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Using Geospatial Technologies to Separate Soil Units and Predict Some of Their Characteristics in Basra Governorate (Indices)

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ABSTRACT

This study was conducted to classify the soils of eastern Basra Governorate, southern Iraq, within the administrative borders of Abu Al-Khasib District extending south to Al-Faw District, using remote sensing techniques and geographic information systems. The soil units were separated by adopting remote sensing technology through the use of satellite image from Landsat8, the TIRS - OLI sensor (The Operational Land Imager), and spectral indices with field observations. A map of the soil units was prepared using the GIS program. Eight locations of soil pedons were identified, and they were divided The study area is divided into two paths, and each path contains four typical pedons within the boundaries of the study area as follows:

1 - First stripe: represents the river levees unit within pedons 1, 3, 5 and 7.

2 - Second stripe: represents the river basin unit within pedons 2, 4, 6 and 8.

The results of Indices showed a variation in their values between all the pedons through which spatial variation in surface soil characteristics can be distinguished. The values of NDVI ranged between < 0 – 0.79, < 0 – 1.64 for BSI, and between < 0 – 0.408 for SAVI. The spectral indices NDVI and SAVI gave results that match the ground facts present on the ground, represented by vegetation, while the bare soil index BSI gave reflectivity values similar to barren lands. The lands of the study area were characterized by a lack of vegetation, especially in the low-lying areas of the river plains, while the areas of natural vegetation and the parts close to the river levees were characterized by a medium to high vegetation cover, and these results are consistent with the values of the NDVI and SAVI spectral indices.

KEYWORDS: Remote sensing, Geographic information system, Indices

INTRODUCTION

Soil, with all its types, is one of the basic elements and components of vegetation cover and agricultural production. This research is concerned with studying soil as an important element in soil survey and classification studies and as a product of natural, climatic and biological factors. Soil is one of the natural resources that leads to achieving full benefit when exploited and requires the application of scientific methods and procedures. Modern methods that help achieve sustainable agricultural production. At the forefront of these methods is implementing soil survey work on a large scale, giving the necessary recommendations on how to use and maintain soil units, and determining the suitability of each soil unit for various purposes, especially agricultural ones (Al-Ani 2006) . Remote sensing and geographic information systems are considered the main means of surveying and monitoring land resources, identifying their distribution and characteristics, and preparing plans and programs to achieve development. It is an important source of data that provides information efficiently and effectively that traditional methods cannot provide. What we are witnessing today in the information age is the huge amount of data that requires effective devices to deal with it. Correct, accurate information based on scientific analysis leads to the optimal and sustainable use of earth's resources. The spectral reflectivity of soil is essential for many remote sensing applications, as it depends on the physical and chemical properties of the soil, and based on the quantity and quality of electromagnetic radiation reflected from the soil surface within multiple spectral bands, different types of soil can be characterized and isolated (Lillesand and Kiefer, 1999) . Indices is one of the most important improvements applied to satellite image, and this is of great importance in transforming the spectral properties of visual appearances affected by luminosity. indices is widely used in mineral investigation, plant analysis, desertification, and environmental monitoring. Its importance lies in many cases, as the indices is the best at distinguishing differences that cannot be observed in images with basic color bands, as well as reducing the effect of shadows in multispectral images. Indices is widely used in agricultural and environmental studies due to its relationship to the growth cycle of plants, soil properties, and soil moisture. It is one of the methods for improving the spectral information of satellite data by distinguishing barren soils, vegetative cover, and wet soils, and determining degrees of desertification and drought, as well as providing important information about the soil and plants for uses. agricultural (Zinck, 2008) . This study aimed to separate soil units based on the variation in spectral reflectances and Indices of the Earth's surface and to study the spatial variations of some indices in the study area.

Materials and methods

1 – Study Area

The study area was chosen, which is part of the alluvial plain that contains sediments belonging to the Shatt al-Arab and Karun rivers. The soil of this area is characterized by the fact that it has a calcareous sedimentary source material that belongs to the newly formed soil class, Entisols. The study area is located east of Basra Governorate, southern Iraq, within the administrative borders of Abu Al-Khasib District, extending south to Al-Faw District. It is bordered to the east by the Shatt Al-Arab River and is located between longitudes 48°1'28.56" - 48°31'25.08" north and latitudes 29°. 57'48.98" - 30°26'24.51" east, with an area of 874,405 km^2, as shown in Figure 1. 8 locations were identified to dig typical pedons and projected them on the map using a GPS device and the Universal System UTM.

2 – Field and office work

2–1: Surveying the soil and determining the location of the pedons

The study area was visited in the field several times during the period 10/15/2022 until 12/15/2022 with the aim of determining the locations of the pedons for the study area. The study area was surveyed in a semi-detailed manner based on satellite image for the year 2022, as it was noted that most of the areas are not agriculturally exploited and are Abandoned lands, with the exception of some lands along the Shatt al-Arab River. Correction operations were carried out on the satellite image, converting it into a digital image, then separating it into categories based on spectral reflectivity to obtain an undirected image, Figure 2, and then converting it to a directed image, Figure 3, with spectral bands 7. 5 and 3 to create the best color combination to distinguish the soil of the study area, since these packages are specialized in soil and mineral studies (Faleh and Shawan, 2012). The study area was divided into two stripes, and each stripe contains four pedons within the boundaries of the study area. These paths are sequentially as follows:

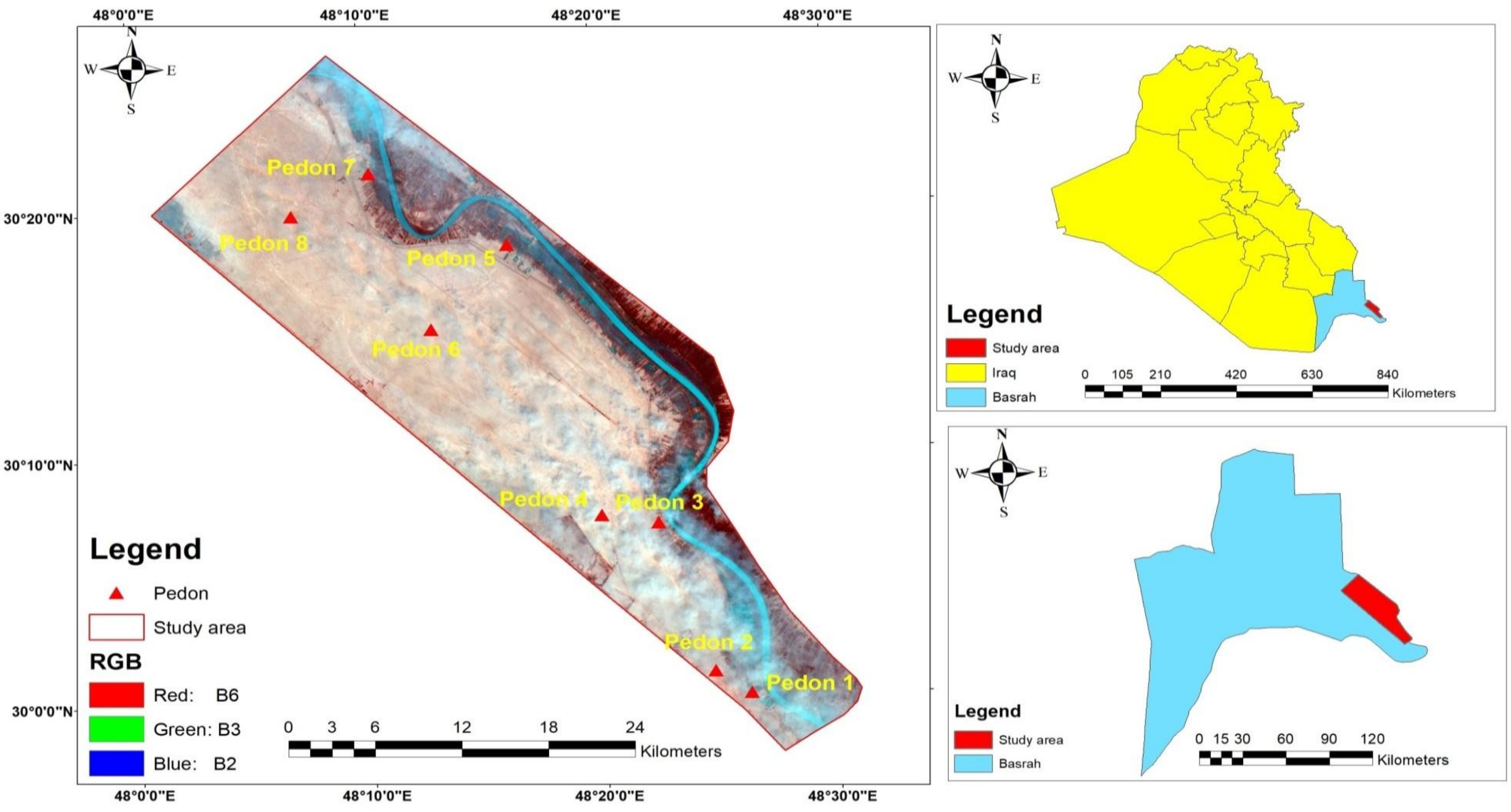

Figure 1 : study area

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The first stripe: This stripe represents the soil unit belonging to the river levees, extending from the Sihan district of Abi al-Khasib district to the Ma'amir district of al-Faw district, represented by pedons 1, 3, 5 and 7, respectively. pedon 7 is located in the Sayhan area, pedon 5 is located in the Siba district, pedon 3 is located in the Al-Bahar district, and pedon 1 is located in the Ma'amer district .

The second stripe: This stripe represents the soil unit belonging to the river basin, which extends from the Sayhan district of Abu Al-Khasib district to the Ma'amer district of Al-Faw district, which is represented by pedons 2, 4, 6 and 8, respectively. pedon 8 is located in the area adjacent to the Sayhan area, pedon 6 is located in the area adjacent to Al-Sibah sub-district, while pedon 4 is located in the area adjacent to Al-Bahar sub-district, pedon 2 is located in the area adjacent to Al-Ma'amer sub-district .

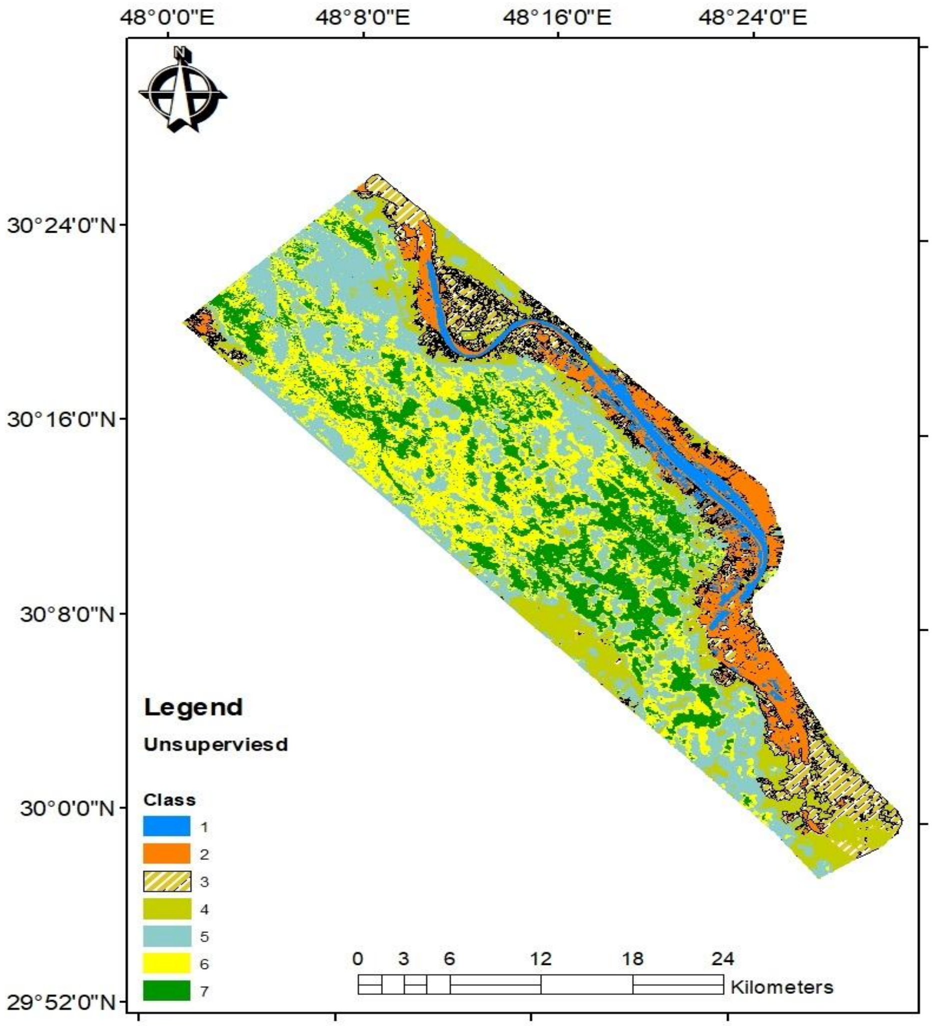

Figure 2 : Unsupervised Classification

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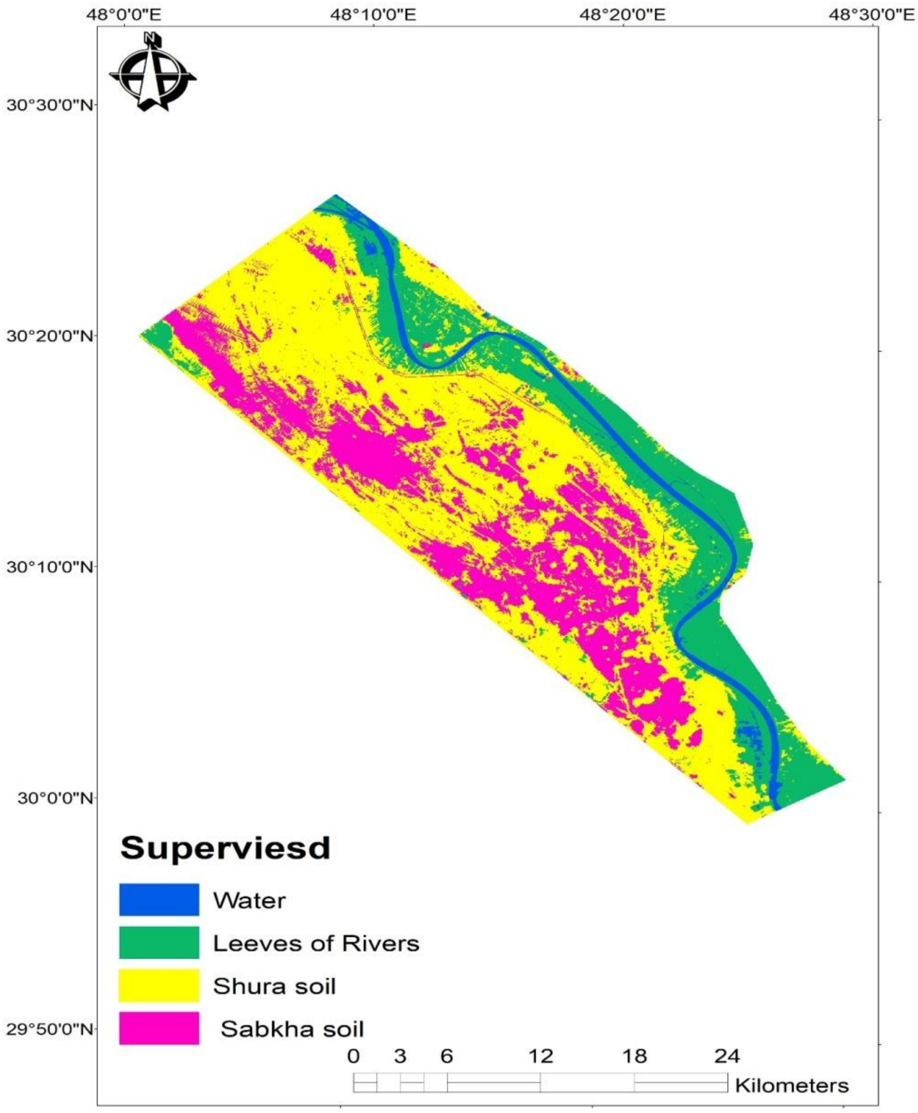

Figure 3 : Supervised Classification

2 – 2: Field procedures

After separating the soil units (Figures 2 and 3) in the study area and determining the locations of 8 pedons distributed within it, a GPS device was used to determine the locations of the pedons and projected them on the map. Information about the soil of the study area was documented in the field, and location information for each of them was recorded, which included both vegetation cover. Land uses and site characteristics (Soil Survey Staff, 2003) .

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2 – 3: Satellite image

The satellite image captured by the Landsat8 satellite, the TIRS - OLI (The Operational Land Imager) sensor, which had eleven spectral bands on September 16, 2022, with a resolution of 30 m, was used, while the eighth band had a resolution of 15 m. The satellite image was used to obtain classification maps(unsupervised and supervised) and indices maps .

2 – 4: Digital processing of Satellite image

The digital processing of the satellite image was done using the computer program Arc map 10.4.1. The spectral bands that have the highest Optimum Index Factor (OIF) were chosen as they are more capable of expressing the difference that were adopted to extract the appropriate combination. The false color combination was chosen for spectral bands 7, 5, and 3 for RGB colors, respectively, to form the best color combination to distinguish the soil of the study area, since these bands are specialized in soil and mineral studies (Faleh and Shawan, 2012) .

2 – 5: Indices

A set of indices were used, including the Normalized Difference Vegetation Index (NDVI) proposed by (Rouse et al., 1974), equation (1), and the Bare Soil Index (BSI) proposed by Jamalabad and Abkar (2004). Equation (2) and the Soil Adjusted Vegetation Index (SAVI) mentioned by (Huete, 1988) Equation (3).

$$NDVI = \frac{NIR-Red}{NIR+Red} = \frac{B5-B4}{B5+B4} \quad \ldots\ldots(1)$$

$$BSI = \frac{(SWIR+Red)-(NIR-Blue)}{(SWIR+Red)+(NIR+Blue)}+1 = \frac{(B6+B4)-(B5+B2)}{(B6+B4)+(B5+B2)}+1 \quad \ldots\ldots(2)$$

SAVI =((NIR-R) / NIR +R +L))* (1+L) ……………………………………..(3)

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Results and discussion

1 – The Normalized Difference Vegetation Index(NDVI)

The results in Table 1 and Figure 4 indicate that there is a state of variation in the values of the Change in Vegetative Cover Index (NDVI) between the pedons of the study area, as the values of the index ranged between < 0 - 0.79, and this represents the state of variation in the vegetation cover. The closer these values are to 1.0 This means the presence of dense vegetation cover. Values less than 0.1 represent abandoned and barren soils devoid of vegetation and residential areas, while values ranging between 0.1 - 0.4 indicate the presence of shrubs and grass, while values higher than 0.4 indicate dense plants such as trees. (Rouse *et al*,. 1974). The results showed that the highest value of the vegetative index in the first path was that these groves were located in the area of river levees with vegetation cover, with the presence of some trees scattered, while barren and abandoned soils prevailed in the rest of the groves of the study area. Therefore, this indices can be used in diagnosing the vegetative cover. Which was based on the ratio between the spectral reflectivity values of the infrared band and the red band that is suitable for this purpose, and then these values appeared very low, and this is an indicator of weak agricultural investment in the study area(Kadhim *et al*,. 2020) .

Table 1: Digital Number (DN) values corrected for the spectral reflectivity of indices

Indices	Range	Description of the indices	Space(km^2)	% Space
NDVI	< 0	water	15.442	1.766
	0.00 – 0.19	low	722.785	82.661
	0.20 – 0.49	middle	110.315	12.616
	0.50 – 0.79	high	25.863	2.957
BSI	< 0	water	68.453	7.829
	0.61 – 0.973	low	142.781	16.328
	0.974 – 1.24	middle	158.798	18.161
	1.25 – 1.64	high	504.373	57.682
SAVI	< 0	water	28.281	3.234

	0.00 – 0.0887	low	725.276	82.933
	0.0888 – 0.158	middle	96.011	10.992
	0.159 – 0.408	high	24.837	2.841

Table 1 and Figure 4 show that the indices of vegetative difference in the study area, and based on unsupervised values, four types of dominant land covers were identified for the studied area. The type of water bodies and wetlands was identified, which are among the values less than zero, and its area is estimated at 15.442 km^2, or 1.766%. The barren land class, whose values ranged between 0 - 0.19 and its area was estimated at 722,785 km^2, with a percentage of 82.661%, and the medium density vegetative cover class, whose value ranged between 0.20 - 0.49, with an area of 110,315 km^2, with a rate of 12.616%. As for the fourth class, the high vegetative cover class, its value ranged between 0.50. -0.79 The area was estimated at 25,863 km^2, representing 2.957%.

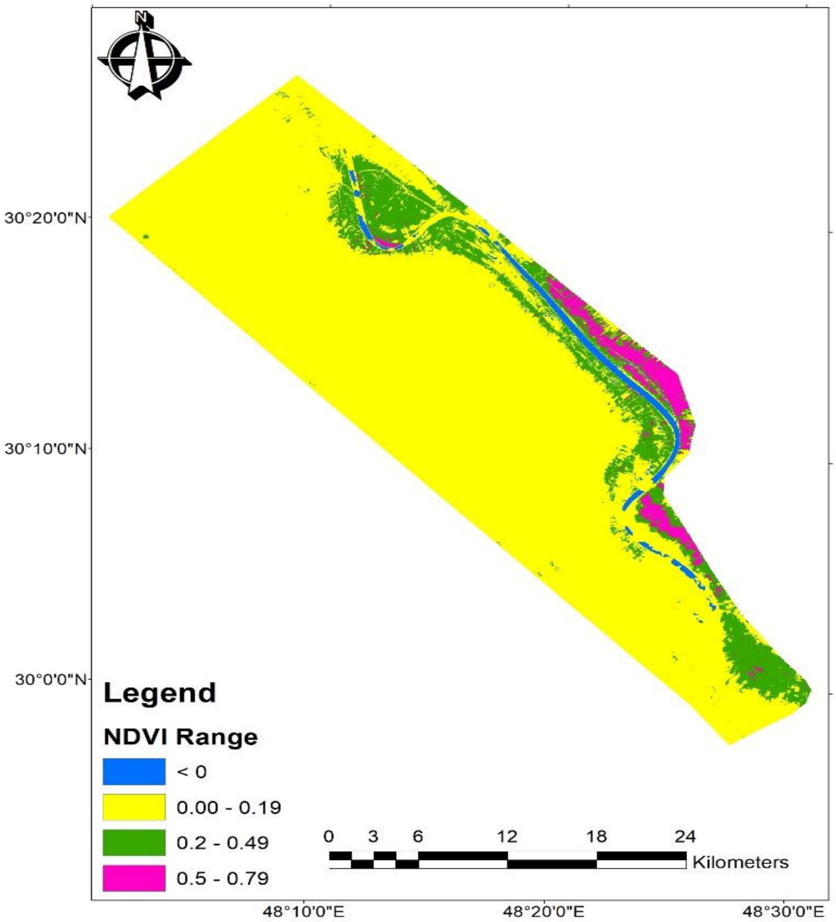

Figure 4: Spatial distribution of NDVI in the study area

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2 – Bare Soil index (BSI)

The results in Table 1 and Figure 5 showed the barren soil index, which indicates the extent to which the soil is devoid of vegetation, as the index values ranged between < 0 - 1.64, and the lowest values appeared in the pedons of the first path, as it has vegetation cover located in levees rivers and is agriculturally exploited, and the highest values were It was in the second track's pedons, which are characterized by high salt content and lack of vegetation. The results also showed that the soil surface was devoid of vegetation, in addition to the high percentage of salts in it, especially in barren lands, which increased the value of this indices. It is clear from the results that there is variation in index values in the study area, and this is due to spatial variation in the percentage of vegetation cover. The results show in Table 1 and Figure 5 the specific land covers indicative of barren soils in the study area. The first category refers to water bodies and occupied a percentage of < 0 and an area of 68,453 km^2 and a percentage of 7.829%, while the second category represents lands with varying vegetation cover and occupied a percentage ranging between 0.61 - 0.973 and an area of 142,781 km^2 and a percentage of 16.328% of the total area. The reason for this is due to the fluctuation of the cover. Vegetation in these areas and a decrease in the percentage of cultivated land. As for the third category, it is lands with very low vegetation cover, ranging between 0.974 - 1.24, and occupying an area of 158,798 km^2, at a rate of 18,161%. While the fourth category refers to lands devoid of vegetation, ranging between 1.64 - 1.25, and an area of 504,373 km^2, or 57,682% of the total area of the study area.

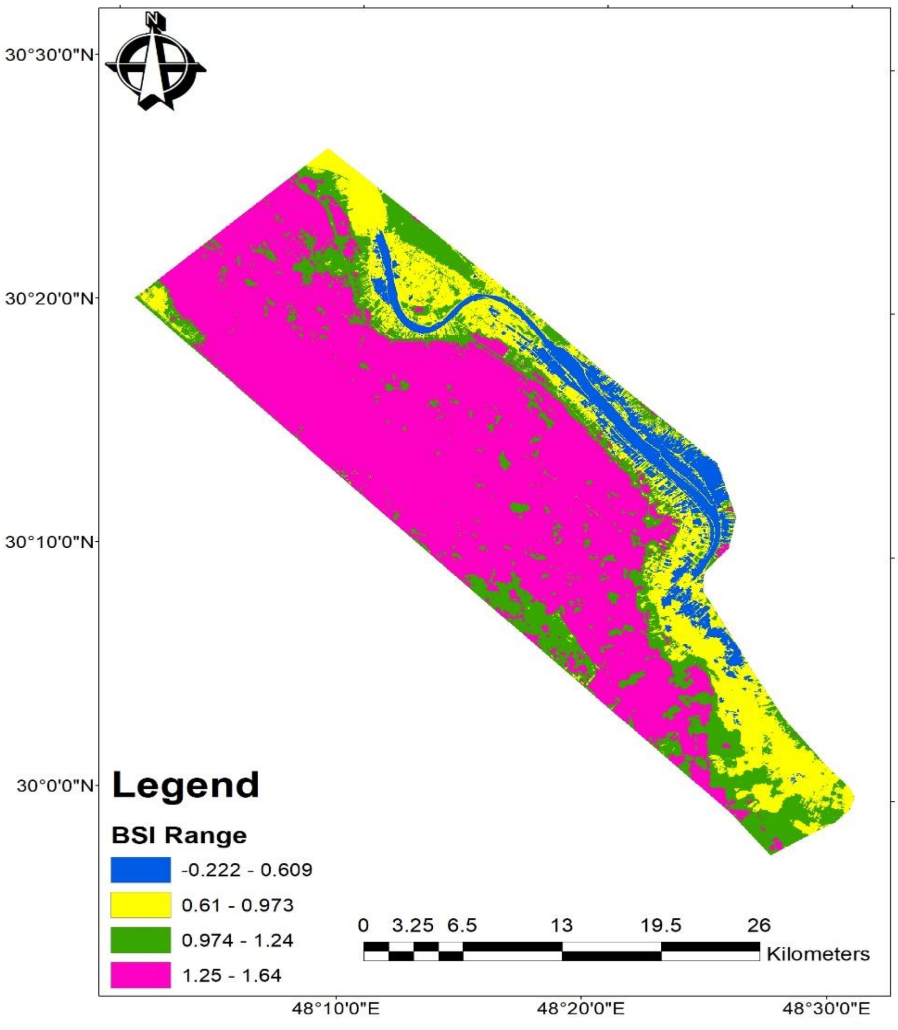

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Figure 5: Spatial distribution of BSI in the study area

3 – soil adjusted vegetation index(SAVI)

The results in Table 1 and Figure 6 showed a variation in the values of the index (SAVI), and the values ranged between < 0 - 0.408, as the negative value represented water bodies and wetlands, whose area is estimated at 28,281 km^2, representing 3.234% of the total area, while the values ranged between 0 - 0.0887 for the barren land type, with an area of 725.276 km^2, representing 82.933%, which represents the dominant type for the study area. As for the third type, the value ranged between 0.0888 - 0.158, representing lands with medium plant density, occupying an area of 96,011 km^2, representing 10.992%, while the values for the fourth type, with high plant density, ranged between 0.159 - 0.408, with an area of 24.873 km^2, representing 2.841% in the study area. The results indicate the dominance of low plants in the study area, which helped to influence the reflectivity values of the visible red and near-infrared spectral bands, which in turn helped to change the values of the modified vegetative index. It is noted that the SAVI values for all vegetative covers are higher than the calculated NDVI values, and the reason for this is calculating the reflectivity of the soil in addition to the vegetative cover when calculating the SAVI values (Huete, 1988) .

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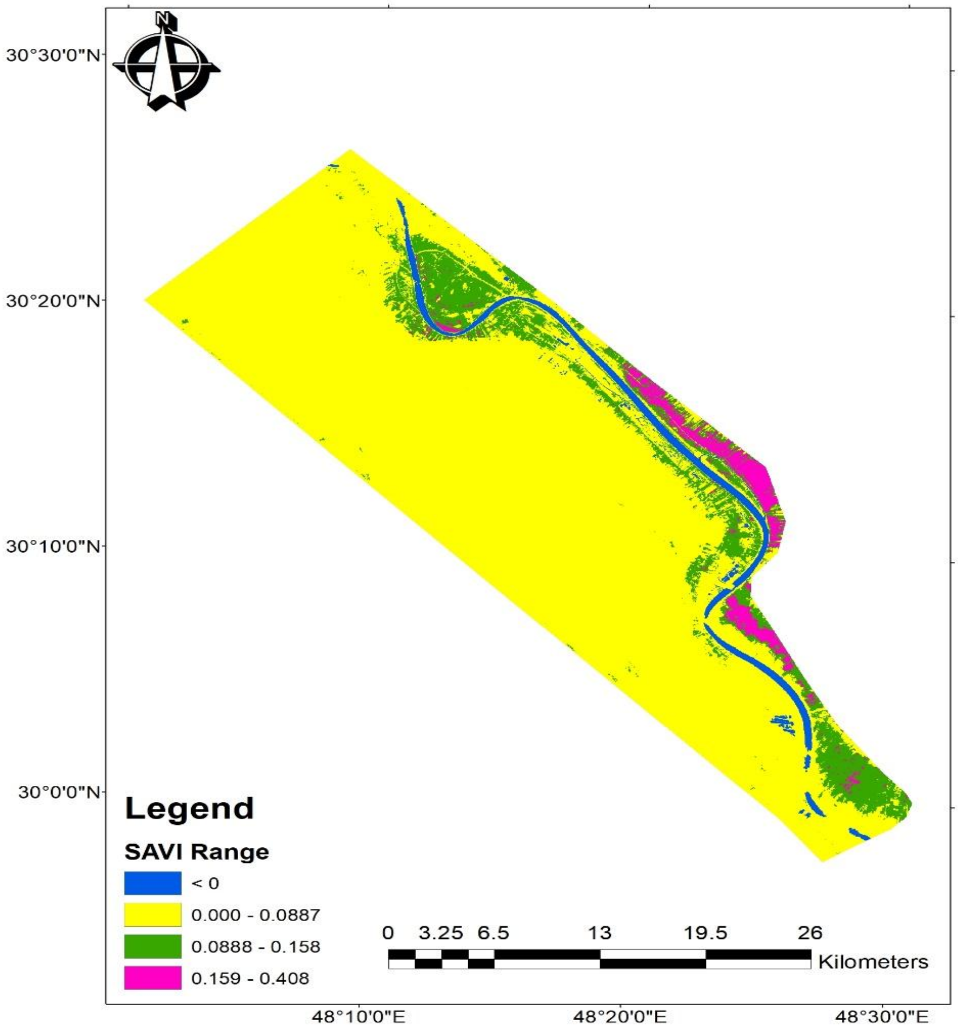

Figure 6: Spatial distribution of the SAVI index in the study area

References

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1. Al-Ani, Amal Muhammad Saleh (2006). Applications of numerical classification in classifying some soil series of river banks in the Iraqi alluvial plain. Doctoral thesis - College of Agriculture - University of Baghdad.Van Gool, D., Peter Tille and Geoff Moore.(2005). Land evaluation Standards for Land Resource Mapping. Department of Agriculture, Government of Western Australia.
2. Faleh, Ali and Jamal Shawan. (2012). Geographic information systems and remote sensing: principles and applications. Infoprint Press. Axe . The Kingdom of Morocco. Huete, A. R. A . (1988). soil-adjusted vegetation index (SAVI). Remote Sensing of Environment, Remote Sons. Environ. 25:295-309.
3. Jamalabad, M.S. and Abkar, A.A., (2004) . Forest canopy density monitoring, using satellite images. P.O. Box 13445-1136, Tehran, Iran.
4. Kadhim, M.A., S.M. Al-Atab and Jassim M. Saadoun (2020). Monitor changes in the spectral indices values of soil surface and their spatial distribution using remote sensing data. Int. J. Agricult. Stat. Sci., 16(Supplement 1), 1981-1987.
5. Lillesand , T . M . and R . W . Kieffer . (1999) . Remote sensing And Image interpretation . 2nd .Ed . John Wiley and sons . Inc.
6. Rouse, J.W. et al., (1974). Monitoring the vernal advancement and retrogradation (greenwave effect) of natural vegetation. NASA/GSFCT Type III Final report. Greenbelt, MD, USA.
7. Soil Survey Staff. (2003). Soil Taxonomy. Abasic system of soil classification for making and interpreting soil survey. 2nd edition. Agriculture Handbook No. 436. USDA.
8. Zinck J ., (2008) . Remote Sensing of soil Salinization : impact on Land management . CRC Press , Technology and Engineering . pp (374) .