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Relationship between the Normalized Difference Vegetation Index (NDVI) and Some Soil Characteristics in the North of Iraq

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Abstract: *To perform a good classification for vegetation by using Remote Sensing data. In this research the study area located in the Erbil and Sulaimanya governorates are located on longitude 36° 11' 24" North 44° 06' 00"east, and 35°40'00" North and 45°30'0" East, respectively. One scene of the Landsat-TM images used to investigate changes of the vegetation distribution by Normalized differential vegetation index (NDVI), the results referred to more green areas in Erbil than Sulaimanya, that's mean, the no vegetation area increased by 247.14 ha because some barren soil and water bodies increased in Sulaimanya. The dense vegetation area increased too in Sulaimanya and poor vegetation decreased because the agriculture exploitation of the land but the other vegetation classes such as moderate, very dense vegetation decrease with small amount. The highest values of K**ast** in studied sites were 60.89, 60.34, 77.73, 55.12 and 88.67 cm.hr^{-1} recorded in surface horizons of P1, P2, P6 (Sulaimanya sites) and P1, P2 (Erbil sites) respectively. The reason of upturn value in hydraulic conductivity was the effect of organic matter content which led to decrease the bulk density and higher porosity, MWD. Pedon 3 in Erbil site situated within the classification dense vegetation, while the pedon 3 Sulaimanya site and pedon 4 Erbil site situated within the classification moderate vegetation, Pedon 5 Sulaimanya site placed within classification poor vegetation, was due to high free iron oxides content in this site.*
Keyword: *Remote sensing, NDVI, Landsat, Kast.*

I. Introduction

NDVI is a commonly used and easily calculated satellite image-based proxy for vegetation productivity **Kunkel**, **2011 and Scanlon, 2002**. Soil and vegetation resources are closely correlated, soils influence plants, and plants affect the characteristics of soils inversely **Allen EB, 1991.** Extreme events, such as droughts under climate change could increase soil desertification especially in arid and semi-arid environment. Desertification refers to land degradation; it is basically defined as a reduction in the biological productivity of the land (**Prince, 2002 and Wessels et al., 2004**). Vegetation indices are defined as dimensionless, radiometric measures that function as indicators of relative abundance and activity of green vegetation, often including leaf-area index, percentage green cover, chlorophyll content, green biomass, and absorbed photo-synthetically active radiation (**Jensen, 2000**). Indices such as Normalized Difference Vegetation Index (NDVI) reflect the overall effect of rainfall and soil moisture on crops and play an important role in drought monitoring and early warning.

The NDVI has become the most important tool for monitoring and detecting drought impacts on agriculture (**Dabrowska-Zielinska et al., 2002 and Singh et al., 2003**). Since climate is a key factor affecting vegetation conditions, the NDVI has been widely used at regional and global scales to identify weather impacts on crop growth conditions and yields (**Li and Lewis, 2004; Vicente-Serrano et al., 2006 and Jain et al., 2009**). **Fadhil (2011)** pointed to the useful of using the NDVI to detect drought impacts in Kurdistan region of Iraq. The study showed a significant decrease in vegetation cover (56.7%) and a decline in soil/vegetation wetness (29.9%). Agriculture drought is one of the most important and lowest studied issues in Iraq. Water deficiency is studied from hydrological and political perspectives (**Rasheed, 2010**). There are few studies on the effect of drought stress on agricultural sector, thus this study aims to:

1. Show the relationship between soil physical and chemical properties with vegetation distribution.
2. Detect drought emergence and severity for some governorates of Iraq using the NDVI index.

Materials and Methods

Description of the Study Area/ Location and area

The study area (fig.1) located in the Erbil and Sulaimanya governorates are located on longitude 36° 11' 24" North 44° 06' 00"east, and 35°40'00" North and 45°30'0" East, respectively.

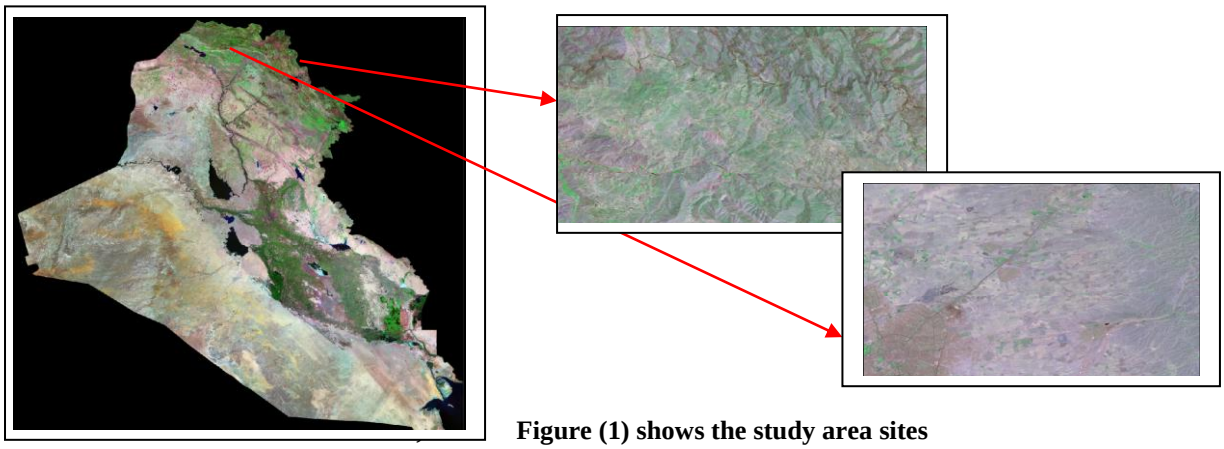


Figure (1) shows the study area sites

Remote sensed dataset

To investigate changes of the vegetation distribution in north of Iraq one scene of the Landsat-TM images of July 23, 2006. The Landsat image consists of seven bands. The characteristics of this Image were show in Table 1.

Table 1: The characteristics Landsat TM sensor image

Landsat-5TM	Spatial Resolution
1. 0.45-0.52 (Blue)	**30m*30m**
2. 0.52.0.60 (Green)	**30m*30m**
3. 0.63-0.69 (Red)	**30m*30m**
4. 0.76-0.90 (NIR)	**30m*30m**
5.1.55-1.75 (Mid-infrared)	**30m*30m**
6.10-4-12.5 (Thermal)	**120m*120m**
7. 2.08- 2.35 (mid-NIR) http://www.usgs.gov.2012	**30m*30m**

All the remote sensing process and geographic information systems carried out at the College of Agriculture/University of Baghdad/Soil and water Resources Department.

Classification

Unsupervised classification was applied as first step to obtain an overview of the spectral differences of the study area. The unsupervised classification result was then used for defining the training areas (using, ERDAS Imagine ver. 10). The training areas were detected with the help of GPS in the field work Erdas Imagine was used for expanding the training area from single coordinate point recorded by the GPS device.

The soil physical and chemical analyses

Disturbed soil samples were air- dried and passed through a sieve of 2000 µm to determine chemical, physical and 4000- 9000 µm sieve to determine aggregate stability parameters. Some physical characteristics measured included: Particle size distribution, bulk density (ρb), total porosity (f), mean weight diameter (MWD) and hydraulic conductivity (*Ksat*), as well as chemical characteristics measured included: Calcium carbonate ($CaCO_3$), cation exchange capacity (CEC), Organic matter (OM), EC and pH of studied pedon according to **Black et al. (1965) (part 1 and 2).**

Vegetation Indices

The remotely sensed dataset based vegetation indices were utilized in this study to map the vegetation status during the study period. The vegetation indices were Normalized differential vegetation index (NDVI):

NDVI= (TM4-TM3) / (TM4+TM3)

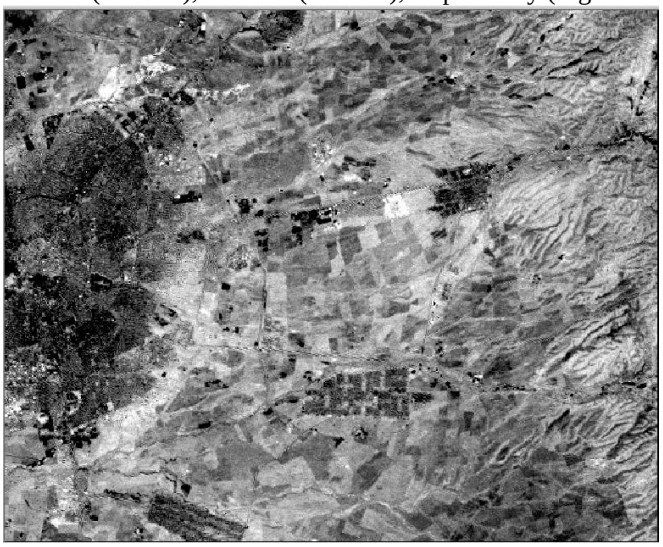
Produce final maps in GIS environment

The main processes in gathering and analyzing the remotely sensed data set remotely sensed dataset of the study area were analyzed qualitatively by visual interpretation and qualitatively using Spectral Mixture Analysis and other indices. The combination of both statistical analyses and spectral change detection techniques were applied to investigate and analyses the results and map production by using geostatistical.

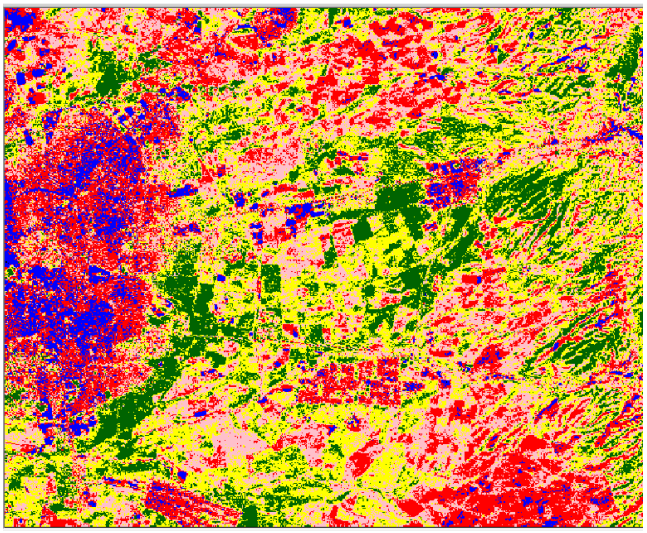
Result and Discussion

Normalized Difference Vegetation Index (NDVI)

Red light is strongly absorbed by photosynthetic pigments (such as Chlorophyll) found in green leaves, while near infrared light either passes through or is reflected by leave tissues, regardless of their color. It means that the areas of bare soil having little or no green plant material are similar in both red and near infrared wavelengths, The areas with much green vegetations show more brightness in the near-infrared and are very dark in the red part of the spectrum (**Yousef et al., 2006**). The total area in study area (Erbil) of the vegetation cover which extracted by using the NDVI image (Fig.3) were 2,7328.95 ha. The no vegetation, poor vegetation, moderate vegetation, dense vegetation, very dense vegetation areas were covered 1688.58 ha (6.18%), 6495.03 (23.77%), 7632.66 (27.93%), 7251.48 (26.53%), 4261.23 (15.60%), respectively (Fig.4 and Table 2).



Scale 1:120,000 Figure (3) The NDVI images of study area

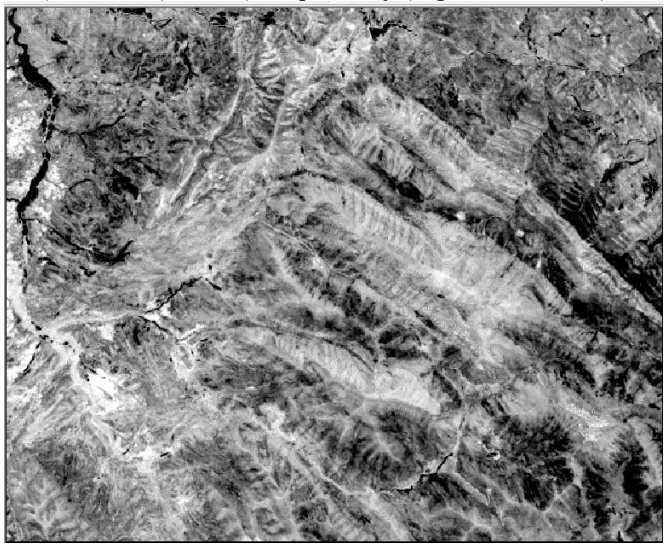


Scale 1:120,000 Figure (4) The Vegetation classes of study area (Erbil)

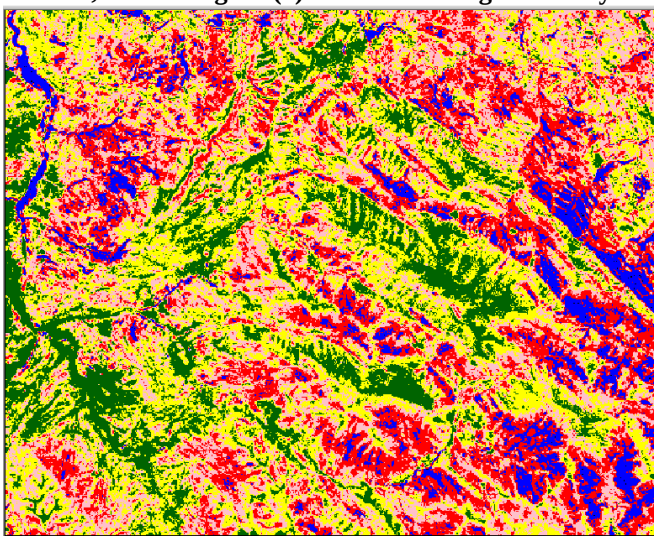
	No vegetation	1688.58
	Poor vegetation	6495.03
	Moderate vegetation	7632.63
	Dense vegetation	7251.48
	Very dense vegetation	4261.23

The total area in the second study area (Sulaimanya) of the vegetation cover which extracted by using the NDVI image (Fig.5) were 2,7362.97 ha. The result referred to no vegetation, poor vegetation, moderate vegetation,

dense vegetation, very dense vegetation areas were covered 1935.72 ha(7.07%), 6105.87 (22.31%), 7586.1(27.72%), 7520.94(27.48%), 4214.34(15.40%), respectively (Fig.6 and Table 2).



Scale 1:120,000 Figure (5) The NDVI images of study area



Scale 1:120,000 Figure (6) The Vegetation classes of study area (Sulaimanya)

	No vegetation	1935.72
	Poor vegetation	6105.87
	Moderate vegetation	7586.1
	Dense vegetation	7520.94
	Very dense vegetation	4214.34

Table 2: The classes of vegetation with area in Erbil and Sulaimanya

Class type	Area ha (Erbil)	Area ha (Sulaimanya)	Change (ha)
No Vegetation	**1688.58**	**1935.72**	**-247.14**
Poor Vegetation	**6495.03**	**6105.87**	**389.16**
Moderate Vegetation	**7632.63**	**7586.1**	**46.53**
Dense Vegetation	**7251.48**	**7520.94**	**-269.46**
V. dense Vegetation	**4261.23**	**4214.32**	**46.91**
Total vegetation	**27362.97**	**27362.97**	**0**

The results referred to more green areas in Erbil than Sulaimanya, that's mean, the no vegetation area increased about 247.14 ha because some barren soil and water bodies increased in Sulaimanya. The dense vegetation area increased too in Sulaimanya and poor vegetation decreased because the agriculture exploitation of the land but the other vegetation classes such as moderate, very dense vegetation decrease with small amount.

Some of physical properties involved in evaluation of the soil quality accredited by **USDA-NRCS (2001)** were estimated (Table 3). It focused on the some physical properties a direct impact on the soil quality and plant growth, including texture, bulk density and aggregate stability and saturated hydraulic conductivity. It is noted the pedons variation in physical characteristics relevant evidence the soil quality. Noting that texture prevailing surface layer ranged from clay to clay loam and this reflects the impact of the situation prevailing in the study area sedimentary.

The results indicate that the values of bulk density of the surface layer of the soil has ranged between 1.19 µg. m^{-3} to 1.55 µg. m^{-3} on the AP horizon for pedon 4 (Erbil) and pedon 2 (Sulaimanya) respectively, these results are consistent with the case of variation in the tissues of soil as well as the impact factor management and use soil for different purposes. Also, shown the pedons study a clear divergence in the values of the mean weight diameter since ranged between 4.45mm to 1.63 mm on the AP horizon for pedon 2 and 3 (Erbil), due to the direct effect of each of the soil content of clay as well as organic matter and calcium carbonate, as shown clear contrast in content of these components has been reflected on the nature aggregate. As well as the results showed that the values of hydraulic conductivity ranged between 0.47 cm. h^{-1} (pedon 5 Sulaimanya) to 88.07 cm. h^{-1} (pedon 2 Erbil) influenced by the qualities of fixed soil which texture as well as the dynamic characteristics: organic matter and cation exchange capacity.

Table 3: Particle size distribution, Bulk Density (*ρb*), Total Porosity (*f*), Mean Weight Diameter (MWD) and Hydraulic Conductivity (*Ksat*) of studied pedon

governorate	Pedon	Horizon	Depth	Sand	Silt	Clay	Tex.	Bulk density	Porosity	MWD	K_{sat}
			cm	g. kg^{-1}				µg. m^{-3}	%	mm	$cm.h^{-1}$
Sulaimanya	P_1	A	0-25	109	364	527	C	1.51	43	2.87	60.89
		Bt_1	25-35	103.3	263.2	633.5	C	1.63	38	3.21	63.12
		Bt_2	35-70	130.6	321.9	547.5	C	1.77	33	2.22	52.11
		Bt_3	70-150	68.7	224.7	706.6	C	1.83	32	2.12	51.33
	P_2	Ap	0-25	479.7	321.15	199.1	L	1.55	36	2.56	60.34
		AB	25-80	333.1	474.37	192.5	L	1.43	41	2.1	56.23
		Bt	80-120	503.1	256.2	240.7	SCL	1.39	40	2	58.21
		Btk	120-180	393.9	307.2	298.9	CL	1.45	40	1.82	42.56
	P_3	Ap	0-20	51.3	386.5	562.3	C	1.44	44.54	2.24	9.89
		AB	20-70	37	344	620	C	1.35	47.95	0.5	2.07
	P_4	Ap	0-25	50	398	552	C	1.37	47.39	1.62	15.88
		Bt	25-80	46	382	572	C	1.39	46.68	1.84	5.65
	P_5	Ap	0-20	540	254	212	SCL	1.49	43.63	3.52	0.47
		Bt	20-75	152	595	253	SiL	1.41	46.7	1.4	0.47
	P_6	Ap	0-25	35	357	608	C	1.19	54.07	2.45	77.73
		Bt	25-75	23	358	619	C	1.55	40.44	1.18	3.77
Erbil	P_1	Ap	0-25	286.5	396.2	317.3	CL	1.44	40	3.21	55.12
		Bt1	25-75	333.9	265.5	400.6	CL	1.51	38	2.76	43.33
		Bt2	75-100	318.8	295.75	385.4	CL	1.61	36	2.11	41.11
	P_2	Ap	0-25	310.7	272.1	417.2	C	1.31	42	4.45	88.67
		Bk	25-75	436.3	359.55	204.1	L	1.4	40	2.45	45.67
		Ck	75-100	553.6	176.7	269.7	SCL	1.4	37	2.34	41.34
	P_3	Ap	0-25	282	148	534	C	1.26	52	2.63	18.7
		Bk	25-80	171	135	377	SC	1.31	49	1.6	33
	P_4	Ap	0-25	289	437	274	CL	1.19	55	2.92	9.89
		Bk	25-80	226	490	284	CL	1.26	51	2.05	1.27

Table 4: Calcium carbonate (CaCO3), cation exchange capacity (CEC), Organic matter (OM), EC and pH of studied pedon.

governorate	Pedon	Horizon	Depth	$CaCO_3$	CEC	O.M	EC	pH
			cm	g. kg^{-1}			dS. m^{-1}	
Sulaimanya	P1	Ap	0-25	175	20.7	27.7	0.16	7.9
		Bt_1	25-35	180	23.9	37.3	0.12	7.7
		Bt_2	35-70	175	25.8	17.5	0.10	7.8
		Bt_3	70-150	178	30.9	17.5	0.17	7.1
	P2	Ap	0-25	268	19.2	23.6	0.24	7.9
		AB	25-80	242	17.7	18.5	0.12	7.8
		Bt	80-120	222	21.6	37.2	0.14	7.8
		Btk	120-180	340	19.2	12.4	0.16	7.1
	P3	Ap	0-20	56	11.5	9.1	0.55	8.4
		AB	20-70	103	10.7	7.6	0.60	8.3
	P4	Ap	0-25	163	20.1	20	0.44	7.8

		Bt	25-80	216	10.1	6.2	0.36	7.6
	P5	Ap	0-20	163	9.5	4.2	0.25	8.3
		Bt	20-75	192	9.1	3.4	0.57	8.1
	P6	Ap	0-25	64	21.8	28.9	0.31	8.2
		Bt	25-75	162	12.1	9.1	0.84	8.0
Erbil	P1	Ap	0-25	293	26.5	30.7	0.18	8.2
		Bt1	25-75	285	27.8	23.4	0.28	8.2
		Bt2	75-100	343	24.7	19.7	0.56	8.2
	P2	Ap	0-25	267	29.3	51.1	0.36	8.3
		Bk	25-75	298	23.3	22.6	0.14	7.9
		Ck	75-100	320	22.5	20.4	0.16	7.9
	P3	Ap	0-25	193	12.1	17.3	0.44	8.0
		Bk	25-80	394	10.2	7.6	0.31	8.4
	P4	Ap	0-25	185	20.2	11.5	0.90	8.4
		Bk	25-80	202	10.2	7.9	0.52	8.3

It well knows that hydraulic conductivity depends strongly on texture and porosity, however in some sites had similar texture but differed in ***Kast***. This may be attributed to other factors such as cementing agents and their interaction. The highest values of ***Kast*** in studied sites were 60.89, 60.34, 77.73, 55.12 and 88.67 $cm.hr^{-1}$ recorded in surface horizons of P1, P2, P6 (Sulaimanya sites) and P1, P2 (Erbil sites) respectively. The reason of upturn value in hydraulic conductivity was the effect of organic matter content (Tables 4) which led to decrease the bulk density and higher porosity, MWD (Table 3).

These sites have been placed within the classification very dense vegetation, as reflected the improvement in the physical and chemical characteristics of soil to the presence of good vegetation cover.

Pedon 3 in Erbil site situated within the classification dense vegetation, due the good of physical and chemical properties led to the formation of good structure (MWD= 2.63 mm) and hydraulic conductivity (***Kast***= 18.7 cm. h^{-1}) correlation with higher content of organic matter (OM= 17.3 g. kg^{-1}). While the pedon 3 Sulaimanya site and pedon 4 Erbil site situated within the classification moderate vegetation. The reason, to have these sites chemical and physical quality properties (Table 3 and 4) less than limits required to field an integrated soil quality, so these soils cover a moderate density line with properties quality. Pedon 4 Sulaimanya site has good physical and chemical characteristics (Table 3 and 4) for plant growth, but the time sampling of this site was where no agricultural exploitation in that area, so is placed within a classification no vegetation. Pedon 5 Sulaimanya site placed within classification poor vegetation, was due to high free iron oxides content in this sites (Fe_2O_3=14 g. kg^{-1}) with decreased in organic content (OM=4.2 g. kg^{-1}), casing to developed soil structure, and increasing of MWD and GMD, at the meantime bulk density was increased with decreasing in porosity of the surface horizon.

Conclusion

Distribution of vegetation cover were affected by some of the physical and chemical characteristics, Areas of very dense and dense vegetation indicate that the physical characteristics of the soil good, It is found that the type of soil texture C-CL, high porosity, high hydraulic conductivity (Ksat) which is influenced by the content of organic matter helped in obtaining high density of vegetation. The no vegetation area increased because some barren soil and water bodies increased in Sulaimanya. The dense vegetation area increased too in Sulaimanya and poor vegetation decreased because the agriculture exploitation of the land but the other vegetation classes such as moderate, very dense vegetation decrease.

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