation of sea water, rivers and lakes as a result of heat. As is known, hot air rises to the top, carrying water vapor with it, and when it reaches the upper layers of the atmosphere its temperature decreases. It begins to condense in the form of clouds and clouds of various types, including cumulus, stratocumulus, depression, and others. Here, raindrops begin to form around the nuclei of condensation and gather from dust particles and others. The more the condensation increases, the more the water droplets increase, and they begin to stick together until their weight becomes heavy and they fall from the clouds to the ground. The clouds became more saturated with water vapor and the rains became more intense and heavier.



3. Benefits of rain?

The benefits of rain are many, we will summarize them in the following points:

- Rain is the world's leading source of drinking water
- Rain is the primary tributary and feeder of groundwater
- If it were not for the rain, all the plants and trees would dry up, and the animals that depend on plants for their food would become extinct, and the matter would end with the extinction of man, as no plants could be eaten, and no animals could be eaten.
- Rain stabilizes the soil and makes it resilient to wind gusts, thus preventing the formation of sand storms
- Rain purifies the atmosphere of dust, impurities and fumes that negatively affect human health (4).

4. Disadvantages and what are the consequences of interruption of rain:

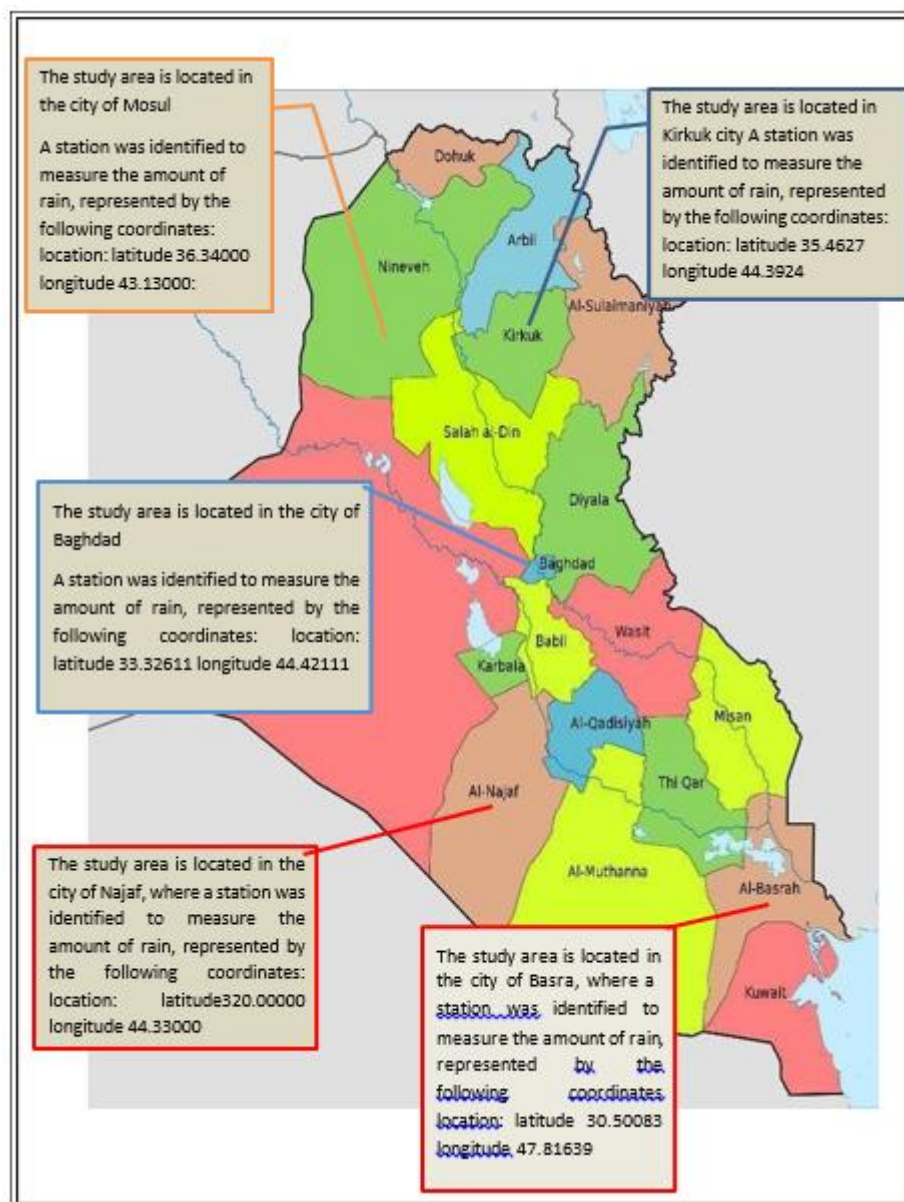
- Famines occur due to lack of irrigation water.
- Massive fires erupt as a result of high temperatures accompanying the absence of rain.
- The production of electrical energy decreases as a result of the lack of the refrigerant, which is water. Water outages also result in a decrease in the flow of water through dams, and thus a decrease in hydroelectric energy.
- Impact on animal life in the environment; The absence of rain leads to the destruction of the animal's original habitat, which leads to a decrease in the number of animals.
- The occurrence of dust storms, as a result of the drought, desertification and erosion affecting the regions.
- Deterioration of natural vegetation and lack of natural pastures.
- Dryness of the soil, which occurs when the percentage of water evaporating from it is greater than the percentage of water entering it. It must be noted that drying of the soil leads to the destruction of agricultural crops and the decline of the agricultural sector (5).

5. Pause with how the rain falls

Among the verses that spoke about clouds and the falling of rain is the Almighty's saying: "And We have placed therein lofty mountains and given you abundant water" [Surat Al-Mursalat: 27]. That is: He made therein mountains, firm and lofty, on their summit's clouds gather, and from

them falls of fresh water. Could this be due to power, discretion, wisdom, and planning? High mountains are a source of rain, as they intercept winds laden with water vapor, forcing the moist air to rise to the top, cool, condense, and bring down heavy rain. And God Almighty said: “And We send down from the cisterns abundant water that We may bring forth thereby grain and vegetation and gardens in multitudes” [Surat Al-Naba’: 14-16]. “And We sent down from the mountains”: that is, the clouds. “Thajaja water”: that is, very much.

Modern science has proven that after the clouds are formed, a circular air current passes through them, rotating like a juicer, and with its rotation, it raises this cloud saturated with water vapor to the top, so it cools, condenses, and pollinates as well. The process of squeezing begins at a specific point in a specific place in the upper layers, and the rain falls, and then it does not take long. To raise another amount of air saturated with water vapor from the bottom to the top, and it condenses and the water descends. Through squeezing, water descends from the clouds all at once, and not in a continuous flow. This phenomenon is often seen in tropical regions where convection currents are strong, carrying the clouds, rain falls, and forests abound. They intertwine, and the trees wrap around each other.



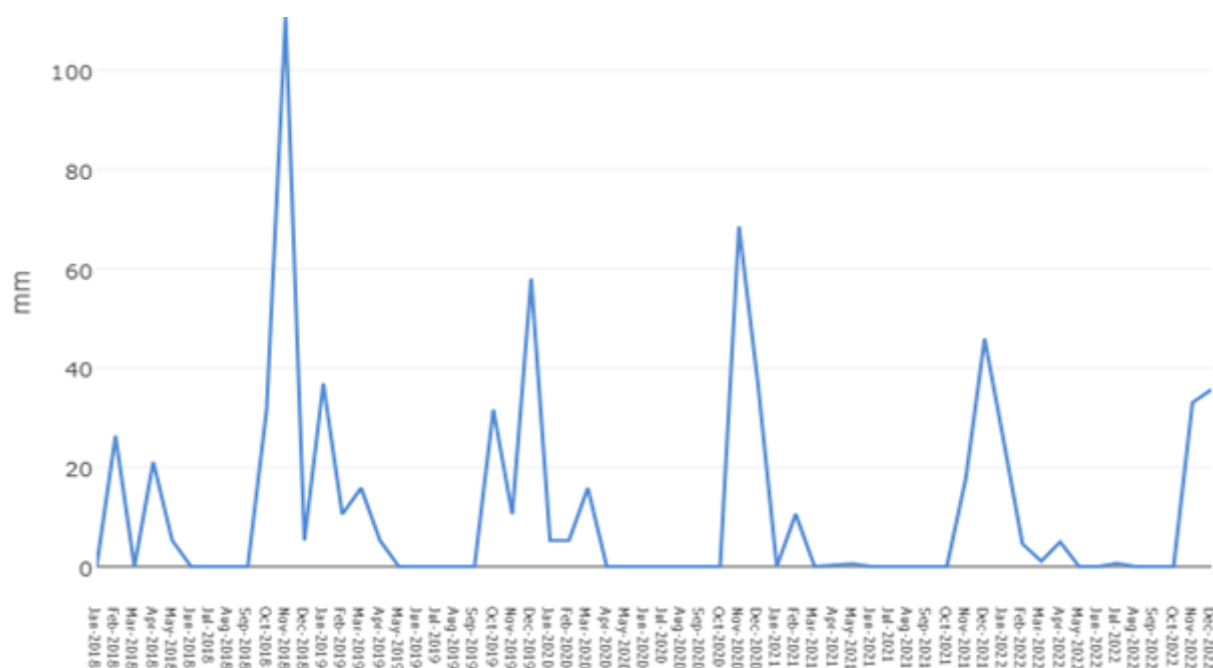
It is the center of the arithmetic mean, and calculating it becomes a set of numbers and then divides the result by the number of those numbers. For example, the median of 2, 3, 3, 5, 7, and 10 is 30 divided by 6, which is 5. The median is the numeric number of a set of numbers; That is, half the

number has a value greater than the median and the other half has values smaller than the median.)10(

In this chapter, we used the method of calculating the arithmetic average, where we took rainfall values from various governorates in Iraq and various locations in Iraq, for example, in the south of Basra, the center of Baghdad, and the north of Kirkuk, and we calculated the value of the arithmetic average from it, by taking the percentage of rainfall for each year excluding 12 months and dividing it by a number The most famous rainfall figures were taken from the website

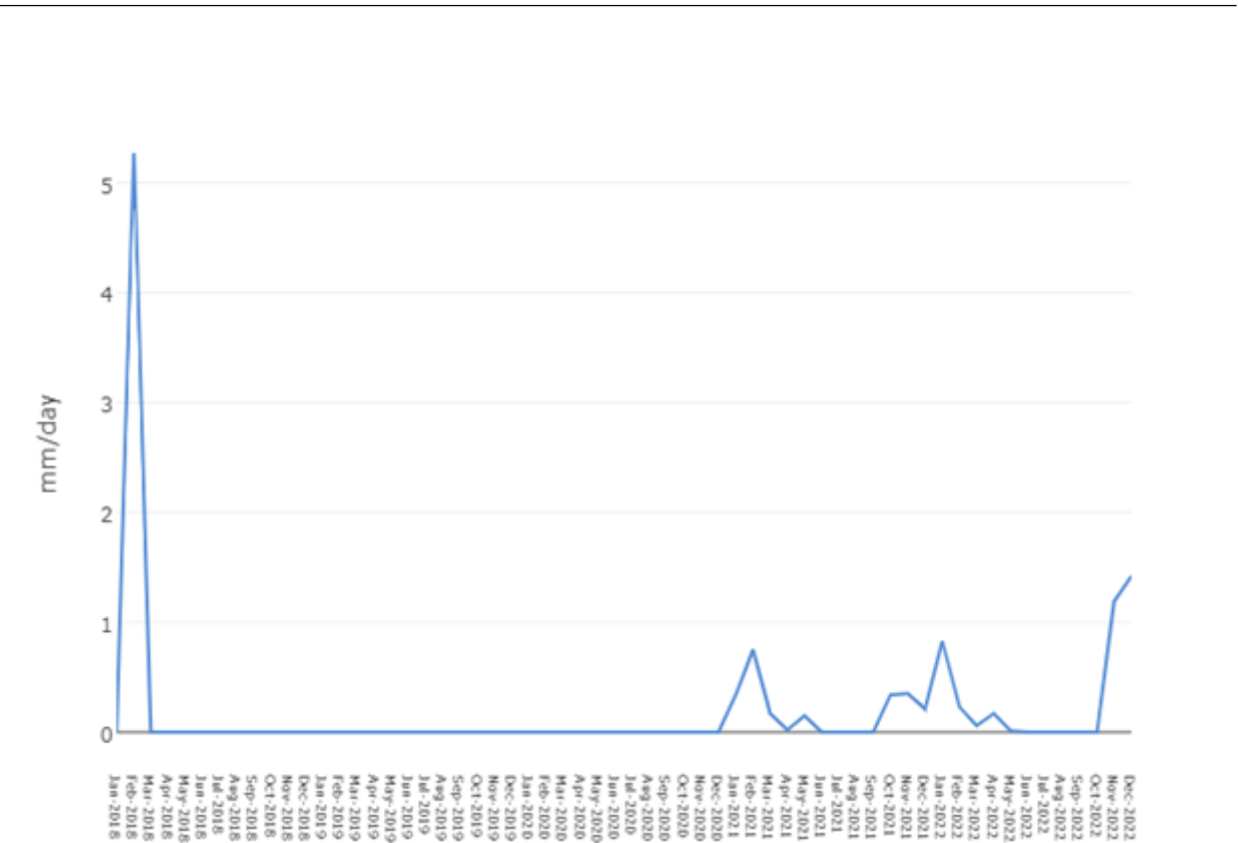
The amount Of rain measured in Basra governorate

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2018	14.15	18.25	24.02	27.35	33.84	39.8 2	41.37	40.70	37.73	30.07	19.99	14.99
2019	12.51	14.44	17.93	25.15	34.83	40.31	40.26	40.55	37.72	31.37	19.43	14.41
2020	12.76	15.76	20.85	27.85	34.84	39.15	42.69	39.4	37.72	28.69	21.75	13.64
2021	13.01	61.57	21.69	29.81	36.77	39.6	42.57	40.94	36.06	31.4	22.02	16.41
2022	11.79	16.44	20.29	29.37	33.44	40.4	41.24	42.08	36.83	29.54	18.83	15.02



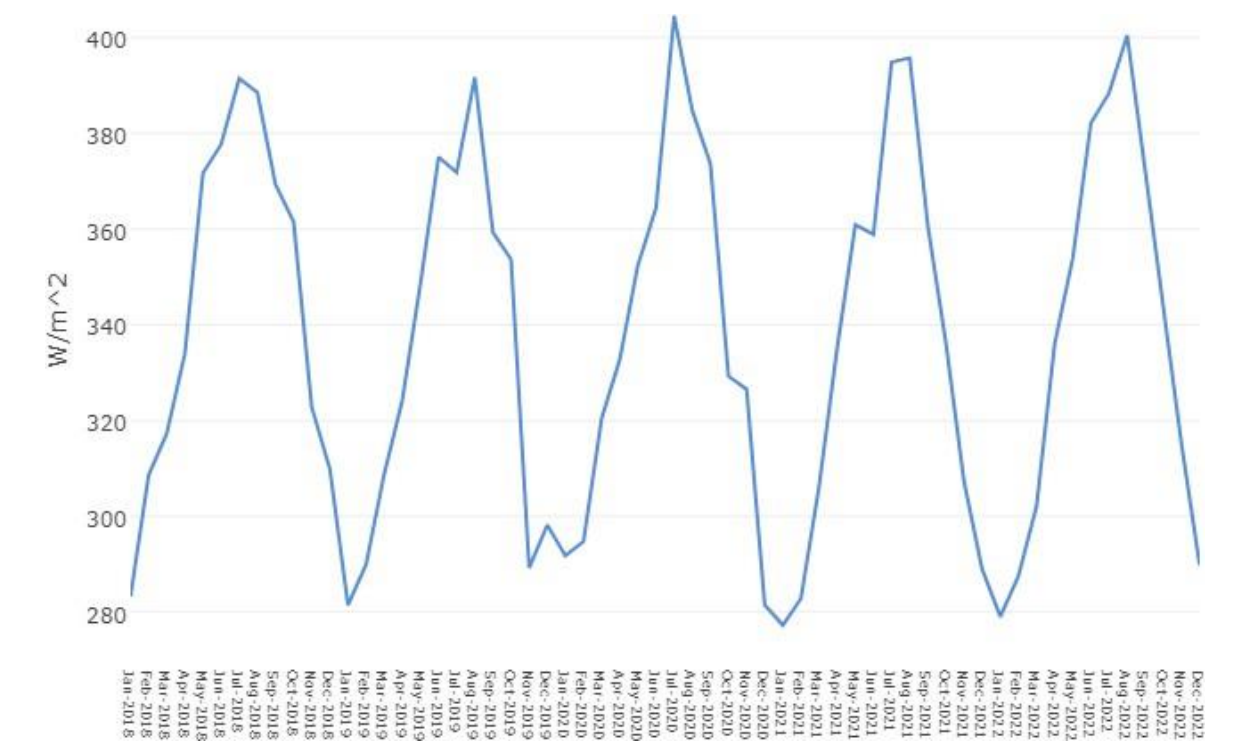
The amount Of rain measured in Baghdad governorate

year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2018	10.32	14.07	19.36	22.79	28.71	35.55	38	37.46	34.88	28.0 2	16.92	12.0 5
2019	8.96	11.34	14.46	20.33	30.04	37.6	37.8 7	38.75	34.33	28.4 4	17.73	11.9 4
2020	9.67	11.56	17.62	23.51	31.23	36.05	40.8	37.87	36.05	26.8 7	18.93	10.9 8
2021	10.17	12.69	17.34	25.85	33.64	36.48	40.6 5	39.43	34.69	28.6 7	18.57	12.7 5
2022	10.73	14.01	19.48	22.62	28	34.55	36.3 7	63.37	34.06	27.6 8	16.88	12.3 6



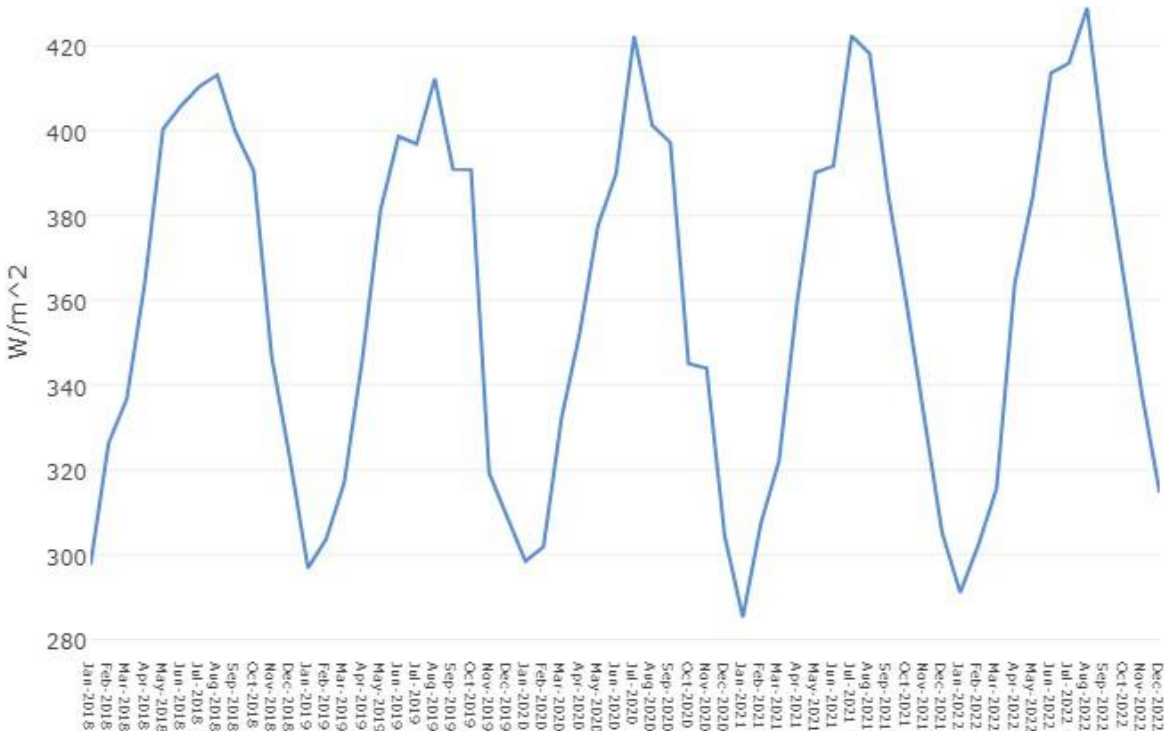
The amount Of rain measured in Kirkuk governorate

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2018	7.21	10.23	15.26	19.51	25.33	33.26	37.55	36.66	32.71	25.61	14.36	9.19
2019	6.07	8.2	10.74	16.01	24.68	33.62	36.13	38.03	31.87	26.05	13.9	9.65
2020	6.48	8.08	14.2	19.18	27.33	34.08	39.55	36.47	34.05	25.13	15.72	8.62
2021	7.94	9.71	13.82	23.64	31.32	34.53	39.12	38.25	31.17	24.44	14.55	9.05
2022	5.1	9.94	10.72	20.86	26.03	35.47	37.7	38.3	32.88	25.9	15.98	21.9



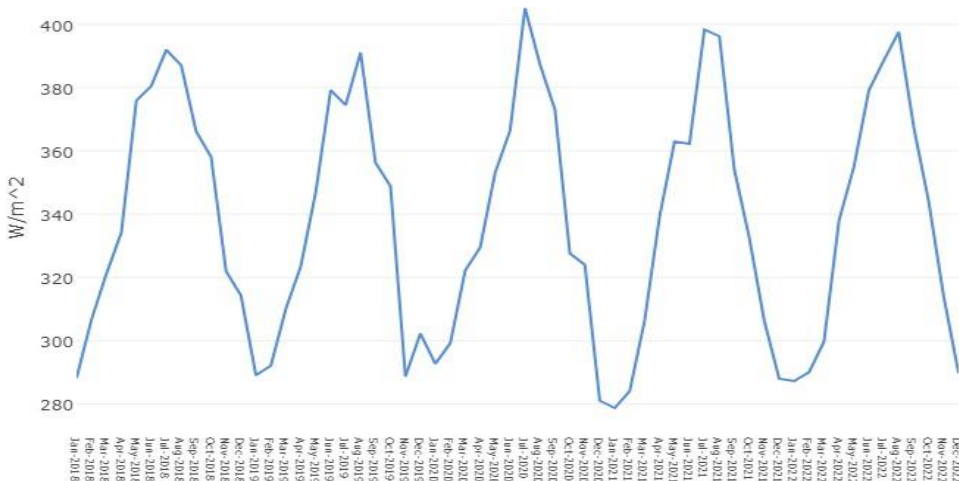
The amount Of rain measured in najf governorate

year	jan	fep	mar	apr	may	Jun	jul	aug	sep	oct	nov	dec
2018	11.02	15.24	20.54	24.54	30.44	37.26	38.61	37.83	35.66	27.94	17	12.52
2019	9.3	11.88	15.44	21.74	32.25	39.26	38.68	39.14	35.44	29.56	18.65	11.96
2020	10.51	12.02	18.05	24.83	32.29	36.84	41.74	37.46	36.4	27.18	19.69	11.25
2021	10.06	12.99	18.12	26.77	32.53	37.03	41.46	39.83	33.93	28.13	19.03	13.28
2022	9.08	14.13	16.62	26.06	30.98	38.86	38.98	39.87	35.05	29.4	19.7	13.28



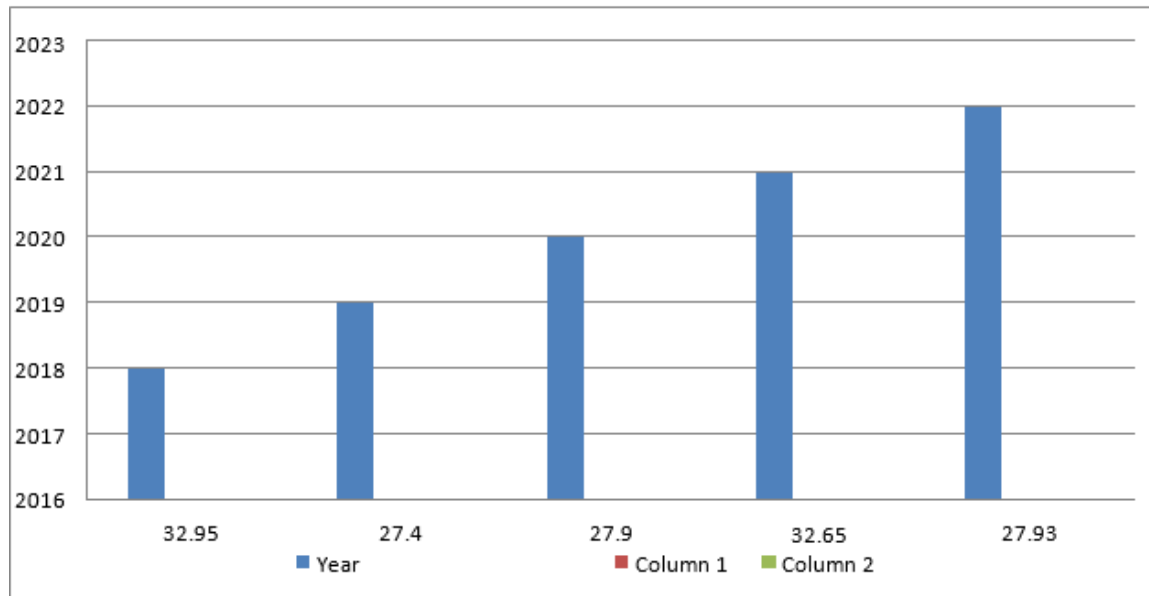
The amount Of rain measured in mousl governorate

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2018	6.17	9.46	14.82	19.12	24.8	33.12	36.96	36.11	31.71	23.84	13.28	8.25
2019	4.86	7.43	10.23	15.08	24.09	32.37	35.47	37.19	30.62	24.98	13.44	8.48
2020	5.22	6.81	13.31	17.4	24.73	32.49	38.32	35.65	33.17	24.25	14.46	7.5
2021	6.12	8.69	12.44	22.44	22.18	29.87	38.26	37.23	30.33	22.91	14.15	7.55
2022	3.75	8.9	9.65	19.77	24.73	34.26	37.37	32.06	24.4	13.87	8.66	8.66



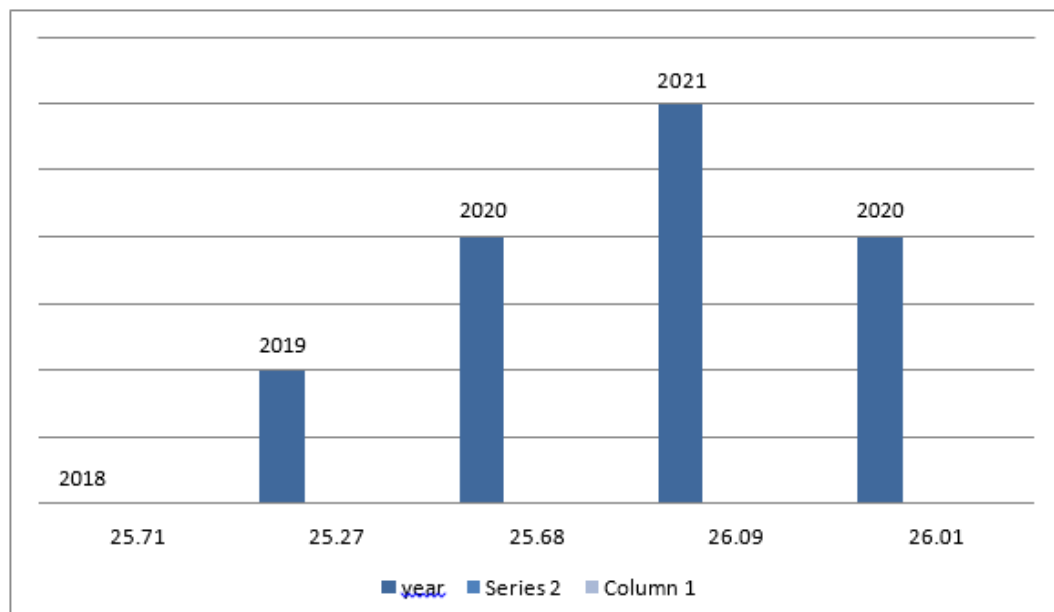
We use the arithmetic rate law method to extract the rainfall rate for Basra Governorate

Year	The average
2018	32.95
2019	27.4
2020	27.9
2021	32.65
2022	27.93



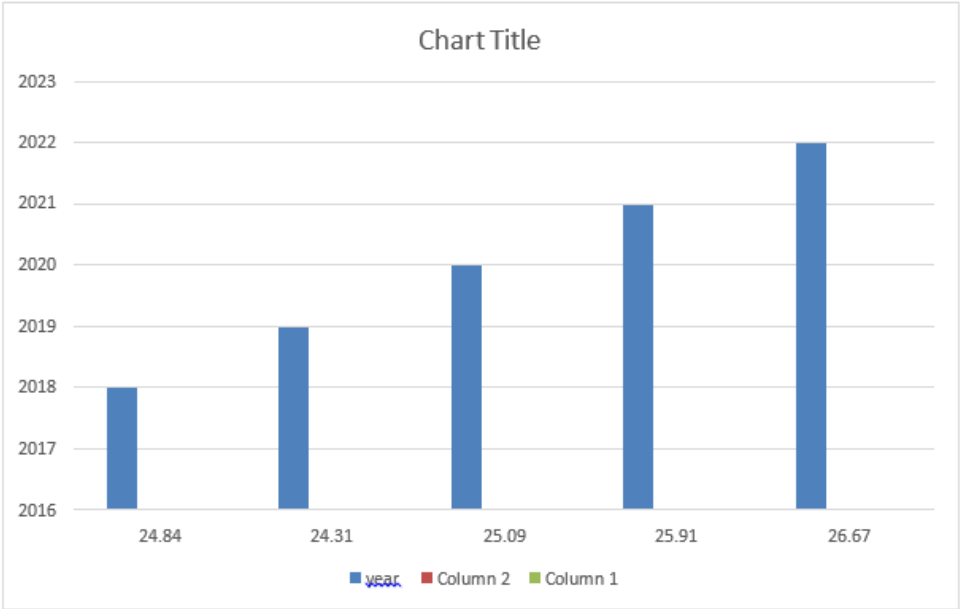
We use the arithmetic average law method to extract the rainfall rate in Najaf Governorate

Year	The average
2018	25.71
2019	25.27
2020	25.68
2021	26.09
2020	26.01



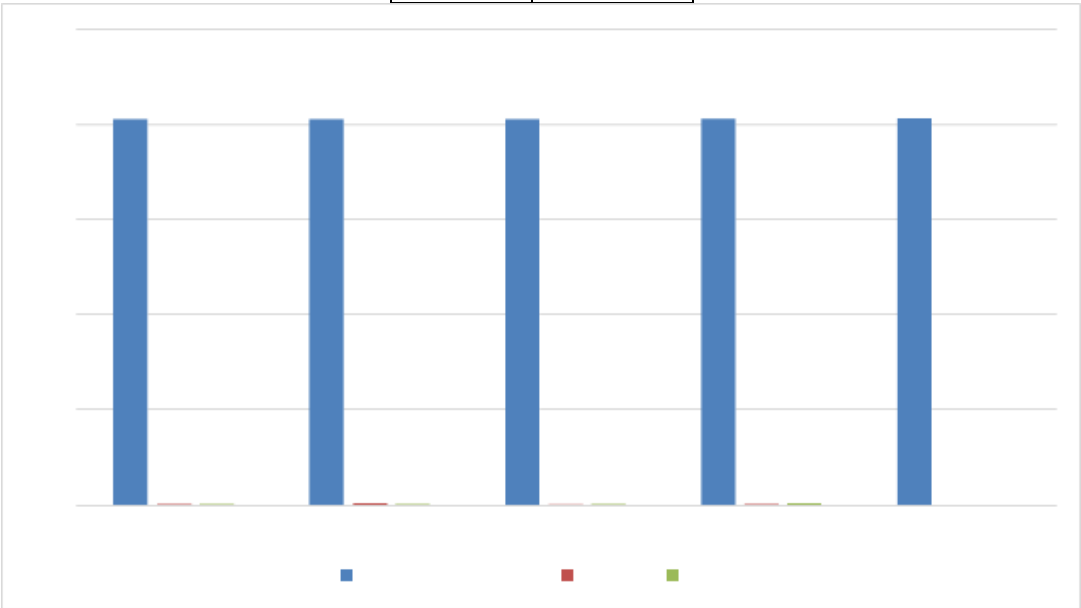
We use the arithmetic rate law method to extract the rainfall rate in Baghdad Governorate

year	The average
2018	24.84
2019	24.31
2020	25.09
2021	25.91
2022	26.67



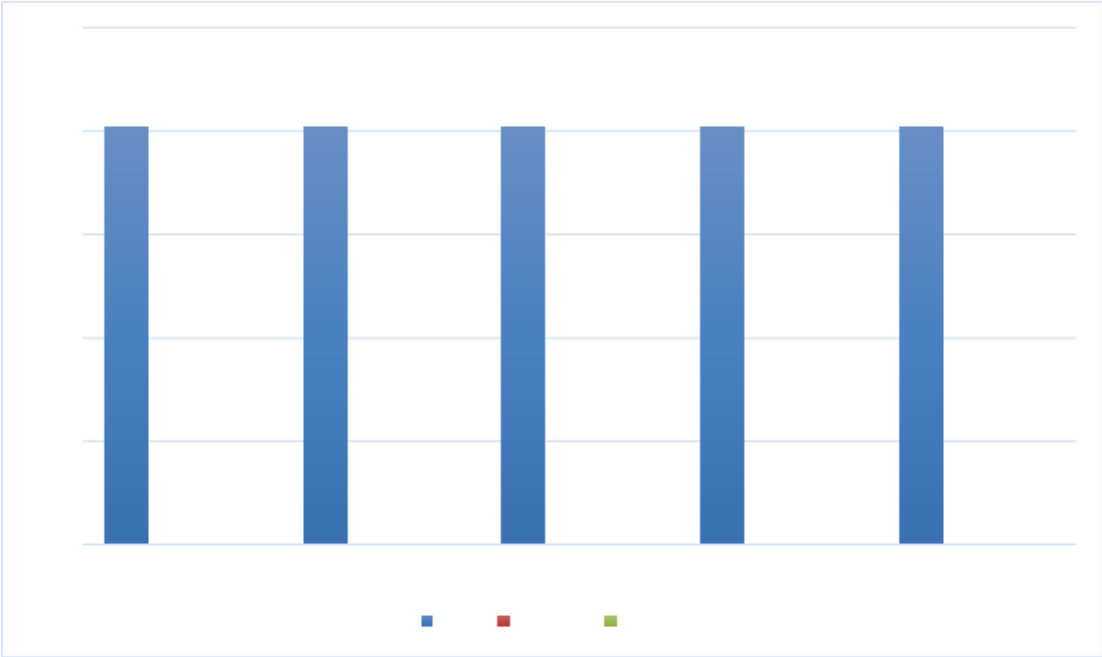
We use the arithmetic average law method to extract the rainfall rate in Kirkuk Governorate

year	The average
2018	22.23
2019	21.24
2020	22.40
2021	23.12
2022	23.3



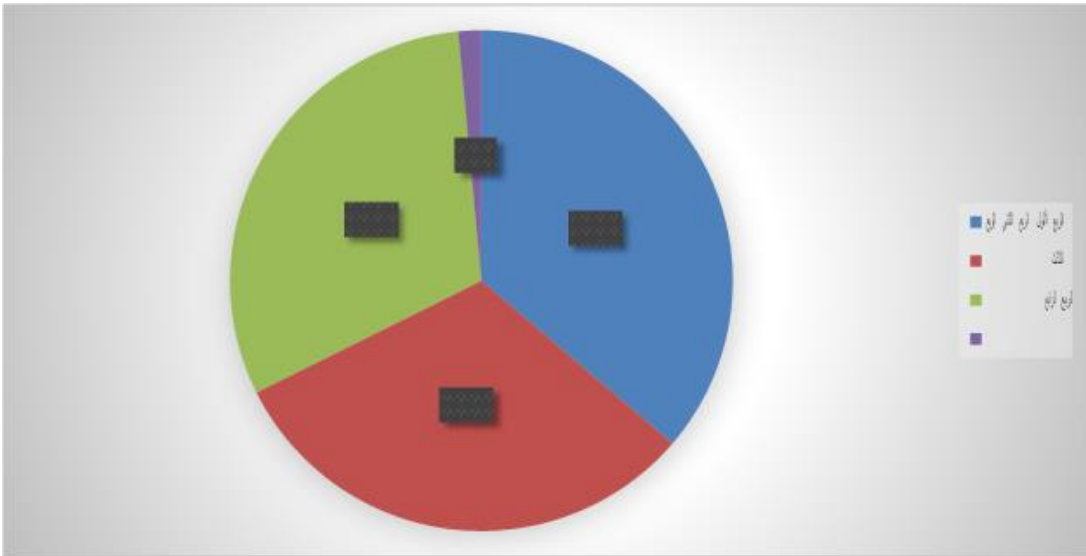
We use the arithmetic rate law method to extract the rainfall rate in Mosul Governorate

year	The average
2018	19.48
2019	20.35
2020	21.94
2021	21.01
2022	18.84



Comparison of rainfall rates over five years between the studied governorates (11)

Governorate	The average
Basra	18.45
Najaf	20.32
Baghdad	22.30
Kirkuk	29.76
Mosul	25.75



Discussion and final grades:

1. Annual rainfall rates vary and become more variable as we advance into the future, in addition to their trend toward decline, as they reached in Kirkuk (18.45 mm/year), Mosul (20.32 mm/year), Baghdad (25.36 mm/year), and Najaf (25.75 mm/year). And in Basra (29.76 mm/year).
2. Evapotranspiration from available water constitutes the largest percentage, reaching 90% in the dry months, of the total amount of evapotranspiration in the region.
3. The region suffers from a climatic water deficit, in the third period, in the Amara and Ali Al-Gharbi stations, respectively, and it is increasing as we advance into the future.

First: The most important conclusions reached by the studies:

1. Preparing a future action plan by the relevant ministries (Ministry of Water Resources and Environment) to follow the best modern methods that work to reduce water consumption and water losses.
- 2 Following modern policies in purifying and desalinating water for urban use, by the Ministry of Municipalities, and renovating private facilities to supply drinking water in a manner appropriate to reducing the loss and consumption accordingly to benefit from rainwater.
- 3- Annual rainfall rates vary and become more variable as we advance into the future, in addition to their trend toward decline
- 4 - Evapotranspiration from available water constitutes the largest percentage, up to 90% in the dry months, of the total of evapotranspiration in the region.
- 5- Some areas suffer from a climatic water deficit as the years progress.

Second: The most important recommendations:

1. Conduct comprehensive studies of the regions regarding rainfall.
2. Expanding the construction of many dams with the aim of storing water in order to benefit from it for a long period.
3. Individual awareness of how to consume water by rationalizing the use of rainwater.
4. Companies must be obligated to address oil pollution if it occurs and reduce its impact as much as possible.
5. Activating research studies on the subject of statistical climate studies with the aim of benefiting from them and employing them in the service of cities.
6. The need to educate citizens about climate change and beware of its dangers, and to establish research centers specialized in water in Arab countries in general and in countries that suffer from severe water shortages in particular.
7. Relying on renewable and alternative energy such as (wind, solar, and water energy).
8. Intensifying efforts to educate the public about the need for economy and not to be wasteful in the use of water for the purpose of reducing water rates.

Waste and loss in it.

9. Benefiting from advanced technologies in the beauty of water uses in various economic aspects, especially in the agricultural field, as usual, using the drip irrigation method and others.
10. Conduct future research in this field.

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