ACADEMIC JOURNAL

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International Journal of Culture and Modernity

INTERNATIONAL JOURNAL OF CULTURE AND MODERNITY

Article

CLIMATE IMPACT ON THE VARIATION OF THE AREA OF WATER COVER AND VEGETATION IN VALLEY FOUAD BASIN

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Citation: Ali Khazaal Jawad Al-Kulabi , Lamis Saad Hamid Al-Zuhairi. ***CLIMATE IMPACT ON THE VARIATION OF THE AREA OF WATER COVER AND VEGETATION IN VALLEY FOUAD BASIN***. International Journal of Culture and Modernity 2025, 5(1), 1-7.

Received: 01th Dec 2024
Revised: 21th Dec 2024
Accepted: 28th Dec 2024
Published: 16th Jan 2025

Abstract: The objective of the current study is to determine the variance in the Valley Fouad Basin's water and plant cover area using geographic information systems software and remote sensing data. The water cover index analysis of satellite images revealed that the maximum area reached approximately 218.4 km2 and a percentage of 84% during the winter season on January 18, 2023, while the area of inhabited lands reached approximately 234 km2 and a percentage of 90% during the summer season on June 11, 2023. On March 23, 2023, the area with dense vegetation cover reached a maximum area of 58.5 km2 and a percentage of 22.5 percent from the spring season, whereas the area with low-density vegetation cover reached a maximum area of roughly 52 km2 and a percentage of 20 percent. A direct and negative association between the rates and monthly total of climatic components and the water and vegetation cover index was also demonstrated by the study; the relationship ranged from complete to extremely strong. Additionally, the study's findings indicated that the basin's overall area was around 260 km².

Keywords: Fouad Valley, climate, vegetation index, water cover index, water area, vegetation area

I. INTRODUCTION

Among other things, environmental circumstances have a significant impact on how water and plant cover are distributed. Climate change, which refers to changes in long-term environmental circumstances, is predicted to be more varied across regions and less consistent than temperature increases, with some areas likely to grow drier and others wetter. The growth rates and persistence of plant species in a given area are directly correlated with changes in water availability. The region's soil moisture will be directly impacted by reduced rainfall. Decreased soil moisture will alter the dynamics of the ecosystem overall and negatively impact plant development.

Because the study area experienced rainy periods during the middle and upper Miocene eras, as well as the Pliocene and Pleistocene eras, which were marked by an increase in rainfall, the past climatic conditions had the greatest influence on the features of the valley surface. In contrast, the current climatic conditions are caused by a decrease in rainfall, an increase in temperatures, and an increase in evaporation, which has resulted in a decrease in the volume of water flow, which is limited only during the winter and spring seasons and the end of autumn. As a result, one of the basins with seasonal flow is the Valley Fouad basin , Consequently, the study demonstrated the fluctuation in water and plant cover due to the influence of climate change.

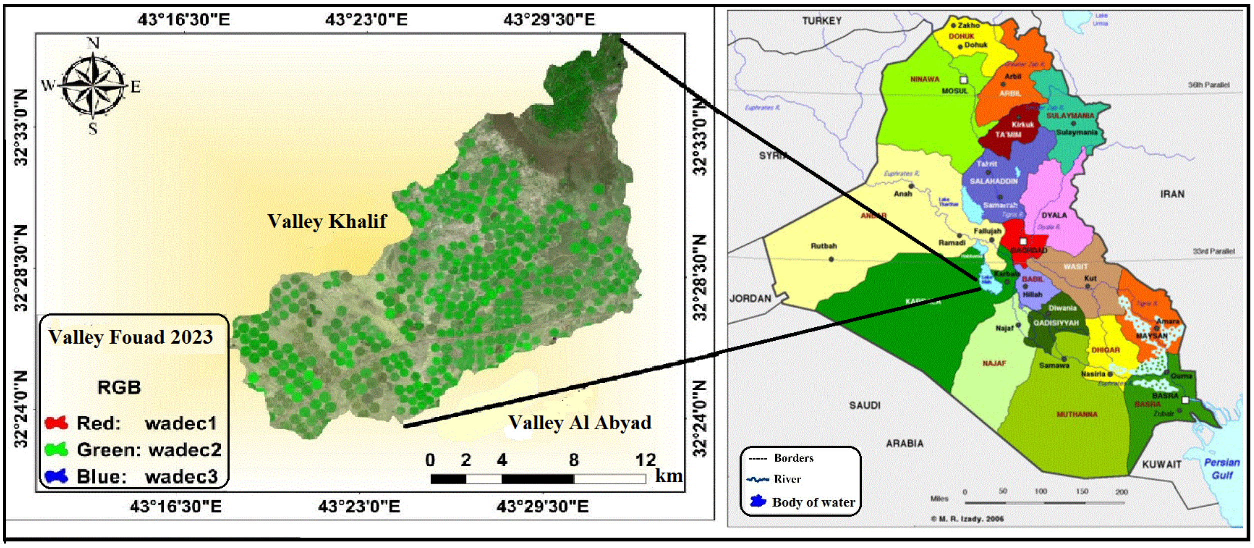
1- Research problem:

The following is a formulation of the study problem: "How does the climate affect the variation in the area of water and vegetation cover in the Valley Fouad Basin?"

2- Research hypothesis:

The Valley Fouad Basin's climate affects the variation in the area of water and vegetation cover. In the winter, when there is more rainfall, lower temperatures, and more evaporation, the area of water cover increases, whereas in the summer, when there is less rainfall, higher temperatures, and more evaporation, the area of water cover decreases. Additionally, the environmental conditions are not appropriate for its climatic needs because the area of vegetation cover increases in the spring due to the appropriate climatic conditions and decreases in the summer due to the lack of rainfall, the increase in temperatures, and the amount of evaporation.

Map (1) The study area's location



Source: Researcher's work based on:

Source: Researcher's work based on:

1- Republic of Iraq, Ministry of Water Resources, General Survey Directorate, Administrative Map of Iraq, scale 1:1000000, for the year 2010.

2- Satellite image captured by Landsat (8) satellite, for the year 2023 and outputs of Arc GIS 10.5 program.

3- Location of the study area:

The western plateau contains the Valley Fuad basin, which stretches southwest-northeast across portions of the governorates of Karbala and Anbar. It ends in the southwest corner of Lake Razzaza, at the village of Al-Din in the Ain Al-Tamr district. Valley Al-Abyad borders it to the south and east, while Valley Khalif and Lake Razzaza border it to the west and north. According to map (1), the valley's astronomical location is between latitudes 11" 36′ 32° - 6" 23′ 32°) and longitudes (10" 18′ 43° - 58" 32′ 43°). The basin's total size is 256.22 km. The study's time constraints included examining how Valley Fouad's climate affected the extent of water and plant cover in 2023.

4- Research objective:

calculating the variation in the area of water and vegetation cover during the study period's seasons due to the fluctuating effects of climatic elements, such as temperature, evaporation, and rainfall, using remote sensing techniques and geographic information systems (GIS).

5- Research Methodology:

In addition to employing the integrated analysis method to analyze remote sensing data using the geographic information systems program, such as creating maps of vegetation cover and water, the researcher used the quantitative and statistical method to study and analyze the climatic elements.

6- Data and programs used in the research:

In order to investigate the variation in the area of water and vegetation cover, the research used a number of sources, including the Ain Al-Tamr station's climate, the American satellite's (8-landast) satellite image, the water cover index (NDWI), the vegetation cover index (NDVI) based on spectral bands (4,5), and the program (10.5 ARC GIS).

7- Research Structure:

The study was divided into three chapters: the first chapter covered the introduction and the theoretical framework (the problem, hypothesis, objective, methodology, location of the study area, data, and programs used in the research); the second chapter illustrated the Valley Fouad Basin's climatic features; and the third chapter included the statistical analysis of the correlation between the water and vegetation cover index and the climatic elements, along with conclusions, suggestions, and a list of sources.

II. Results and discussion.

Solar radiation, temperature, wind, relative humidity, rain, and evaporation are the climatic components that will be discussed in order to determine how the current environment affects the variation of the water and vegetation cover area in the Valley Fouad Basin. The Razzazah station was selected to do this, as indicated in Table (1), which also shows the study area station's location with respect to the latitude and longitude lines and its elevation above sea level.

Table 1shows the chosen station's location based on its height above sea level, anode number, latitudes, and longitudes.

T	Station	Location coordinate	
		Longitude/East/Degree	Latitude/North/Degree
1	Razzaza	°43.97	°32.55

Source // Researcher's work based on the Ministry of Agriculture, Agricultural Meteorology Center, unpublished data, 2023.

The chosen climatic components of the research region are as follows:

First: The amount of solar radiation: -

Table (2) and Figure (1) make it evident that the maximum rate of solar radiation throughout the research period was about 26.09 calories/cm2/second in July, while the lowest rate was approximately 9.52 calories/cm2/second in December. Table (2) and Figure (1) also make it evident that the winter months, which have the lowest monthly rates of solar radiation, saw the highest amount of solar radiation, approximately 14.94 calories/cm2/second, in February and the lowest amount, approximately 9.52 calories/cm2/second, in December.

While the monthly rates drop to their lowest level in March, reaching 19.09 calories/cm2/second, they start to rise to their highest level in the summer months, reaching a minimum of 22.97 calories/cm2/second in August and a maximum of 22.69 calories/cm2/second the month of May. In the spring, the monthly rates gradually increase to reach a maximum of 22.69 calories/cm2/second the month of May.

Due to the large angle of incidence of solar rays and the clarity of the sky, the study area receives more solar radiation in the summer than in the winter. This results in high temperatures, which raises the rates of evaporation and transpiration as well as the values of water losses from the soil surface. This has a negative impact on the amount of water that plants require to complete their life cycle.

Table 2 Monthly solar radiation rates for the Razzazah station in 2023, expressed in calories/cm2/second

month	Monthly averag	month	Monthly averag
December	9.52	June	25.23
January	10.94	July	26.09
February	14.94	August	22.97
March	19.09	September	19.88
April	21.85	October	14.37
May	22.69	November	11.44

Source // Researcher's work based on the Ministry of Agriculture, Agricultural Meteorology Center, unpublished data, 2023.

Table (2) and Figure (1) make it evident that the monthly rates progressively decline throughout the fall months, peaking at roughly 19.88 calories/cm2/second in September and falling to about 11.44 calories/cm2/second in November.

Figure (1) shows the monthly solar radiation rates for the Razzazah station in 2023, expressed in calories/cm2/second.

Source: Based on Table (2), the researcher's work.

Second: Temperature rate:

A- Temperature rate:

Table (3) and Figure (2) make it evident that the monthly average temperature records its lowest rates during the winter months. It decreased to its lowest limit during the study period in January, reaching 9.29 °C, while reaching its maximum of approximately 13.87 °C in February. Then, when the maximum average temperature in May reaches around 27.68°C and the lowest in March reaches approximately 15.36°C, the monthly averages start to rise steadily.

Table 3 shows the Razzazah station's monthly temperature rates for 2023.

month	Monthly averag	month	Monthly averag
December	13.35	June	34.48
January	9.29	July	35.49
February	13.87	August	36.55
March	15.36	September	32.66
April	24.06	October	27.36
May	27.68	November	18.59

Source // Researcher's work based on the Ministry of Agriculture, Agricultural Meteorology Center, unpublished data, 2023.

With a maximum of 36.55 °C in August and a low of 34.48 °C in June, the summer months saw the highest monthly average temperature. Then, as solar energy decreased during the fall, the monthly average temperature started to progressively drop. It ranged from a maximum of 32.66 °C in September to a minimum of 18.59 °C in November.

Figure (2) shows the Razzazah station's monthly temperature rates for 2023.

Source // Researcher's work based on Table (3).

Third: Winds:

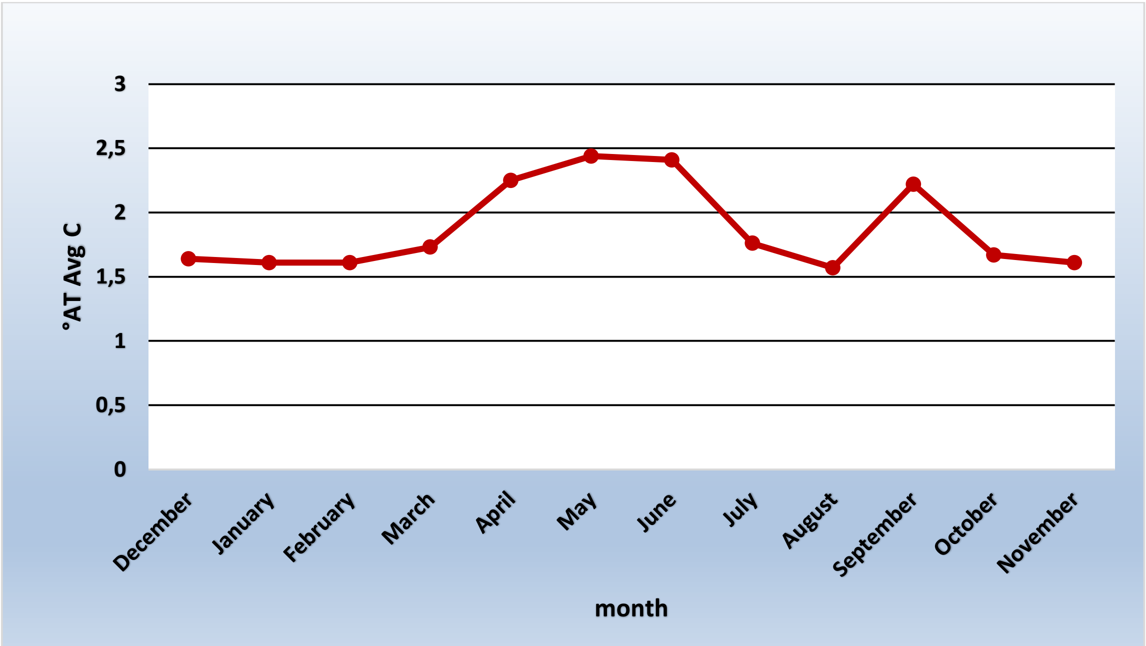
Table (4) and Figure (3) make it evident that over the winter months, the monthly wind speed rates varied from a high of 1.64 m/s in December to a minimum of around 1.61 m/s in January and February. Regarding the spring months, the monthly rates varied from a low of 1.73 m/s in March to a maximum of 2.44 m/s in May, While Figure (3) suggests that the monthly averages of wind speed during the summer months reached a maximum of approximately (2.41) m/s in June and a minimum of approximately (1.57) m/s in August, the monthly averages of wind speed start to progressively decline during the autumn months. The monthly average of wind speed reached a maximum of approximately (2.22) m/s in September and a minimum of approximately (1.61) m/s in November.

Table (4)shows the Al-Razzazah station's monthly average wind speed (m/s) for 2023.

month	Monthly averag	month	Monthly averag
December	1.64	June	2.41
January	1.61	July	1.76
February	1.61	August	1.57
March	1.73	September	2.22
April	2.25	October	1.67
May	2.44	November	1.61

Source // Researcher's work based on the Ministry of Agriculture, Agricultural Meteorology Center, unpublished data, 2023.

Figure (3)shows the Al-Razzazah station's monthly average wind speed (m/s) for 2023.



Source // Researcher's work based on Table (4).

Fourth: Relative humidity: -

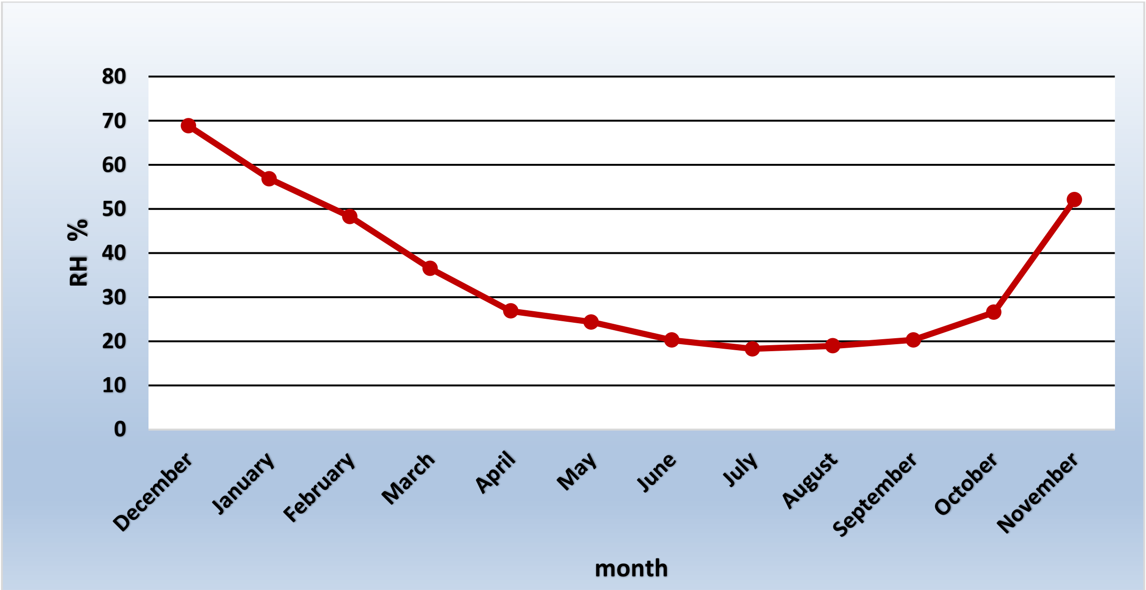
The evaporation of water from soil and water bodies, as well as transpiration from plants, are the sources of atmospheric moisture. Because transpiration and evaporation happen less often when a plant reaches saturation with moisture and more frequently in dry air, they have an impact on the water balance of a plant. Since it produces the majority of condensation, including rain, showers, drizzle, and other phenomena that affect plant life, relative humidity is one of the most significant climatic factors. The way tissues regulate their water content changes when the atmosphere's relative humidity rises , Given that the highest monthly rate during the study period was recorded at approximately 68.83 percent in December and the lowest monthly rate during the winter months reached approximately 48.28 percent in February, it is evident from Table (5) and Figure (4) that the monthly rates of relative humidity peak during the winter months. Regarding the spring months, Figure (4) illustrates how the monthly rates progressively decline throughout this time of year. The maximum monthly relative humidity rate was around 36.49 percent in March, while the lowest rate was approximately 24.34% in May.

Table (5)shows the Razzazah station's monthly relative humidity rates (%) for 2023.

month	Monthly averag	month	Monthly averag
December	68.83	June	20.26
January	56.84	July	18.26
February	48.28	August	18.97
March	36.49	September	20.29
April	26.85	October	26.55
May	24.34	November	52.09

Source // Researcher's work based on the Ministry of Agriculture, Agricultural Meteorology Center, unpublished data, 2023.

Figure (4)shows the Razzazah station's monthly relative humidity rates (%) for 2023.



Source // Researcher's work based on Table (5).

According to Figure (4), the monthly relative humidity rates are lowest in the summer months. The highest rate, which was around 20.26 percent in June, is followed by a decrease in July, which is about 18.26 percent, which is the lowest monthly rate during the study period. According to Table (5) and Figure (4), the monthly relative humidity rates increased gradually throughout the autumn months, peaking at roughly 52.09 percent in November. The lowest monthly rate of the season was recorded in September at roughly 20.29%.

Fifth: Rain:

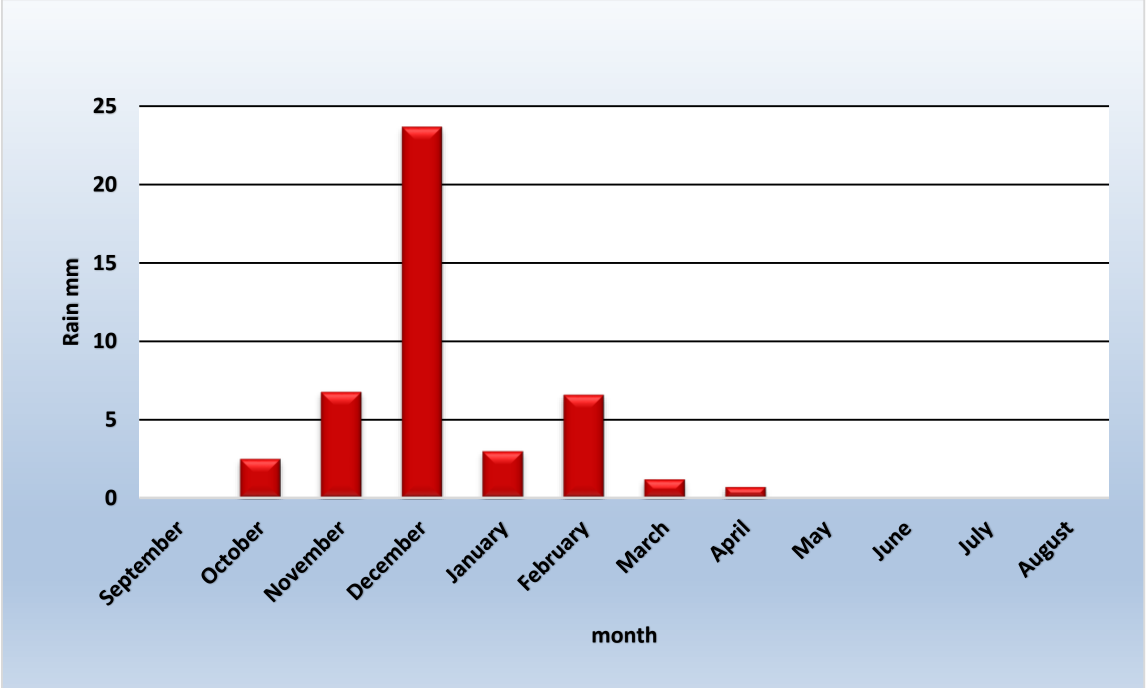
It is clear from Table (6) and Figure (5) that the monthly totals of the rainfall that falls in the stations fluctuate during the course of the research period's months and seasons. Rain is an important supply of nutrients for subterranean reservoirs in arid and semi-arid settings. It also contributes to the natural environment industry with its diverse composition.

Table (6)shows the Razzazah station's total monthly rainfall for 2023.

month	Monthly averag	month	Monthly averag
September	0	March	1.2
October	2.5	April	0.7
November	6.8	May	0
December	23.7	June	0
January	3	July	0
February	6.6	August	0

Source // Researcher's work based on the Ministry of Agriculture, Agricultural Meteorology Center, unpublished data, 2023.

Figure (5)shows the Razzazah station's monthly total rainfall (mm) for 2023.



Source // Researcher's work based on Table (6).

Figure (5) shows that the monthly totals of rainfall during the autumn months continue to rise, with the highest amount reaching approximately 6.8 mm in November and the lowest reaching approximately 0 mm in September , Figure (5) shows that monthly rainfall totals reach their highest point in the winter, peaking at 23.7 mm in December, and then falling to their lowest point in January, at about 3 mm. Regarding the spring months, the highest amount of rainfall in April was around 1.2 mm, while the lowest amount in May was approximately 0 mm. Additionally, Figures (6) and (5) show that there was no rainfall recorded in the monthly totals during the summer.

Sixth: Evaporation:

It is evident from Table (7) and Figure (6) that the monthly evaporation totals fall to their lowest value during the winter months. The highest monthly total during the study period was approximately 83.15 mm in February, while the lowest monthly total during the study period was approximately 53.5 mm in December.

Table (7) shows the Razzazah station's monthly evaporation totals (mm) for 2023.

month	Monthly averag	month	Monthly averag
December	53.5	June	279.4
January	60.2	July	256
February	83.15	August	227.1
March	126.6	September	222.1
April	199.7	October	153.6
May	238.4	November	85.3

Source // Researcher's work based on the Ministry of Agriculture, Agricultural Meteorology Center, unpublished data, 2023.

Figure (6)shows the Razzazah station's monthly evaporation totals (mm) for 2023.

Source // Researcher's work based on Table (7).

Figure (6) makes it evident that the monthly evaporation totals climb progressively over the spring months, peaking in May at about 238.4 mm. The lowest monthly total was observed in March, at 126.6 mm. Figure (6) makes it evident that the monthly totals peak during the summer months, particularly in June when they hit a maximum of 279.4 mm, which is regarded as the highest monthly total during the study period. In August, the monthly totals were at their lowest, coming in at about 227.1 mm , The monthly totals start to progressively decline in the fall, peaking at 222.1 mm in September. They then fall to their lowest point at the conclusion of the season, particularly in November, when they hit 85.3 mm.

Section Three

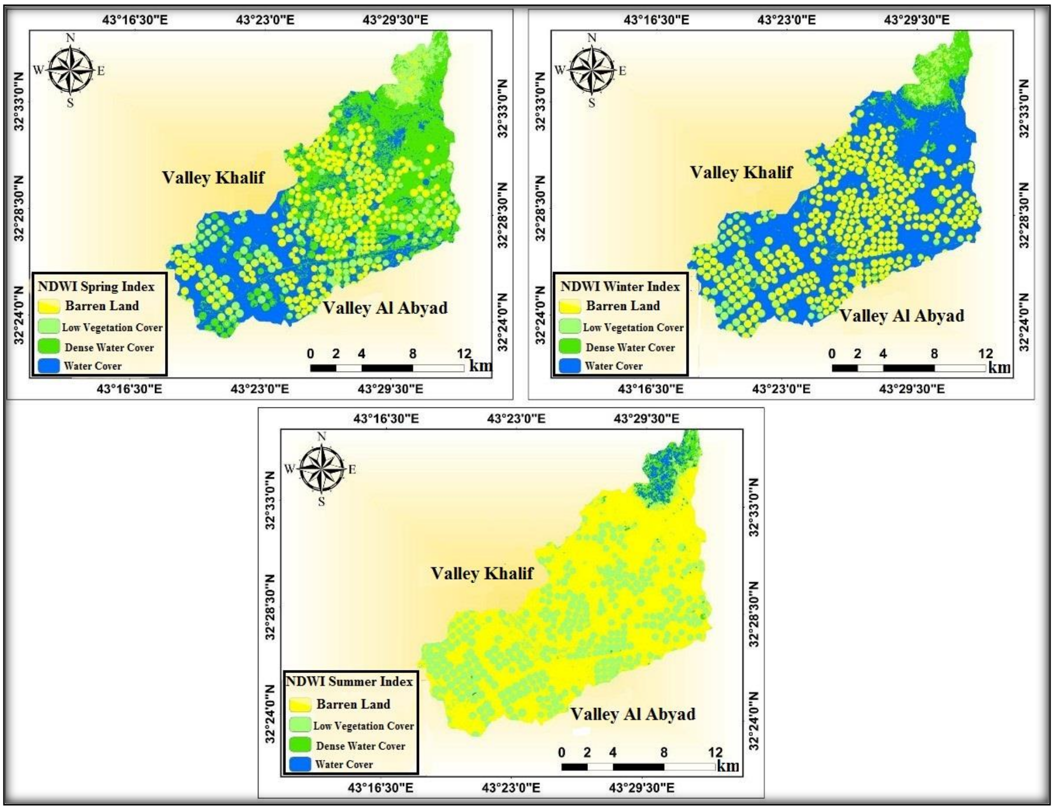
Statistical analysis between climate elements and variation in the area of water cover and vegetation in the Valley Fouad Basin

The variance in the area of water cover, vegetation, and land was impacted by the influence of climatic factors on the research region. The water cover reached its maximum area during the study period in 2023 at approximately (218.4) km2 as a maximum and at a percentage of (84%), during the winter season on 01/18/2023, as shown in Table (8) and Map (2). The water cover index (NDWI) and the satellite's visibility (Landsat 8) also show that the water cover reached its lowest area during the summer season on 06/11/2023, where it decreased by approximately (5.2) km2 and at a rate of 2% , In contrast, the lowest area was recorded at approximately (3.9) km2 and a percentage of (2%) during the spring season on 03/23/2023, while the largest area was recorded at approximately (234) km2 and a percentage of (90%) during the summer season on 06/11/2023, as Table (8) and Map (2) make evident.

Table (8) and Map (2) make it evident that the area of low-density vegetation cover in 2023 reached its maximum area of approximately 52 km2 and a percentage of 20 percent on 03/23/2023. The area then decreased to its lowest value during the summer on 06/11/2023, reaching 19.5% km2 and a percentage of 7.5%. In contrast, the area with dense vegetation cover reached its maximum area during the spring on 03/23/2023, reaching 58.5 km2 and a percentage of 22.5%, and then decreased to its lowest area during the summer on 06/11/2023, reaching approximately (1.3) km2 and a percentage of 0.5%.

The impact of the study area's climatic factors is the cause of this variation. For example, when the angle of incidence of solar rays decreases, the number of theoretical and actual hours of sunshine decreases, solar radiation decreases, wind speed decreases, relative humidity increases, rainfall increases, and evaporation/transpiration decreases, the area of water cover increases, which in turn causes a decrease in the area of lands with dense vegetation cover, particularly in January, while the area of vegetation cover increases as water cover decreases on these lands, particularly in March , The area of water cover and sparse and dense vegetation starts to decrease during the summer months of June, while the area of inhabited lands devoid of water cover and vegetation increases. These factors include the increase in the angle of incidence of solar rays, the number of actual and theoretical hours of sunshine, the increase in wind speed, the decrease in relative humidity, the increase in evaporation/transpiration, and the absence of rain.

Map (2) Seasonal fluctuations in the Valley Fouad Basin's water and plant cover



Source: The researcher's work is based on the satellite image captured by the Landsat 8 satellite on the dates (01/18/2023, 03/23/2023, and 06/11/2023) and the outputs of the Arc GIs 10.8 program.

Table (8) shows the Valley Fouad Basin's seasonal change in the area index and vegetation water cover % for 2023.

season / Cursor	Area (km2)			Percentage (%)		
	Winter	Spring	Summer	Winter	Spring	Summer
Water cover	218.4	145.6	5.2	84	56	2
Burned land	5.2	3.9	234	2	1.5	90
Low density vegetation	26	52	19.5	10	20	7.5
Dense vegetation	10.4	58.5	1.3	4	22.5	0.5

Source: Researcher's work based on Map (2).

Relationships correlations between the water and vegetation cover index and climate factors

Because some climatic elements have a direct influence while others have an indirect one, it was necessary to identify which climatic elements have the greatest influence in order to illustrate the variation in the Valley Fouad Basin's water and vegetation cover area. Additionally, the amount of this variation had to be determined using statistical methods. The direction of the climatic element's influence is also shown by statistical methods; some have a positive influence, meaning that they directly increase the variation in the area of water, vegetation, and land; others have a negative influence, meaning that they have an inverse relationship that decreases the area of water, vegetation, and land in the study area.

In order to find statistical relationships between climatic elements, water area, cultivated lands, low-density vegetation cover, and dense vegetation cover in the Valley Fouad Basin, the Pearson correlation coefficient was used to determine the strength of the correlation, and the interpretation or determination coefficient (R2) was used to interpret the degree of influence of the dependent element in the dependent element as well as the regression coefficient. Cultivated fields and the water area are linked in the satellite photos., As shown in Table (9), the monthly rates of solar radiation rate, temperature rate, relative humidity, rainfall, and evaporation were utilized for the months of 01/18/2023, 03/23/2023, and 06/11/2023 in order to determine the low-density and dense vegetation cover in the Valley Fouad Basin.

Tableau (9) Monthly climate data from the Al-Razzaza station for 2023

month	Total solar radiation rate Mj/m2	Average normal temperature (C)	Relative humidity (%)	Rainfall rate (mm)	Evaporation rate (mm)
January	10.94	9.29	56.84	3	60.2
March	19.09	15.36	36.49	1.2	126.6
June	25.23	34.48	20.26	0	279.4

Source // Researcher's work based on the Ministry of Agriculture, Agricultural Meteorology Center, unpublished data, 2023.

Because these months correspond to the middle of each season of the year, the researcher selected space photographs taken during these times to provide more realistic findings from the interaction between them and the climatic components. The statistical relationships of the researcher are displayed as follows:-

1- The statistical correlation between the Valley Fouad Basin's water and vegetation cover index and monthly rates of total solar radiation (Mj/m2):

The monthly average of total solar radiation and the area of water cover had a correlation value of -0.97, indicating a very strong inverse correlation without statistical significance below the significance level (0.05) and confidence level (95%). In contrast, the areas of low-density vegetation cover and dense vegetation cover showed very weak inverse correlations, reaching -0.11 and -0.07, respectively. This suggests that any increase in solar radiation will result in a reduction in the area covered by water, low-density vegetation, and dense vegetation.

However, a strong direct correlation coefficient of approximately 0.82 was found between the area of inhabited lands and the monthly average of total solar radiation, suggesting that any increase in solar radiation will also result in an increase in the area of inhabited lands.

Table (10) shows the statistical correlation between the Valley Fouad Basin's water and vegetation cover index for 2023 and monthly rates of total solar radiation (milliwatts/cm2/day).

Test / Cursor	Correlation coefficient	Calculated T	Tabular T	Regression coefficient	Interpretation coefficient
Water cover area	-0.97	1.57	2.920	-14.6	0.93
Area of cultivated land	0.82	0.86		15.15	0.67
Area of sparse vegetation	-0.11	1.26		-0.26	0.01
Area of dense vegetation	-0.07	0.27		-0.29	0

Source // The researcher's work is based on Tables (8) and (9).

The calculated T test value was less than the tabular T value, indicating the lack of a significant correlation, even though the regression coefficient shows that the change in the monthly average of solar radiation is what drives the rate of change in the area of water cover, the area of sparsely vegetated cover, and the area of densely vegetated cover. When the monthly average of solar radiation increases by 1 milliwatt/cm2/day, the area of water cover, sparsely vegetated cover, and densely vegetated cover decreases by (-14.6), (-0.26), and (-0.29) km2, respectively, Since the area of inhabited lands rises by 15.15 km2 every time the monthly rate of solar radiation increases by 1 milliwatt/cm2/day, the regression coefficient shows that the rate of change in the area of inhabited lands is a result of the change in the monthly rate of solar radiation. This implies that the area of inhabited lands and the monthly rate of solar radiation are directly correlated, and that the monthly rate of solar radiation, water cover, low-density vegetation cover, and dense vegetation cover are inversely correlated.

The interpretation factor for the area of inhabited lands, the area of low-density vegetation cover, and the area of dense vegetation cover is that the monthly average of solar radiation in the area of water cover caused 93% of the change, meaning that other factors account for the remaining 7% of the change in area. By describing how the monthly average of solar radiation affects the index of water and vegetation cover and is linked to it by direct and inverse correlation relationships, this proves the validity of the researcher's hypothesis that solar radiation influences the area of water and vegetation cover in the Valley Fouad basin.

2- The statistical correlation between the Valley Fouad Basin's water and plant cover index and monthly averages of normal temperature (°C):

According to Table 11, there is a very strong inverse correlation without statistical significance below the significance level (0.05) and confidence level (95%). The correlation value between the area of water cover and the monthly average of normal temperature was -0.99. In contrast, the areas of dense and low-density vegetation cover showed weak inverse correlations, reaching -0.43 and -0.46, respectively. This means that the amount of water cover, low-density vegetation cover, and dense vegetation cover will all drop in tandem with any increase in the average normal temperature.

The area of inhabited land and the monthly average of normal temperature showed a very strong direct correlation coefficient, reaching approximately 0.97. This suggests that any increase in the monthly average of normal temperature will be accompanied by an increase in the area of inhabited land.

Table (11) shows the statistical correlation between the Valley Fouad Basin's water and plant cover index and monthly averages of normal temperature (°C) until 2023.

Test / Cursor	Correlation coefficient	Calculated T	Tabular T	Regression coefficient	Interpretation coefficient
Water cover area	-0.99	1.47	2.920	-8.19	0.99
Area of cultivated land	0.97	0.89		9.79	0.94
Area of sparse vegetation	-0.46	0.85		-0.6	0.21
Area of dense vegetation	-0.43	0.17		-0.99	0.18

Source // The researcher’s work is based on Tables (8) and (9).

The calculated T test value was less than the tabular T value, indicating the lack of a significant correlation, even though the regression coefficient shows that the change in the monthly average of the normal temperature is what causes the rate of change in the area of water cover, the area of sparsely vegetated cover, and the area of densely vegetated cover. For every degree Celsius that the monthly average of the normal temperature increases, the area of water cover, sparsely vegetated cover, and densely vegetated cover decreases by -8.19, -0.6, and -0.99 km2, respectively. Since the area of inhabited lands increases by 9.79 km2 for every degree Celsius that the monthly average of normal temperature rises, the regression coefficient shows that the rate of change in the area of inhabited lands is a function of the change in the monthly average of normal temperature. This implies that the extent of populated areas and the monthly average of the normal temperature are directly correlated. It also demonstrates that the area of water cover, the area of low-density vegetation cover, the area of dense vegetation cover, and the monthly average of normal temperature are all inversely correlated.

Regarding the interpretation factor, the area of water cover experienced a change of 99% due to the monthly average of the normal temperature, which indicates that other factors contributed to the remaining 1% of the change in the area. This is also true for the areas of inhabited lands, low-density vegetation cover, and dense vegetation cover. This makes clear the direct and inverse correlations between the monthly average of the normal temperature and the water and vegetation cover index. This confirms the researcher's hypothesis that the average temperature in the Valley Fouad Basin affects the water and plant cover.

3- The statistical correlation between the Valley Fouad Basin's water and vegetation cover index and monthly relative humidity (%) rates:

As indicated in Table (12), a very high direct link with a correlation value of 0.97 between the monthly average of relative humidity and the area of water cover was discovered, with no statistical significance below the significance threshold (0.05) and confidence level (95%). Conversely, the regions with dense and low-density plant cover had relatively modest direct connections, with 0.08 and 0.12, respectively. Accordingly, if the rate of relative humidity rises, the area covered by water, low-density vegetation, and dense vegetation will all extend.**Table (12) shows the statistical correlation between the Valley Fouad Basin's water and vegetation cover index and monthly relative humidity rates (%) for 2023.**

Test / Cursor	Correlation coefficient	Calculated T	Tabular T	Regression coefficient	Interpretation coefficient
Water cover area	0.97	1.63	2.920	5.73	0.94
Area of cultivated land	-0.83	0.51		-5.99	0.69
Area of sparse vegetation	0.12	-0.4		0.12	0.02
Area of dense vegetation	0.08	-0.73		0.14	0.01

Source // The researcher’s work is based on Tables (8) and (9).

There was a significant negative association between the monthly average relative humidity and the amount of occupied land, up to a value of -0.83. According to this, the extent of populated land will drop in tandem with any increase in the monthly average relative humidity.

There is no significant correlation, as the calculated T test value was less than the tabular T value, even though the regression coefficient shows that the change in the monthly average of relative humidity is what drives the rate of change in the area of water cover, the area of sparsely vegetated cover, and the area of densely vegetated cover , As the monthly average of relative humidity increases by 1%, the area covered by water, sparsely vegetated cover, and densely vegetated cover all increase by 5.73, 0.12, and 0.14 km2, respectively. There is a clear correlation between the monthly average relative humidity, the area of water cover, the area of dense vegetation cover, and the area of low-density vegetation cover. However, as the area of cultivated lands shrinks by (-5.99) km2 for every 1% rise in the monthly average relative humidity, the regression coefficient shows that the rate of change in the extent of cultivated lands is a function of the relative humidity, This implies that the area of cultivated areas and the monthly average relative humidity have an inverse relationship.

The interpretation factor for the area of inhabited lands, the area of low-density vegetation cover, and the area of dense vegetation cover is that the monthly average of relative humidity in the area of water cover caused 94% of the change, meaning that the remaining 6% of the change was caused by other factors in the area ,This demonstrates how the monthly average of relative humidity affects the water and vegetation cover index and how there are both direct and inverse links between the two. This confirms the researcher's hypothesis that relative humidity affects the water and plant cover in the Valley Fouad Basin.

4- **The ValleyFouad Basin's water and plant cover index and monthly total rainfall (mm) have a statistical relationship:**

Table (13) demonstrates that there is a very strong direct correlation without statistical significance below the significance level (0.05) and confidence level (95%). The correlation between the monthly total rainfall and the area of water cover reached 0.96, while the area of sparsely dense vegetation cover recorded a very weak direct correlation with statistical significance, reaching 0.08, and the area of dense vegetation cover recorded a very weak direct correlation without statistical significance, reaching 0.03. This implies that any increase in the monthly total rainfall will be accompanied by an increase in the area covered by water, the area covered by sparsely thick vegetation, and the area covered by dense vegetation.

Table (13) shows the statistical correlation between the Valley Fouad Basin's water and plant cover index and monthly total rainfall (mm) in 2023.

Test / Cursor	Correlation coefficient	Calculated T	Tabular T	Regression coefficient	Interpretation coefficient
Water cover area	0.96	1.97	2.920	68.65	0.91
Area of cultivated land	-0.80	1.03		-70.19	0.64
Area of sparse vegetation	0.08	3.14		0.86	0.01
Area of dense vegetation	0.03	1.24		0.68	0

Source // The researcher’s work is based on Tables (8) and (9).

The amount of inhabited lands and monthly total rainfall showed a significant inverse correlation coefficient, up to -0.80, which suggests that any rise in monthly total rainfall will be accompanied by a drop in the area of inhabited lands. However, the calculated T test value was higher than the tabular T value for the area of sparsely populated vegetation cover, indicating the presence of a significant correlation, whereas the calculated T test value was lower than the tabular T value for each of the water cover area, the cultivated land area, and the dense vegetation cover area, indicating the absence of a significant correlation.

However, the regression coefficient indicates that changes in the monthly total rainfall are responsible for the rate of change in the areas of water cover, sparse vegetation cover, and dense vegetation cover. The area of water cover, sparse vegetation cover, and dense vegetation cover increase by 68.65, 0.86, and 0.68 km2, respectively, with every 1 mm rise in the monthly total rainfall rate , This indicates that there is a direct relationship between monthly precipitation totals, water cover, clairsemée vegetation, and dense vegetation. On the other hand, the coefficient of regression indicates that the rate of change of the inhabited land surface is determined by the variation of the monthly precipitation total because it decreases each time the monthly precipitation total increases by 1 mm. There is an inverse link between the monthly total pluviometry and the surface area of inhabited land, as seen by the inhabited land's surface area of (-70,19) km2.

In terms of the interpretative element, the monthly total pluviometry in the water coverage zone was responsible for 91% of the change, with other factors contributing the remaining 9% to the zone's alteration. Consequently, in the area pertaining to the surface of inhabited land, the low-density vegetation zone, and the densely vegetated zone, this explains why the monthly total pluviometry affects the index of hydric and vegetative coverage and is connected to it through direct and inverse correlations. This demonstrates the validity of the researcher's hypothesis that rainfall affects the water's surface and the bassin's vegetation cover. The Fouad Valley.

5- **The statistical association between monthly total evaporation (mm) and the water and vegetation cover index in Valley Fouad Basin.**

Table (14) shows a weak inverse correlation between monthly total evaporation and the area of water cover, with correlation values of (-0.40) and (-0.36), respectively, below the significance level (0.05) and confidence level (95%). Increased monthly evaporation leads to less water cover, low-density plant cover, and dense vegetation cover.

Table (14) shows the statistical association between monthly total evaporation (mm) and the water and vegetation cover index in Valley Fouad Basin for the year 2023.

Test / Cursor	Correlation coefficient	Calculated T	Tabular T	Regression coefficient	Interpretation coefficient
Water cover area	-1	-0.25	2.920	-0.96	1
Area of cultivated land	0.95	-3.06		1.12	0.91
Area of sparse vegetation	-0.40	-1.77		-0.06	0.16
Area of dense vegetation	-0.36	-1.8		-0.1	0.13

Source // The researcher’s work is based on Tables (8) and (9).

A statistically significant direct correlation coefficient (0.95) was found between monthly total evaporation (mm) and the area of inhabited lands. This suggests that increasing monthly total evaporation (mm) leads to an increase in inhabited lands.

The calculated T test value was lower than the table T value for water cover area, low-density vegetation cover, and dense vegetation cover, indicating no significant correlation. However, the calculated T test value was higher than the table T value for cultivated lands, indicating a significant correlation.

According to the regression coefficient, the area covered by water, sparse vegetation, and thick vegetation is impacted by variations in monthly total evaporation. The area covered by water, sparse vegetation, and thick vegetation decreases by (-0.96), (-0.06), and (-0.1) km2 when evaporation rises by 1 mm. The area covered by water, low-density vegetation, and dense vegetation is inversely correlated with the monthly total evaporation. According to the regression coefficient, changes in the monthly total evaporation are what cause the rate of change in the area of cultivated land. For instance, the amount of cultivated land grows by (1.12) km2 if the monthly total evaporation rises by 1 mm.

The monthly total of evaporation resulted in a 100% shift in the area of water cover, followed by populated lands, low-density vegetation, and thick vegetation. This illustrates how the monthly total of evaporation influences the water and vegetation cover index, which is related to it via direct and inverse connection interactions. This supports the researcher's conclusion that evaporation affects the amount of water and plants in the Valley Fouad basin.

III. Conclusion

1. The Valley Fouad Basin has an area of 260 km2.
2. The water cover index analysis of satellite images revealed that the maximum area reached (218.4) km2 and a percentage of (84%) during the winter season on 01/18/2023, while the area of inhabited lands reached about (234) km2 and a percentage of (90%) during the summer season on 06/11/2023, and the area of low-density vegetation cover recorded a maximum area of (52) km2 and a percentage of (20%) during the spring season.
3. The statistical investigation of the association between climatic variables and the water and vegetation cover index in the Valley Fouad Basin for the year 2023 revealed the following:
4. The monthly average of total solar radiation has a strong inverse correlation with the area of water cover (-0.97), while the areas of low-density and dense vegetation cover have weaker inverse correlations (-0.11 and -0.07), respectively. However, there is a strong direct correlation coefficient between the monthly averages.
5. The area of water cover and the monthly average normal temperature have a high negative relationship (-0.99), but the areas with sparse and thick plant cover have modest inverse relationships (-0.46 and -0.43, respectively). The monthly average normal temperature, however, has a significant direct connection relationship.
6. The regression coefficient indicates that changes in monthly total evaporation have an effect on the area covered by water, sparse vegetation, and dense vegetation. When evaporation increases by 1 mm, the area covered by water, sparse vegetation, and dense vegetation decreases by (-0.96), (-0.06), and (-0.1) km2. The monthly total evaporation has an inverse relationship with the area covered by water, dense vegetation, and low-density vegetation. The regression coefficient indicates that the pace of change in the amount of cultivated land is caused by variations in the monthly total evaporation. For example, a 1 mm increase in monthly total evaporation results in a 1.12 km2 increase in the quantity of farmed land.
7. There was a significant negative association (-0.80) between the extent of occupied areas and the monthly total rainfall. There was, however, a very weak direct association with statistical significance in the sparsely dense vegetation cover region (0.08) and a very poor direct correlation without statistical significance in the dense vegetation cover area (0.03). The area covered by water and the monthly total rainfall had a 0.96 correlation value.
8. While the monthly total evaporation (mm) and the area of inhabited lands displayed a very strong direct correlation coefficient with statistical significance, reaching roughly 0.95, the areas of sparse vegetation cover and dense vegetation cover displayed a weak inverse correlation, reaching -0.40 and -0.36, respectively. The area of water cover and monthly total evaporation, on the other hand, had a correlation value of -1, which indicates a full inverse relationship that is not statistically significant.

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