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Research Paper

Climate changes impact on the distribution of vegetation in Wasit and Nineveh regions of Iraq

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ABSTRACT

Climate changes have a direct or indirect impact on many vital systems, including human and animal, as well as vegetation. The monthly precipitation and temperature for the period (1981-2021) and vegetation images (NDVI) for the period (2000-2022) from the satellite (NASA) for the regions of Ninevah and Wasit of Iraq were used to find out their variations over the space and time. It was found that the temperature was increasing with time, but the precipitation was in a state of turbulent increase in the two study areas. The distribution of vegetation was also in a state of change with time as well as within a region. The vegetation area increased with increase in precipitation which was greater in the Ninevah region than in the Wasit region. When there was a lack of precipitation, the vegetation cover area decreased in the two study areas. The increase in temperature also resulted in a decrease in the density and area of vegetation. It was found that the change in the amount of precipitation was more influential than the change in temperature on the vegetative distribution.

Keyword : Vegetation, climate changes, precipitation, temperature, NDVI.

Vegetation as a significant part of earthbound biological systems, it not just assumes a significant part in directing biodiversity, yet additionally has a significant commitment to earth's environment guideline and soil and water preservation. The powerful difference in vegetation cover is firmly connected with ecological parameters like environment, soil and water, so it is viewed as the "marker" of natural biology (Li *et al*., 2016). It is broadly accepted that environmental change can cause changes in vegetation cover and may ultimately prompt expanded recurrence and seriousness of territorial outrageous occasions (desertification, salinization, dust storms, floods etc.) (Tan *et al.,* 2015). Precipitation is one among the primary parts of hydrological cycle and is considered as standard wellspring of water to the earth (Kumar and Bhardwaj, 2015). The changing in the occasional precipitation has extraordinarily affected on spillover, evapotranspiration and penetration, albeit, the changing in yearly complete precipitation could be missing which impacts on liability of biological system, stream release (Small *et al*., 2006). Modification of precipitation designs can possibly cause significant changes in vegetation, soils, biodiversity and natural cycles in earthly biological systems (Brown *et al*., 1997). The rise in earth temperature makes the plant lose water through the course of evaporation or the process of transpiration in which how much water lost is more prominent than how much water retained, which prompts parchedness, withering and passing of the vegetation. Therefore, investigating the inborn relation between the transient and spatial changes of vegetation and environmental change can uncover the advancement interaction of local ecological circumstances and anticipate the future improvement pattern (Ashby and Pachico, 2012). Sajan *et al.,* (2023) analyzed the land cover changes and their effects on land surface temperature (LST) and normalized difference vegetation index (NDVI) in Muzaffarpur district, Bihar, India and found that vegetation and fallow land are crucial determinants of the spatial and temporal variations in NDVI and LST, relative to urban and water cover categories. Sur *et al*., (2018) examined the MODIS time series NDVI datasets for 17-years (2000-2016) to detect greenness regeneration over Western Rajasthan and the Gujarat region of India. MODIS NDVI satellite data product. Rainfall data for the same period were also analyzed to understand its impact over vegetation. NDVI time series datasets of MODIS 16-day composite proved sufficient for

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deriving statistically significant trend values for identifying areas of change in vegetation cover. Areas showing positive changes in NDVI trend was clearly correlated with areas which were brought under irrigational network over these areas, indicating an increase in vegetation, due to availability of water supply.

Many previous studies identified the vegetation green cover through the NDVI index in Iraq. Najeeb (2009) used the NDVI to estimate the plant cover over eastern Baghdad while Abdul-Hammed and Mahdi (2022) reported that the vegetable area decreasing over Baghdad. Muhsin (2017) reported an increase in the vegetation cover over the 1985-2015 time period in Karbala province of Iraq. This study aims to know the effect of climate change on the distribution and density of vegetation cover for two regions (Nineveh and Wasit) of Iraq and to compare this effect between both the regions.

MATERIALS AND METHODS

Study area

For the present study, two stations viz. Ninevah (lat. 36.35 ^{0}N, long. 43.16 ^{0}E and elevation 223 m amsl) and Wasit (lat. 32.5 ^{0}N, long. 45.83 ^{0}E and elevation 30 m amsl) representing two provinces of Ninevah and Wasit were selected. These two governorates differ in terms of area, geological characteristics, vegetation cover, soil nature, climate (Mediterranean Sea, steppe, desert and semi-desert) and differ in terms of their latitude and longitude and their height above sea level. Nineveh Governorate is distinguished by its location in northern Iraq. It has a Mediterranean climate and is high above sea level, with mountainous terrain. As for Wasit Governorate, it is located in the eastern part of central Iraq and has a desert climate, plain terrain, and a low elevation above sea level compared to Nineveh Governorate.

Data used

The monthly mean temperatures and monthly precipitation for the time period (1981-2021) for the two locations and the satellite images of the vegetation cover for the two study areas for the time period2000-2021)) were extracted from the NASA website (NASA/POWER CERES/MERRA2). The Normalized Difference Vegetation Index (NDVI) is the most frequently utilized and is a functional, worldwide based vegetation record, incompletely because of its “proportion” properties, which empower the NDVI to counterbalance a huge extent of the commotion brought about by changing sun points, geography, mists or shadow, and barometrical circumstances (Huete *et al*., 1999). In this study, the NDVI categories approved by the Iraqi Ministry of Agriculture and the Meteorological Network were used Table 1. The NDVI value close to one indicates a dense vegetation cover and its density and close to zero indicates no vegetation.

Table 1: Categories of NDVI

Range	Categories NDVI
0 -0.1	No vegetation
0.1-0.2	Spread vegetation
0.3 - 0.2	Low vegetation
0.30.5 -	Moderate vegetation
0.50.75 -	Dense vegetation
0.751.0-	Very dense vegetation

Table 2: Regression equations for temperature and precipitation

Station	Temperature	Precipitation
Ninevah	y = 0.0047x + 18.8	y = 0.0104x + 18.0
Wasit	y = 0.0023x + 25.4	y = 0.0206x + 18.8

RESULTS AND DISCUSSION

Spatial and temporal variation of temperature and precipitation

The spatial distribution of temperature and precipitation in Wasit and Ninevah provinces of Iraq are presented in Fig.1. It may be seen that the distribution of temperature and precipitation differed between the two regions as well as within a province. In Wasit the temperature varied from 24.2 to 25.5 ^{0}C while in Ninevah it varied from 19.6 to 20.9 ^{0}C. The highest temperatures is observed in the southeastern part both the regions. In Wasit governorate, the lowest temperature is observed in the northwestern part of the governorate while in Ninevah province the lowest temperature is observed in the northeastern part of the governorate (Fig.1).

The spatial variation of precipitation in two provinces (Fig.1) indicates that in Wasit region the precipitation varied from 138 mm in southern and western part to 203 mm in northeastern part of the province. In Nineveh governorate, the greatest value of precipitation (258.5 mm) is in the northeastern part and the lowest values (124.2 mm) in southern part. In both the provinces, the distribution of precipitation was generally negatively associated with the temperature.

The temporal variation of temperature and precipitation during 1981-2021 period at Ninevah and Wasit locations reveals that the temperature is increasing with time at both places. The mean temperature at Wasit station is greater than that of Ninevah station but rate of increase at Ninevah is greater than that of Wasit (Table 2). Similarly, the amount of precipitation is also increasing at both the stations viz. Ninevah and Wasit. This increase was found to be due to the amount of precipitation occurring in a short period of time, meaning that the increase is very extreme and is not a continuous increase over a long period (Table 2).

Spatial and temporal change of the vegetation

Using satellite images of the vegetation cover for the period from 2000 to 2022, the NDVI categories were classified and area under each vegetation cover categories were determined. It was observed that there was a large spatial and temporal variation in NDVI categories in both the provinces. The volatility of the vegetation cover increases with the variability of the climatic

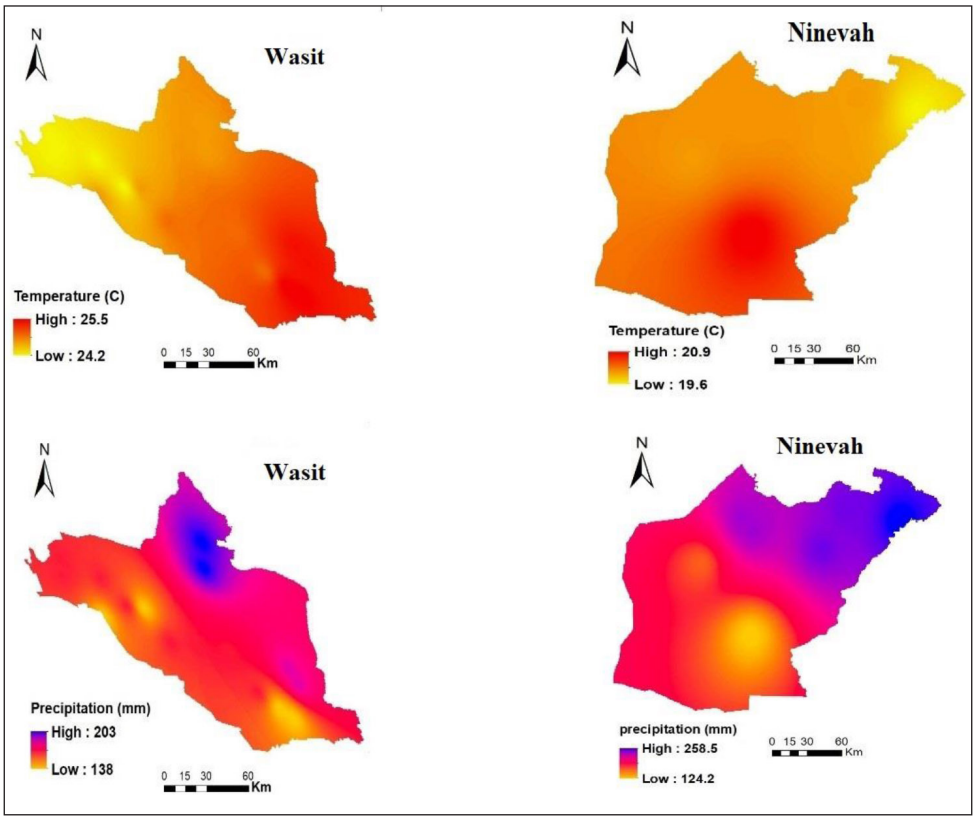

Fig. 1: Spatial distribution of temperature and precipitation in Wasit and Nineveh

Table 3: Lowest and highest percentage area under different NDVI categories in Wasit and Ninevah provinces

Categories of NDVI	Wasit				Ninevah			
	Lowest		Highest		Lowest		Highest	
	Year	(%) Percentage	Year	(%) Percentage	Year	(%) Percentage	Year	(%) Percentage
No vegetation	2020	11.29	2004	50.13	2019	0.32	2008	67.82
Spread vegetation	2004	15.38	2016	52.76	2002	14.38	2021	54.63
Low vegetation	2009	2.55	2002	35.01	2008	4.76	2004	20.06
Moderate vegetation	2021	0.13	2002	11.55	2008	3.98	2020	29.13
Dense vegetation	2007	0	2021	1.88	2008	1.26	2019	37.78
Very dense vegetation	2007	0	2002	0.002	2008	0.001	2020	2.61

parameters, and it changes according to the nature of the region, so the highest and lowest values for each type of vegetation cover were determined and are presented in Table 3. It is evident from the data that the area under NDVI categories of the No vegetation, the Spread vegetation and the Low vegetation are high in both the regions. These three categories are the resultant of lack of rain during those years. Between the two regions, in Ninevah region the highest No vegetation category (67.8%) observed in 2008 was higher that that of Wasit (50.1%) observed in 2004. Similarly, the highest area under the Spread category of NDVI was also higher (54.6%) in Ninevah region than that of Wasit (52.7%) (Table 3). The differences between the highest and lowest values for this category results from the change in the amount of rain and the change in temperature. The areas under different categories of NDVI viz Low vegetation, Moderate vegetation, Dense vegetation were found to decrease with increasing vegetation intensity. The area under Very dense vegetation was virtually nil in Wasit province while it was very less (<2.6%) in Ninevah province. This is due to the fact that the very dense vegetation type refers to forests and dense vegetation which are found in Ninevah province and not found in Wasit province. The fluctuation and change in the area of different vegetation types varied between Nineveh Governorate and Wasit Governorate, because of the variation in climatic elements in the two governorates.

Spatial distribution of NDVI

Fig. 2 depicts the variation of NDVI over the two provinces. Using satellite images of the vegetation cover of the two studies areas for the time period (2000-2022), it was found that the vegetation cover is in a state of continuous and fluctuating change, and this change in the area of vegetation cover is greatly affected by climatic parameter, in addition to many causes, including human causes, such as settling agricultural lands and establishing residential complexes as well as overgrazing and other causes, including migration from the countryside to cities due to major services. Cities and others, but the main reason for the change in vegetation area

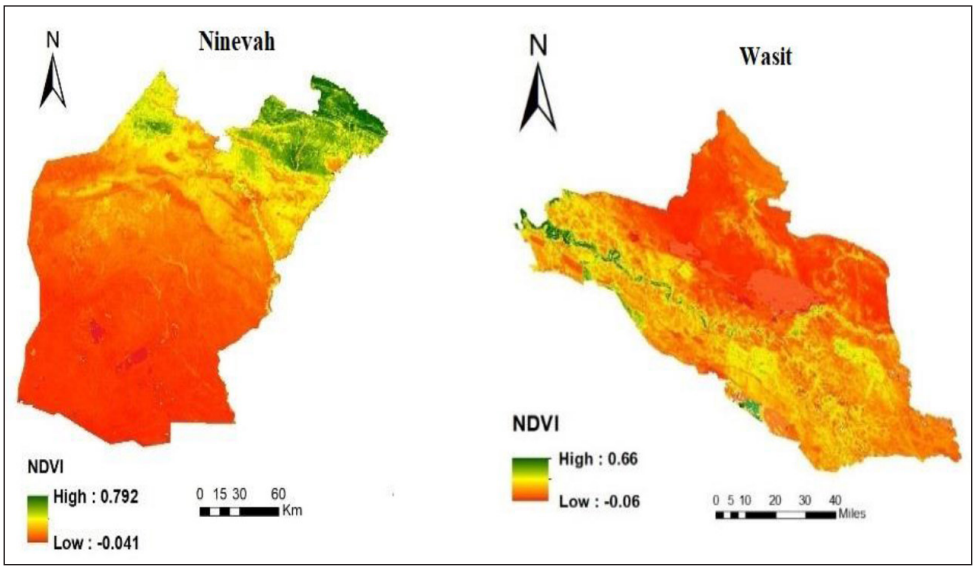

Fig 2: Distribution of NDVI in Wasit and Nineveh governorate, Iraq

Table 4: Regression equations for temperature and precipitation

Station	Mean NDVI
Ninevah	y = 0.0007x + 0.207
Wasit	y = 0.0018x + 0.1243

remains the result of climate change. Climate changes are volatile and not at the same pace or quantity, by following images of the vegetation cover of the two study areas.

The area of vegetation cover is large in the two study areas in the years (2019 and 2020) due to the abundance of rain and water. Its quantity in Nineveh Governorate was more than in Wasit. The lowest value of the vegetation area for the year (2008) is for the Nineveh and Wasit region, and was the result of the decrease in the amount of rainfall falling with the rise in temperatures and the occurrence of drought and aridity. Desertification in the study areas, which leads to a decline in the area of vegetation cover. The decrease in the area of vegetation cover in Wasit Governorate is more than in Nineveh Governorate. This is because the decrease in the amount of rain and the increase in temperature is relatively more than in Nineveh Governorate (Fig. 2)

Temporal changes in mean NDVI

The vegetation cover is constantly changing with time, and this change is the result of climatic reasons related to rain and temperature. As the vegetation cover in Nineveh governorate is larger in area and density than the vegetation cover in Wasit Governorate as a result of the abundance of rain, as for the nature of the change in the area of vegetation cover, it is affected by climate change, and this change in Wasit Governorate has a greater impact on the area of vegetation cover and the fluctuation of its area, and in both cases. The regression line fitted using temporal variation of NDVI for the time period (2000-2022) of two studies areas (Table 4), suggests the vegetation cover is changing with time.

CONCLUSION

The vegetation cover was in a state of continuous change in terms of area and density, and on the contrary, the barren lands are in a state of continuous change with time for the regions of Ninevah and Wasit governorate. The change in the vegetation cover was closely related to the climatic changes in addition to the nature of the study area. The fluctuation in the rate of vegetation cover is greater in Ninevah than in Wasit region.

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