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Short communication

Investigation of changes in vegetation cover over Mosul and Wasit provinces of Iraq

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Vegetation cover protects the soil, reduces erosion and maintains ecosystem balance. Knowing about vegetation changes is an important step comprehending the world as a whole and determining why and where changes have happened (Al-Doski *et al.,* 2013; Al-Lami *et al.,* 2023; Muter *et.al.,* 2021). Remote sensing data encompasses a multitude of application domains, including land cover classification (Gandhi *et al.,* 2015).Vegetative indices (VIs) have been derived by combining several wavebands for examining the effectiveness of these soil-adjusted and soil-unadjusted vegetation indices at the regional scale (Ren and Feng 2015). Moderate Resolution Imaging Spectroradiometer (MODIS) data has been extensively utilized in drought studies since it continuously monitors the earth's surface and is openly accessible (Muhaimeed and Al-Hedny 2013). Several studies concluded that the normalized difference vegetation index (NDVI) was the most common form of vegetation index (Muhaimeed and Al-Hedny 2013; Mustafa Alee *et al.,* 2023; Mahal *et al.,* 2022). Mahal *et al.,* (2022) aimed to establish a link between changes in land use/ land cover and urbanization in Baghdad city. Sobhani *et al.,* (2018) identified the seasonal variation of vegetation covering in Iran using enhanced vegetation index (EVI). Malav *et al.,* (2024) related NDVI with land surface temperature (LST) in India while Tawfik and Al-Lami (2025) related vegetation cover with LST in Basra Iraq. This study aimed to examine the change of vegetation cover using NDVI and EVI in two different climate zones in Iraq using MODIS data.

Two sites of Iraq (Mosul and Wasit provinces) representing two climate zones were chosen for the study. Mosul is situated in the northern part of the country and experiences 383.5 mm of rainfall every year with an average temperature of 20.6°C (Saleh and Ahmed 2021). Wasit Province is located 172 km south of Baghdad, has a dry climate with intermittent rain and experiences an extended dry season from May to October. The NDVI and EVI data were acquired from MODIS Terra (MOD13Q1) product for years 2000, 2010 and 2024. The dataset was downloaded from site (http://earthexplorer.usgs.gov/) and extracted with ArcGIS. The monthly images were downloaded and obtained 3 monthly images of NDVI for January, April, July for each year (2000, 2010 and 2024).

Two indices normalized difference vegetation index (NDVI) and enhanced vegetation index (EVI) were calculated using following equations.

$$\mathrm{NDVI} = \frac{\mathrm{NIR} - \mathrm{RED}}{\mathrm{NIR} + \mathrm{RED}}$$

The vegetation was classified into four categories using NDVI values as 0 (other), 0.2-0.4 (sparse vegetation), 0.4-0.6 (moderate vegetation) and 0.6-1 (dense vegetation).

The following equation was used for EVI calculation.

$$\mathrm{EVI} = \mathrm{G}\,\frac{\rho NIR - \rho RED}{\rho NIR + C1\rho red - C2\rho blue + L}$$

Where, C1 and C2 are the coefficients with values of 6.0 and 7.5, respectively, while L is the soil adjustment factor with a value of 1.0 and G is the gain factor with a value of 2.5. ρ is the atmospherically corrected reflectance in NIR, red and blue bands. In this study, the EVI images were classified into two categories.

Fig. 1 and Fig. 2 show the maps of vegetation cover that were produced using the NDVI and EVI analyses for April 2024 in Mosul and Wasit provinces. Table 1 reveals the categories of NDVI and EVI values between 2000 and 2024 in both governorates. In April_2000 (5960.77 km^2, 2905.13 km^2 and 485.61 km^2) with highest percentages (34.75%, 16.93% and 2.83%, respectively). The relationship between NDVI and precipitation unveiled a robust correlation during spring of Wasit. During 2024, the peak of vegetation cover in april_2024 were about (5645 km^2 and 6541.19 km^2) with percentage (15.1% and 17.5%) of the total area in Mosul city. Undoubtedly, the accumulative precipitation that fell in 2024 exceeds that during the rainy seasons that of 2000, 2010. Similar results were reported from India by Sur *et al.,* (2018).

As for the results patterns of EVI value over Mosul and Wasit. It is evident that the years 2000 and 2024 saw the highest

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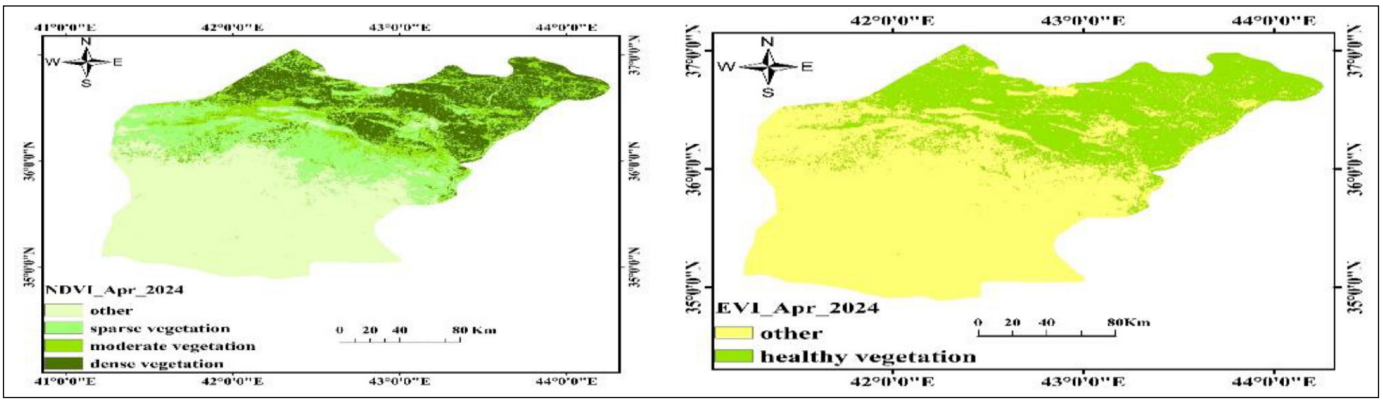

Fig. 1: Patterns of (a) NDVI and (b) EVI value over Mosul in April 2024

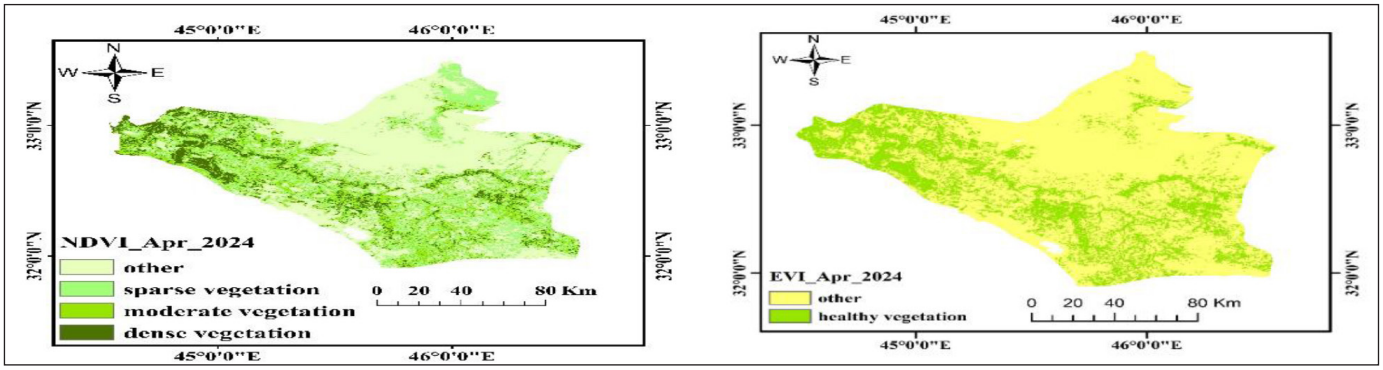

Fig. 2: Patterns of (a) NDVI and (b) EVI values over Wasit in April 2024

Table 1: Area under different categories of NDVI and EVI.

Year	Months	Rainfall (mm)	(%) NDVI density area				EVI density area	
			other	Sparse vegetation	Moderate vegetation	Dense vegetation	Healthy vegetation	other
					Mosul			
	February	11.2	63.5	22.6	10.1	3.6	17.0	82.9
2000	April	14.3	70.8	15.8	9.2	3.9	14.3	85.6
	July	0.7	81.0	13.5	4.0	1.3	5.3	94.6
	January	12.8	57.9	23.6	12.4	5.8	16.7	83.2
2010	April	28.3	54.1	19.4	15.1	11.2	28.2	71.7
	July	0.0	59.2	28.6	8.3	3.7	4.4	95.5
	January	40.6	55.6	19.8	16.4	8.0	22.3	77.6
2024	April	15.9	46.9	20.4	15.1	17.5	31.5	68.4
	July	0.1	59.3	31.8	6.5	2.2	7.1	92.8
					Wasit			
	February	8.4	53.5	28.1	12.2	6.0	15.0	84.0
2000	April	11.9	45.4	34.7	16.9	2.8	27.7	72.2
	July	0.0	47.7	36.0	14.6	1.5	28.5	74.5
	January	64.5	51.4	28.0	14.9	5.4	14.2	85.7
2010	April	13.3	51.4	28.0	14.9	5.4	23.1	76.9
	July	5.4	49.9	34.5	13.6	1.8	23.2	76.7
	January	5.7	53.5	22.6	14.5	9.2	20.9	79.1
2024	April	24.7	46.4	26.9	17.8	8.7	26.3	73.6
	July	0.0	50.8	37.5	9.1	2.3	23.2	76.7

EVI levels, in these years the vegetation was more spread in rainy season during January and April. In Mosul the peak of the increase was in the period Jan_2024 when areas covered by healthy vegetation increased from (6370.98 km^2) 17.06% to (8344.91 km^2) with percentage 22.35% of total area. In April 2000, there was a significant increase in healthy vegetation cover from (5369.75 km^2)

(14.38%) with the highest area value (11775.64 km^2) at (31.55%) recorded in April 2024, where vegetation covers the majority of healthy vegetation area grew to (4521.5 km^2) (26.3%) in April 2024 for Wasit. the results were similar in July 2010 and July 2024.

Thus, the results show that the distribution of vegetation is affected by the seasons and the relationship is directly proportional between vegetation indices and rainfall rates, as the vegetation cover increased in the rainy seasons (April) and decreased in the summer (July).

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