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Impact of short-term climate change on precipitation ranges in arid and semi-arid basins Case Study: Northeast Libya - Wadi al-Lulb Basin

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Abstract.
Climate change is one of the most prominent environmental issues of global and local concern, with impacts varying between regions. Dry and semi-arid areas, and among the important effects caused by short-term climate change is the change in precipitation patterns. In this context, the study relied on some appropriate quantitative statistical methods that explain the characteristics of rain, with the use of geographic information systems in spatial analysis during the time period from 1961 to 2021. The study included three stations representing different locations within the study area. The results showed that there was a decrease in the number of rain periods and an increase in annual droughts, and a significant increase in the length and intensity of droughts, in addition to the change in the pattern of precipitation, as precipitation became less regular and more extreme, which contributed to forming a large proportion of the total annual. These short-term changes indicate that there are potential environmental and economic impacts, including increased risks of flooding, soil erosion, and degradation of vegetation cover, as well as destruction of agricultural crops. This is attributed to prolonged droughts with intense precipitation occurring over short periods of time, hindering recharge operations of surface and underground water sources, which depend mainly on moderate and continuous precipitation. Especially in the arid and semi-arid areas of North Africa that are at risk of drought and desertification.

Keywords: time series, Short-term climate change, arid and semi-arid regions.

تأثير التغير المناخي قصير المدى على نطاقات هطول الأمطار في الأحواض الجافة وشبه الجافة: دراسة حالة: شمال شرق ليبيا - حوض وادي اللولب

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الملخص:

يُعدّ تغير المناخ من أبرز القضايا البيئية ذات الأهمية العالمية والمحلية، وتختلف آثاره بين المناطق. ومن أهم الآثار الناجمة عن تغير المناخ على المدى القصير تغير أنماط هطول الأمطار، لا سيما في المناطق الجافة وشبه الجافة. في هذا السياق، اعتمدت الدراسة على بعض الأساليب الإحصائية الكمية المناسبة لتفسير خصائص الأمطار، وذلك باستخدام نظم المعلومات الجغرافية في التحليل المكاني خلال الفترة من عام 1961 إلى عام 2021م. وشملت الدراسة ثلاث محطات تمثل مواقع مختلفة ضمن منطقة الدراسة. أظهرت النتائج انخفاضًا في عدد فترات هطول الأمطار وزيادة في حالات الجفاف السنوية، وزيادة كبيرة في طول وشدة حالات الجفاف، بالإضافة إلى التغير في نمط هطول الأمطار، حيث أصبح هطول الأمطار أقل انتظامًا وأكثر تطرفًا، مما ساهم في تشكيل نسبة كبيرة من إجمالي هطول الأمطار السنوي. تشير هذه التغيرات قصيرة الأجل إلى وجود آثار بيئية واقتصادية محتملة، بما في ذلك ازدياد مخاطر الفيضانات، وتآكل التربة، وتدهور الغطاء النباتي، فضلاً عن تلف المحاصيل الزراعية. ويعزى ذلك إلى فترات الجفاف الممتدة المصحوبة بهطول أمطار غزيرة خلال فترات زمنية قصيرة، مما يعيق عمليات تغذية مصادر المياه السطحية والجوفية، التي تعتمد بشكل أساسي على هطول أمطار معتدلة ومستمرة. ويتجلى ذلك بشكل خاص في المناطق القاحلة وشبه القاحلة في شمال أفريقيا المعرضة لخطر الجفاف والتصحر.

الكلمات المفتاحية: السلاسل الزمنية، تغير المناخ قصير الأجل، المناطق القاحلة وشبه القاحلة.

1 Introduction.

Changes in precipitation rates, and their fluctuation, are witnessing global interest in various fields, and of great importance in all areas of life, which increased interest in studying them and knowing the extent of change in their rates, especially after the emergence of the phenomenon of climate change. The study is concerned with the change in precipitation trends, and shifts or changes in their rate that occur in the natural rates of precipitation quantities, whether by increase or decrease, as part of this phenomenon, as rain is one of the most important climate elements on which life is based and agriculture arises, as the seasonal distribution of precipitation controls the dates of rain-fed agriculture, as well as being the main source of feeding underground reservoirs with water, as well as their impact on humans and their activity. It was possible to collect recent data on precipitation in the study area in three stations (Battah – Al Bayadah - Taknes) for the period 1961-2021, which was able to understand the nature of the precipitation of the green mountain, its monthly and seasonal distribution, and its future trends. The fluctuation for precipitation affects the potential of water resources in the study area, which depends on underground reservoirs like other areas in the north of Libya. Precipitation data were analyses by studying the monthly and quarterly distribution of precipitation, then studying its characteristics and return periods, and the likelihood of its fall in the study area, as well as the drought cycle as well as the general trend of precipitation.

2 study area

The study area is astronomically located between the meridiansº 21.3 and º21.24 east longitude, and between the latitudesº32 .26 andº32.40 north longitude in the northeastern part of Libya in the Cyrenaica region, it includes the watershed between the Marj plain to the west, the Bayadah region to the east, and the slopes of the first edge to the north. To the south, its upper tributaries extend to the Taknes region in; Wadi al-Lulb is one of the most important wadis in the Cyrenaica region of eastern Libya, which has a number of internal wadis with large water drainage. It covers an area of 560 km2, and its upper tributaries originate from the first and second plateaus, at an altitude ranging from 350 to 475 meters above sea level. It has 759 tributaries with a total length of 515 km, flowing towards its mouth, which cuts through the slopes of the first edge towards the sea. Therefore, this basin enjoys abundant water resources through surface runoff from rainwater the second plateau.

Table 1. Meteorological stations in the study area

Station	Position	North latitude	Longitude East	Height in meters	Distance from the coast
Battah	First Terrace	°32.17′.37″N	°21. 6′.57″ E	290	18km
Al Bayadah	Second Terrace	°32. 25′.74″N	°21.14′.74″ E	360	23km
Taknes	Second Terrace	°32. 28′.81″ N	°21. 8′58″ E	460	35km

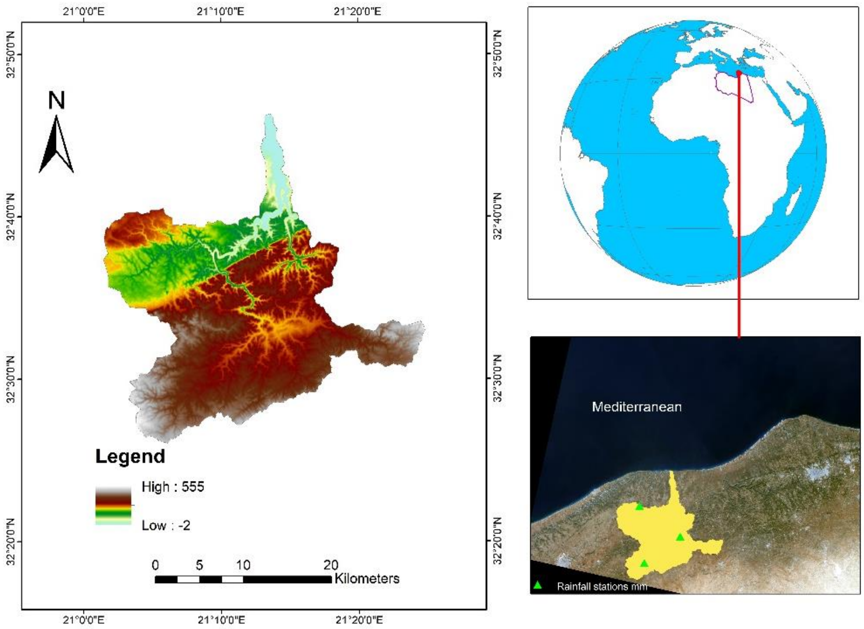

Fig. 1. Location

2 Data and methods

A quantitative statistical approach was used to study short-term annual and monthly changes in precipitation rates using statistical methods such as the Demartonne scale, correlation coefficient, standard deviation, and triple and quintuple time series from 1961 to 2021. Cartography was also used to analyze the spatial and temporal distribution of precipitation during the specified period. Using the isohyet method and Thiessen polygons to represent precipitation in millimeters/year, these methods helped reveal trends and patterns of short-term changes in precipitation and assess the extent of the impact of these changes on The Demartonne equation, also known as the Demartonne drought index, is a mathematical equation used to assess the degree of drought in a given area. It is calculated based on the average annual temperature and annual precipitation. The formula is: Demartonne aridity index $(IAD) = P / (T + 10)$ Where: P: average annual precipitation (in millimeters), T: average annual temperature (Anastasios, 2012) (in degrees Celsius). Interpretation of results: *If IAD < 5: arid climate. If 5 ≤ IAD < 10: semi-arid climate. If 10 ≤ IAD < 20: semi-humid climate. If 20 ≤ IAD < 30: humid climate. If IAD ≥ 30: very humid climate* (Gaetano, Tommaso, & Ilaria, 2019).

Station	Decemb er	January	Februar y	March	April	May	June	July	August	Septem ber	October	Novem ber
Battah	82.0	94.7	57.0	36.9	12.1	0	0	0	0	3.9	32.0	47.4
Al Bayadah	71.5	70.0	50.0	32.1	9.5	0	0	0	0.2	6.4	26.0	36.8
Taknes	63.5	60.7	44.9	25.2	8.2	0	0	0	0	2.5	27.3	30.7
Monthly Total	217	225.4	151.9	94.2	29.8	0	0	0	0.2	12.8	85.3	114.9
Monthly average	72.3	85.1	50.6	31.4	9.9	0	0	0	0.06	4.2	28.4	38.3

Table 2. Monthly and annual precipitation rates (mm) for the period 1961-2021

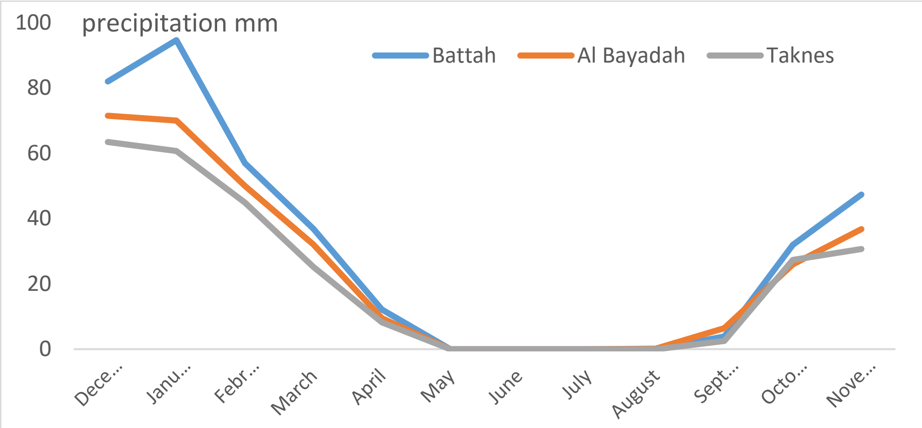

Fig. 2. Precipitation curves for monthly averages in mm for the period 1961-2021

3 Data preprocessing

The missing precipitation data in an area station was estimated in a study based on the precipitation data in nearby measurement stations and the observation of the annual precipitation characteristics in nearby stations within 10% of the annual precipitation of the monitored stations (De Silva, N.D.K. , & M D , 2007).

$$PX = 1/m\ (P1 + P2 + \ldots Pm)$$

$^{PX:}$ missing annual precipitation data for station $x^{P2,\ P1---Pm:}$ Annual precipitation recorded at m number of nearby stations. When there is a large variation in precipitation data for nearby stations, the normal ratio method is applied if the normal precipitation for each $^{(m+1)}$ of the stations is $^{Nx,\ N2\ldots Nm,\ N1)}$ When *Nx* annual rains in station x we use the equation: (D, et al., 2012)

$$3PX = Nx / m\ (P1/N1 + P2/N2 + \ldots Pm/Nm)$$

This method was used to find the missing values in the precipitation data for Batta, Al Bayada and Taknes stations for the period 1980-1990.Climatic information was provided for the study of the rain element of the study area, from the data of the National Center for Aerial Recycling, Tripoli, where it included the monthly rates of rain, recorded by three stations surrounding the study area, namely, Batta, Bayadah and Taknes located within the boundaries of the basin, to reflect the change in the rain element along the area of the basin. Monthly precipitation rates were taken for sixty-one consecutive years 1961-2021 to observe a trend throughout the recording period. The difference in the geographical distribution of the three climatic stations surrounding the study area, the difference in their heights and the area they represent, the uneven distance between the stations, and the irregular shape of the basin lead to a difference in the area of impact of each station with varying rain rates between one station and another, and determining the value of these rates statistically, and taking into account the weight of each station, and to measure precipitation, many methods were used, one of which is the Thiessen polygon method, which is a graphical technique named after Alfred H. Thiessen , the American meteorologist 1872–1956 (Thiessen polygon, n.d.)

who developed it, where these polygons are used to calculate the areas associated with rain gauges in measuring stations specifically and thus calculate the average amount of precipitation that fell in a particular basin during the storm, and the control points are distributed regularly to be the centers of spatial units that make regular geometric shapes, whether in the form of

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squares, rectangles, hexagons or irregular polygons, and then choose the centers in them according to radial divisions emitted from a specific center, and this method is characterized by not falling into the error of bias, as well as being in line with the nature of the spread of the phenomenon studied. This method helps to use the data of some adjacent stations when extracting weighted averages. Fig 3 shows this method where the connection is made between monitoring stations within the valley basin or on its edges with straight lines, and from the middle of those lines, and from the middle of the columns meet the bisecting columns of the lines connecting the other stations. The basin is divided into polygons, located in the middle of each polygon is a rain monitoring station, and then the area of each polygon is calculated from the area of the total basin, and the drop rate in each station is multiplied by that percentage, and the resultant is the average amount of precipitation on this basin, or the amount of precipitation is multiplied for all stations, and the amount of precipitation in each station is multiplied by the area of its polygon, and the product is added between them, and then the resultant sum is divided by the total precipitation in all stations, and the result is the average amount of the weighted precipitation $\bar{P}$: The average precipitation over the area of the collector. P1, P2…, *and Pm*: Precipitation values recorded at stations. A1, A2 .Am: Thiessen polygon area per station. A: *Side space* A1 + A2 +…. + Am Ai/A: Weight coefficient per station (1, 2, m) (Hanefi & F. Sezer, 2025).

$$p = \frac{P1A1 + P2A2 \dots . PMAM}{A1 + A2 \dots \dots \dots \dots . +AM}$$

$$P = \sum_{I=1}^{n} \frac{PiAi}{A}$$

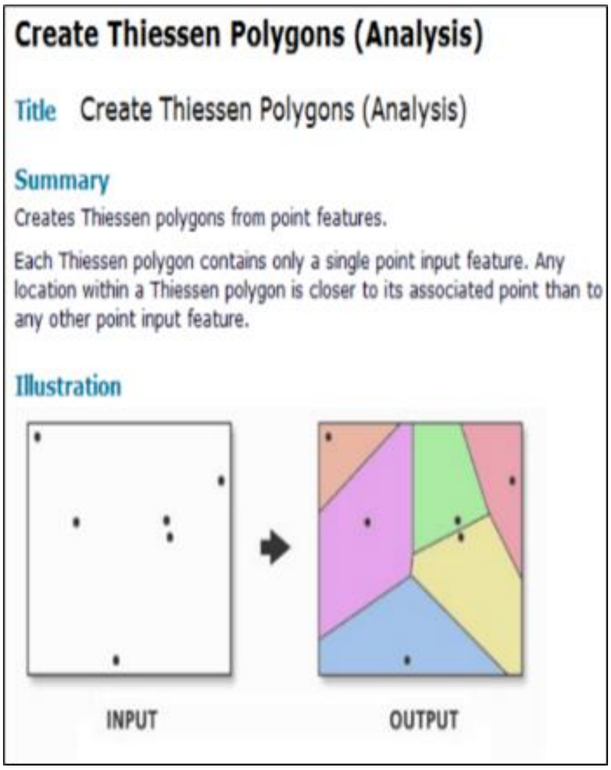

Fig. 3. Stages of creating Thiessen polygons. Software GIS

4 Results and discussion

4.1 Climate classification of stations in the study area

comparing the output of the effectiveness of the precipitation for Demartonne with the precipitation data in the stations of the study area, and in the event that the output is less than 5, it is characterized by drought, and becomes semi-arid if the output of the coefficient is between 5-10, while it becomes relatively humid if the output is 10-20, (Denis, 2025) as the values of this coefficient reached 12.4 at Batta station, while it recorded a slight decrease in the stations of Al Bayada and Taknes, where it reached 10, 8.6 respectively, and this makes it fall within the range of the semi-arid climate, but this coefficient varies from one season to another, but it appears that the study area is dominated by drought , noting that this distribution may change from year to year with fluctuations in precipitation rates and temperature in general. Based on Demartonne's coefficient, the year can be divided into two seasons: the rainy season, which begins in October and ends in March at all stations in the valley basin, and the dry season, which begins in April and ends in September. The proposed boundaries for distinguishing between the different types of dry and wet climates for Demartonne's aridity coefficient reflected a clear variation between monitoring stations, as well as between all seasons for the same region.

Stations	Temperature Range Annual	Rain Rate Annual	Actual value of precipitation	Type Climate
Batta	19.5	366	12.4	Relatively humid climate
Al Bayadah	20.5	302.5	10	Semi-arid climate
Taknes	20.6	263.3	8.6	Semi-arid climate

Table 3. Demartonne's dehydration coefficient

4.2 Distribution of annual and seasonal precipitation

This method involves drawing the locations of stations in the study area on a map, and then connecting points that are close to each other in terms of the amount of precipitation with lines, which leads to the formation of what looks like ranges (Reza, 2007). Fig.4 shows that the precipitation distribution takes the form of longitudinal bands extending from northwest to southeast, and takes a geographical extension that corresponds to the extension of the topography of the study area, and it is noted that the highest values of annual precipitation bands during the period 1961-2021 were recorded at the Bata station located in the northwestern part of the study area. Precipitation ranges decrease in the southeast and south at the Taknes station near the water division line south of Jebel Akhdar. The precipitation bands diverge from each other and slope gently from the south and southwest towards the north and northeast to the precipitation band 95 mm. They then converge towards the sub-mountainous region until they begin to gather north of the precipitation band 310 mm, accompanied by a steep slope until they reach the precipitation band 365 mm in the far north and north-west of the study area at Bata station. However, this spatial disparity takes the form of narrow and close ranges in the north of the basin, while they are wide and far apart in the central and southern regions. This means

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that precipitation is primarily heavy, with annual precipitation values in the northern region reaching 366-302.3 mm, as is the case at the Bata and Bayada stations. In the southern region of the basin, annual precipitation values of 263.3 mm were recorded at the Taknes station. These records show that the precipitation values in the northern region are about twice as much as what the southern region receives. It should also be noted that there is a spatial disparity between the amounts of precipitation at stations located within the same region, and this is evident in Al Bayada and Taknes stations, although the two stations are located in the second terrace at 360 meters above sea level and the amount of precipitation is 302.5 mm, while Taknes station is located at 460 meters above sea level and the amount of precipitation is 263.3 mm. The previous fig 4 also show that the precipitation values at Al Bayad station are higher than Taknes station, although Taknes station is located at higher altitudes than Al Bayad station, due to the presence of local differences within the same basin, where the effect of winter depressions decreases towards the south, while the situation is different at Bata station located on the slopes facing the winter marine depressions.

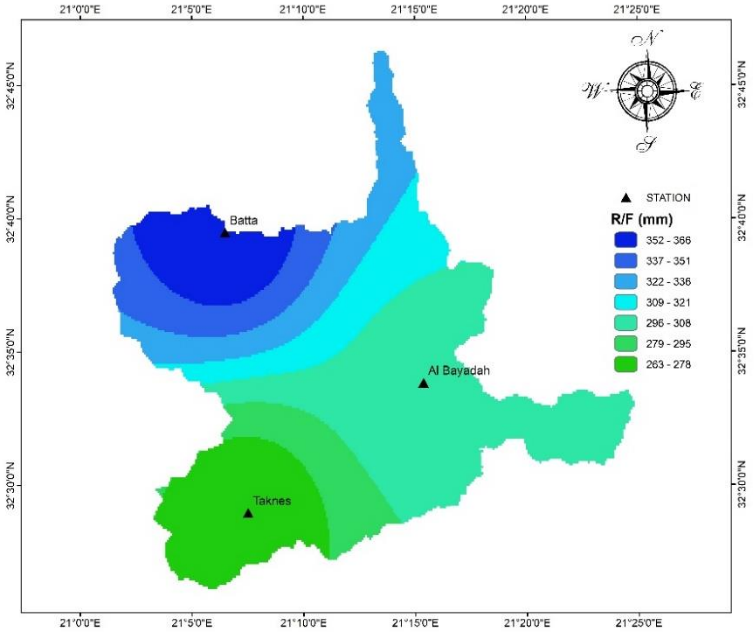


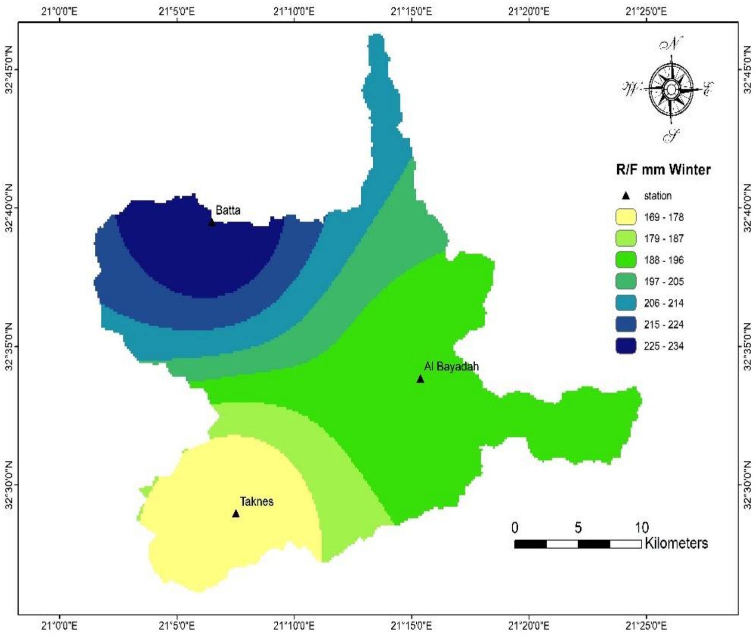
Fig. 4. Annual distribution of precipitation for 1961-2021

Table 4 show the seasonal distribution of precipitation at the stations located in the study area, through which it is clear that the winter months are the rainiest months, which is normal, representing 63.8% at Bata station, 63.4% at Al Bayadah station, and 64.4% at Teknis station. The winter season represents 63.8% of the amount of precipitation that falls in the dry year on the stations of the study area, as the total amount of precipitation in all climate stations in the basin reached 594.4 mm, which constitutes 63.8% of the annual distribution. Autumn ranks second after winter in terms of seasonal precipitation rates, as the total precipitation in this season reached 213 mm, with a rate of 22.8% distributed over three stations, Battah 22.9%, Al Bayadah 22.9%, and Taknes 23.0%. Spring is the least rainy season in the study area, accounting for 13.4% of the total precipitation, with a total seasonal precipitation of 124 mm.

Table 4. Quarterly precipitation distribution mm1961-2021

Rainy season	Batta Quarterly Total	%	Al Bayadah Quarterly Total	%	Taknes Quarterly Total	%	Total R/F	%
Winter	233.7	63.8	191.5	63.8	169.2	64.4	594.4	63.8
Spring	49.0	13.3	41.6	13.3	33.4	12.6	124	13.4
Autumn	83.3	22.9	69.2	22.9	60.5	23.0	213	22.8
Total R/F	366	100	302.3	100	263.1	100	931.4	100

Fig. 5. Winter precipitation rates in 1961-2021



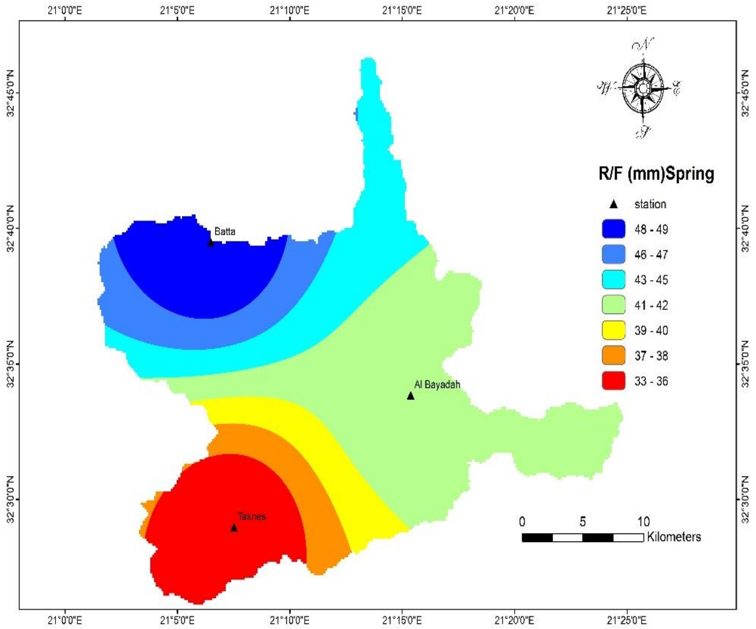


Fig. 6. Spring precipitation rates in 1961-2021

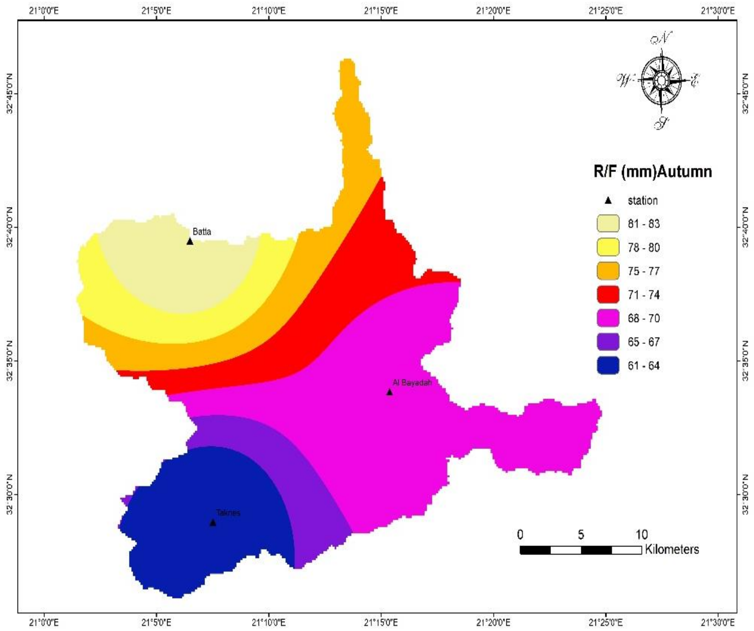


Fig. 7. Spring precipitation rates in 1961-2021

4.3 Analyzing by the Thiessen polygon method

he main objective of the results of the spatial analysis of the precipitation maps is to calculate and quantify the spatial variations in precipitation amounts during the study period. An aeria precipitation map was produced for all precipitation ranges (Croley & Hartmann, 2003). A set of these shapes was selected in order to study the changes that occurred in the study area, positively or negatively, for the total amount of monthly precipitation. The data of rain measurement stations were analyzed using Thyssen polygons in the Arcmap10.8.2 program, by dividing the study area into cadastral polygons. Each polygon represents a rain measurement station, and these areas are used to calculate the value of the average rain depth on the valley basin. Through Table 5 and Fig 8, it became clear that Al-Bayada station had the highest rain element area coverage of 235km^2, with a rain depth of 136.7 mm during the period from 1961-2021. Batta station comes in second place with an area coverage of 165 km^2, with a rain depth of 107.9mm, while Taknes station recorded an area coverage of 142km^2, with a depth of 66.6 mm of precipitation.

Stations	precipitation mm	Area Km 2	(An/A) %	Thiessen rate mm
Batta	366 pi	Ai 165	29.5	107.9
Al Bayadah	302.5pi	Ai 253	45.2	136.7
Taknes	263.3 pi	Ai 142	25.3	66.6
N total	931.6	A 560	100	311.2

Table 5. Precipitation according to the Thiessen average for the period 1961-2021

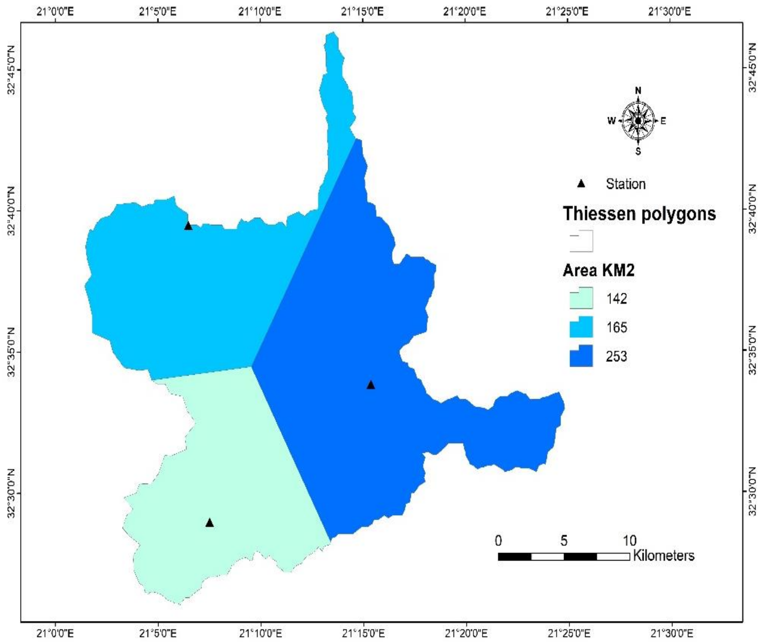


Fig. 8. Spatial distribution of precipitation

Looking at Table 6 and Fig 9, which show the quarterly total precipitation according to Thiessen mean, where the quantities of seasonal precipitation in winter in all stations of the valley basin did not exceed 100 mm, and the amount of precipitation recorded for the spring and autumn seasons reached the lowest level, reaching less than 50mm, which indicates that the region suffers from fluctuating precipitation, and that the area of the less rainy area represents the largest area at all stages with fluctuation and increase or decrease between dry and wet periods during the seasons of the year.

Rainy season	Taknes		Al Bayadah		Batta	
	Thiessen	Quarterly Total	Thiessen	Quarterly Total	Thiessen	Quarterly Total
Winter	42.8	169.2	86.5	191.5	68.9	233.7
Autumn	15.3	60.5	31.2	69.2	24.5	83.3
Spring	8.4	33.4	18.8	41.6	14.4	49.0
Total	66.5	263.1	136.5	302.3	107.8	366

Table 6. Seasonal distribution of precipitation in mm according to Theissen, 1961-2021

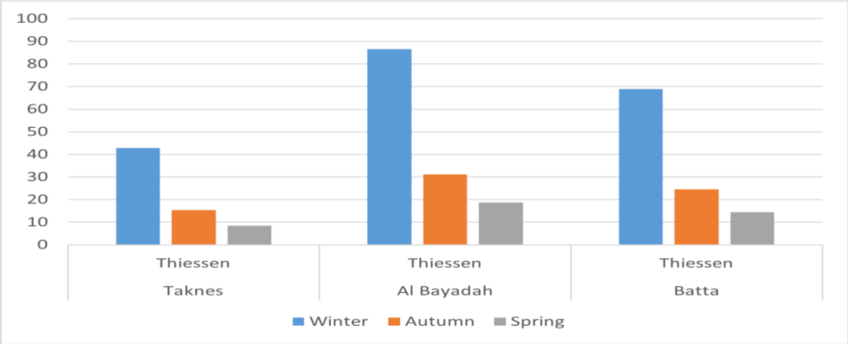


Fig. 9. seasonal distribution of precipitation according to the Thiessen mean for the period 1961-2021

As shown in Table7 which indicates the values of the correlation coefficient and the linear regression equations between the values of the drought coefficient, and the values of the amount of rain falling (Divya, Ajay , & , 2025) in the stations of the study area 1961-2021, there is a strong direct correlation in the stations of the study area Batta, Bayada, Taknes, where the value of the Demartonne drought coefficient is directly proportional to the values of precipitation, as it was found that the highest calculated rate of the drought coefficient in the Batta station, which was 12.4 during the study period, and its climate was classified according to the actual value of rain with a relatively humid climate, while the effectiveness of rain in the two stations of Bayada was 10 and 8.6 in the Taknes station, and thus the two stations are within the semi-arid climate according to Demartonne’s rain efficiency equation.

Table 7. Correlation coefficient values between drought and precipitation

Station	Monthly Correlation Coefficient Values	Link type	Linear regression equation	Coefficient of determination
Batta	0.99	strong centrifugal	y = 0.0348x - 0.0762	R^2 =0.98
Al Bayadah	0.96	strong centrifugal	y = 0.0327x - 0.024	R^2 =0.96
Taknes	97 - 98%	strong centrifugal	y = 0.0323x + 0.0152	R^2 =0.93

5 Return Periods and Precipitation Potential

The calculation of return periods is one of the analytical methods used to estimate the probability of rainfall and the time period within which precipitation is expected to recur, and the return period for a certain amount of rainfall is the period after which that amount of rainfall is expected to recur, and using the hydrological statistical analysis software HYFRANPLUS (Salaheddine & Bernard, January 2015) Through Table 8 and Fig10, it is clear that there is a positive relationship between the increase in precipitation rates and the likelihood of their occurrence. There is also a positive relationship between the increase in precipitation rates and the length of their return period. The probability of precipitation in Batta station during 20 years is estimated at 70.7mm at a rate of 0.95%. The probability of precipitation in 50 years is estimated at 89.1mm at a rate of 0.98%, while this rate will increase to reach after 100 years 104mm and by 0.99% to reach after 200 years a precipitation rate of 120mm and by 0.99. The rest of the stations will witness different return periods in which precipitation amounts vary according to different return periods.

Rain Depth at Batta Station mm	Rain depth in Bayada station mm	Rain depth at Taknes station mm	Likelihood of occurrence %	Return periods in years
70.7	46.6	45.5	0.95	20
89.1	54.2	51.6	97 - 98%	50
104	59.8	59.6	0.99	100
120	65.2	65.4	0.99	200

Table 8. Short-term changes in precipitation over 20-200 years

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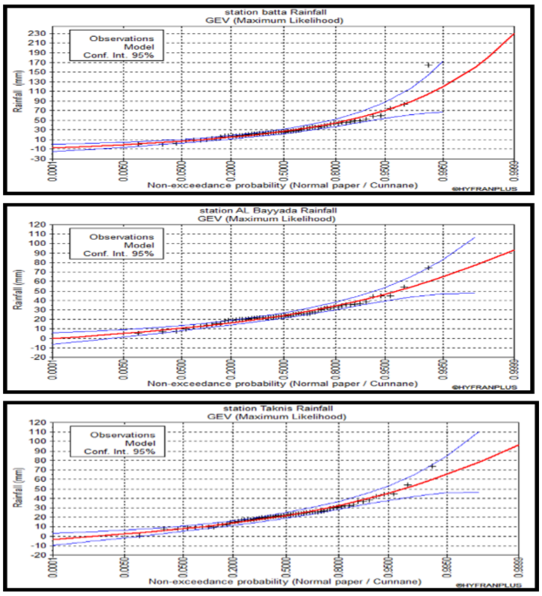

Fig. 10. Short-term probability of change curves from 20 to 200 years, based on statistical analysis of the GEV method using HYFRAN PLUS

6 Triple and quintuple moving averages of short-term precipitation change 1961-2021

he use of moving averages, whether three- or five-year, aims to minimize the fluctuations or irregular cycles found in some climate data, and is calculated by taking values every three or five years. The three- and five-year moving averages method is used to see if the deviation or variation in rainfall from the general rainfall trend line is random or regular (Rahul, et al., 2025). Analysis of Fig 11,12 showed that the study area generally experienced short-term changes of increase and decrease in rainfall rates, with some kind of regularity, as the three-year moving averages of the general annual rainfall in study area of Batta station showed that it was subjected to two periods of decrease in the amount of rain. The first period was from 1980-1990, and the triple average for this period was between, 148.3mm,253.8 mm and the second period 1990-2000, and the triple average for this period ranged between, 253.8mm, 189.3 mm, There are also three periods of increase in the amount of rain, the first of which is the period 1960-1970 with a triple average ranging from 302.7mm to 392.8 mm , and the second period between 1970-1980 with a triple average ranging from 375.8mm to 212.6 mm, while the third period between 2010-2020 with a triple average ranging from 297.1mm to 296.1 mm. It is also noted that there are years that are less than the general average, but most of them take the nature of an increase from the general average. As for the moving averages of the rest of the stations, the disparity and variation in the climatic periods increases, as most stations in the study area agreed that there are periods of decline from the general average in the period 1980-1990 The period 1990-2000 excludes Taknes Station, which witnessed fluctuations between increase and decrease, and the records of its three moving averages, a significant decrease from the general average at the level of all study stations during the period 1960-2020.As for the five-year moving averages, it was generally found that there are irregular periods of increase and decrease in the amount of precipitation from the general trend line of precipitation, but they are less oscillating compared to the three-year moving averages. This may be due to the increase in the length of the average period. For the general average at the level of the study area of the five-year moving averages, the variation appeared at the five-year level. It was found that there were three periods that increased during the period 1965-1970, 1970-1975, 1985-1990, while the decrease witnessed four periods, namely 1975-1980, 1985, 1990-1995-2000, 2005-2015, parallel to the general trend line of precipitation. The variation and irregularity increase in the inward trend, as Taknes station recorded a decrease in all time periods of all five-year moving averages for the period 1960-2020.Using the triple and quintuple moving averages method, the results showed that there was a noticeable decline in the annual average precipitation in the second period, compared to the first period, and that there was an inverse correlation between precipitation and time. The results also showed that the study area was exposed to 4 dry periods during which precipitation quantities decreased significantly in their rates. Results and data models indicate that short-term climate change may be responsible for the decrease in annual and monthly precipitation in the Study area.

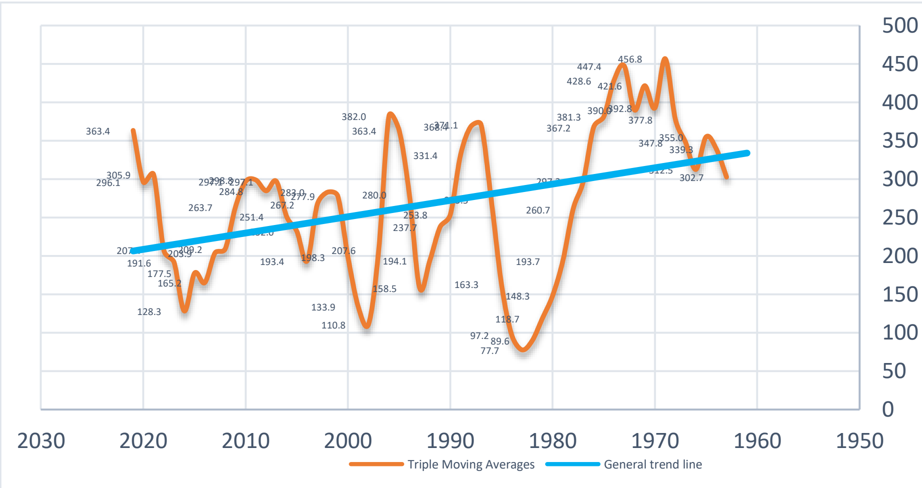

Fig. 11. Triple Moving Averages Station Batta

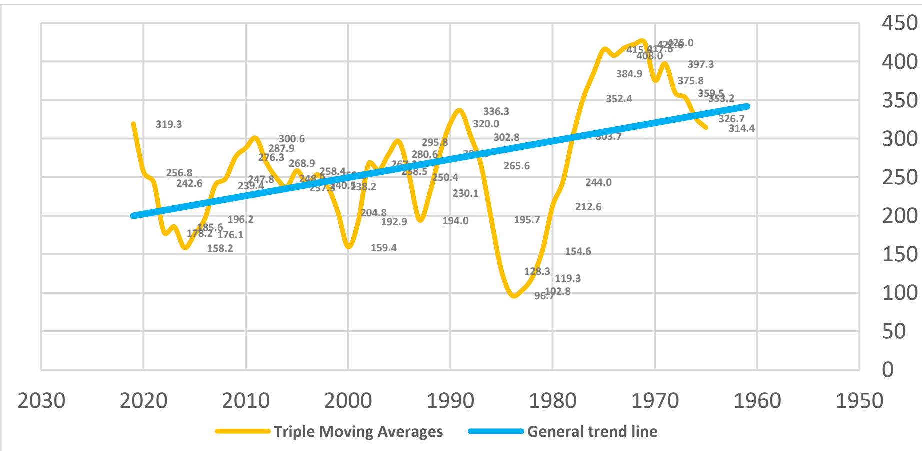

Fig. 12. Triple Moving Averages Station Batta

7 Conclusion

From the characteristics of rainfall in the study area, the results of rainfall maps and statistical measurements of rainfall data during the period 1961-2021, it is clear that the transition from semi-arid to arid regions in the study area occurs at a distance of no more than 30 kilometers to the south. The results of the spatial analysis and the spatial rainfall maps, which represent the monthly distribution of rainfall amounts for the period 1961-2021, also showed that .The area of the IUD basin suffers from low precipitation and the area of the less rainy area represents the largest area during the mentioned time period, with an increase or decrease fluctuation between dry and wet periods during the seasons of the year. Through the results of the DeMarton equation, and by calculating the values of the correlation coefficient, and the linear regression equations between the values of drought and the values of the amount of rain falling in the stations of the study area, the reason for the variation in the drought values can be attributed to the variation in the geographical location of the stations of the study area through distance and proximity to the sea with the variation in the height of the stations above sea level The triangular and quinquennial moving averages showed a significant decline in the annual averages of precipitation, and an inverse correlation between pre-capitation and time. They also showed that the study area was exposed to dry periods during which precipitation amounts decreased significantly from their rates. The results and data models indicate that climate change may be responsible for the decrease in annual and monthly precipitation amounts in the study area-It was also found that there is a strong direct correlation relationship in the stations of the study area of Batta, Al Bayada, and Taknes, where the value of the dehydration coefficient of Demartonne is directly proportional to the values of precipitation Please note that the first paragraph of a section or subsection is not indented. The first paragraphs that follows a table, figure, equation etc. does not have an indent, either. Subsequent paragraphs, however, are indented.

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