SPECTRAL RELATIONSHIPS OF DIGITAL DATA FOR LANDSAT8 OLI VISUALIZATIONS OF LAND COVERS IN FALLUJAH REGION

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ABSTRACT

The study dealt with the effect of reflectivity on the land cover, as the study used a method that combines remote sensing and geographic information systems to achieve this. Basic samples were taken which representing the land-cover features, matching them with spectral reflectivity. To do this, data from the Land sat 8 satellite sensor (OLI) was used to find the reflection wavelengths of these features. When applying the general equation, the study clarified that many of the earth's surface features studied can be distinguished, determinate of their location and studied based on their spectral characteristics. Also, the study showed that the some land coverings cannot be separated naturally by using one wavelength, so the concept of pluralism was used by using more than one wavelength and sensor for purpose of determining the types of land features prevailing in the region. The reflectivity values were presented as follows, as represented by the highest average in the rock cover which represented by the gypsum desert regions at a rate of 0.288, followed by the gravel desert region sat a rate of 0.257, followed by the urban cover as it represented the spectral reflectivity of buildings at a rate of 0.248, followed by the streets at a rate of 0.23), then the vegetative cover as represented the spectral reflectivity of agricultural lands at a rate of 0.148, followed by the abandoned agricultural lands at a rate of0.204. While it represented the lowest spectral reflectivity values in the water cover, as it represented the spectral reflectivity of the river and channels at a rate of 0.077, followed by the surface of lake Habbaniyah, as it represented the highest (0.057).

Keywords

Spectral Reflectivity, Land Cover, Electromagnetic Spectrum, Geospatial Techniques.

Introduction

Spectral reflection represents the amount of sunlight which randomly spread on the surface of the earth a certain wave length. The amount of light reflected on the earth surface was varied according to different wavelengths. It is known that the rate of spectral density of the light reflected to the light incident representing the spectral reflectivity (Clark, P., 2013, p36). The Spectral radiation is the intensity of the radiation flux from the earth's surface, i.e. the amount of radiation returning from the earth's surface at the time of optical capture. It is known that the land sat visuals do not contain the radiation flux in the entire solar spectrum, but capture and record the radiation flux in separate spectral ranges. The spectral radiation of the earth's surface in Land sat visuals can be divided into two parts, the thermal spectral radiation and the reflected spectral radiation (Walid, A., 2013, p243).

The first type is the amount of radiation flux emitted by the earth's thermal infrared field, which is called climatically terrestrial radiation or sensible thermal flux, because it is a reflection of the earth's surface temperature, and is also responsible of air heating. This type of radiation is recorded in the eleventh and twelfth bands of the OLI visuals. The second type refers to the radiation reflected from earth's surface in the visible and near infrared field. These radioactive fluxes are recorded in channels 2,3,4,5,6 and 7 of the OLI visuals. The second type concerns us in this research. Land uses in the study area interaction with solar radiation by scattering, reflection and absorption. It is known that the increasing of scattering and reflection (albedo) reduces the amount of absorbed energy which that raises the earth's temperature, which is converted to terrestrial radiation that is the source of direct heating in the atmosphere (Walid, A., 2013, p.244).

The types of land coverings play an active role in the reflectivity values, where the reflectivity values differ as a result of the different floor coverings. The reflectivity values can be adopted in determining and diagnosing the earth's surface (Qasi, E. Waayb, Q., 2012, p. 942), as the spectral reflectivity plays a major role in the energy balance on the earth's surface, as it determines the rate of the absorbed portion of the incident solar radiation. Soil reflectivity is a complex feature determined by many soil-dependent and independent environmental properties, in which radiation energy is re-radiated by chemical components (for example, atoms or molecules) of the surface layer approximately half the thickness of the wavelength (Qihao, W. 2010, p.4).

Soil or vegetation that reacts with the radiation incident absorbs the portion of the solar radiation that is not reflected by the earth's surface. The absorbed energy will increase the soil temperature or the rate of evaporation from the surface of the soil system and vegetation. Some of the absorbed energy is re-radiated and converted into heat with a longer wavelength than the incoming radiation, and this explains that the peak of terrestrial radiation occurs in the infrared spectrum while the peak of incident radiation occurs in the blue color - green part of the visible spectrum (Wheitny, G. 1983, p. 688) (Figure 1): The research problem includes the following question: Can geospatial techniques be adopted to determine the spectral reflective relationship and land cover changes?

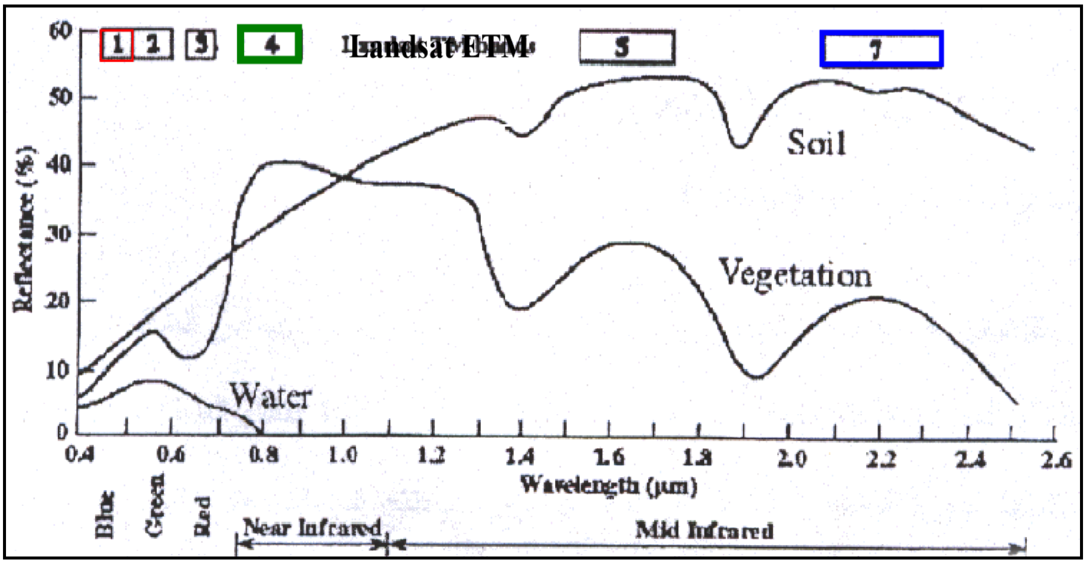

Figure 1. Spectral reflectance curve of the land covers (Wheitny, G, 1983, p. 688).

While the research aims to study the possibility of achieving the following:

1. Determining and diagnosing the land covers (natural resources) from soil, water and plants in the research region by using the multi-reflectivity method.
2. Determining the relationship between land covers and spectral reflectivity.

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Research Resources and Materials

1. Study Region

The study region represented by the spatial boundaries of the Fallujah region located on the Euphrates River in the western part of Iraq, an area of 2,500 km^2 was selected, located 60 km west of the Baghdad, and 47 km from the east of Ramadi, the center of Anbar governorate, which lies between latitudes (33° 00 '- 33° 30') north and a longitude (43° 30' - 44° 00') east (Figure 2).

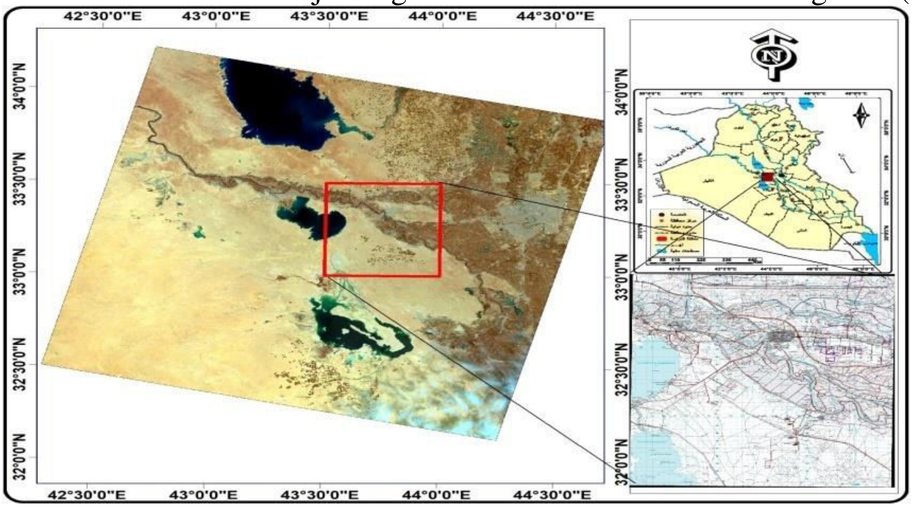

Figure 2. Location map of the study region of Anbar governorate

Source:

1. Republic of Iraq, Ministry of Water Resources, Directorate General of Survey, Administrative Map of Iraq, Scale 1: 10,000,000 of 2010.
2. Republic of Iraq, Ministry of Water Resources, General Directorate of Survey, Fallujah topographic map, scale 1: 100,000of 1999.
3. NASA, the satellite imagery (8 Landsat), type (OLI), discriminatory accuracy of 30 meters, 3/04/2020.

2. Specifications of Satellite Data and Software Used

The satellite data of the study region within the range of 37 Row 37 and 169 Path from the satellite visual scene of the LANDSAT-8 OLI sensor captured on 23 April, 2020, clear of clouds.

A. Programs Used

- ERDAS IMAGINE 2015
- ArcGIS 10.8.1
- 5.3ENVI. program

Materials and Methods

1. Calculation of spectral reflectivity: One of the following methods is used:

A. Arithmetic Operations

Converting the digital numbers of channels to spectral radiance values (Lills and, T. and R., 2000, p.145).

$$\text{Radiance} = \frac{dn}{D\max} \quad (L\max - L\min) + L\min$$

Where:
Radiance = Spectral radiance ($Sr^{-1}\mu mWm^{-2}$)
Dn = Numeric numbers
Dmax = The highest numeric number represented by 255
Lmax and Lmin = Saturation levels and radiation starting value
To find the Reflectance is done through:

$$\text{Reflectance} = \frac{\pi}{E.\sin(a)} \quad (\text{Radiance})$$

Where:
Reflectance = Spectral reflectivity without units and its values are 0-1

E = Solar constant of the given band at the top of the atmosphere (Wm^{-2})
Sin(a) = Sun's elevation angle

B. Using the Electromagnetic Spectrometer: Portable Digital Spectrometer

It is an optoelectronic device that measures the digital reflectivity of objects within the visible spectral range 0.3-0.7 µm and measures the reflected radiance in the lux unit, as it converts electromagnetic energy to electrical energy and the readings are shown on a digital recorder that appears in front of the reader, noting that the device’s sensor is placed perpendicular to the target (Ali, A. and Ahmed K., 2011, p.718).
By Using the 5.3ENVI software: The reflectivity values can be found by using the ENVI software. This method can complete the estimation process automatically without need to write the equations above, which may result in writing unintended errors. Also, this method is adopted to extract the spectral reflectivity (Figure 3).

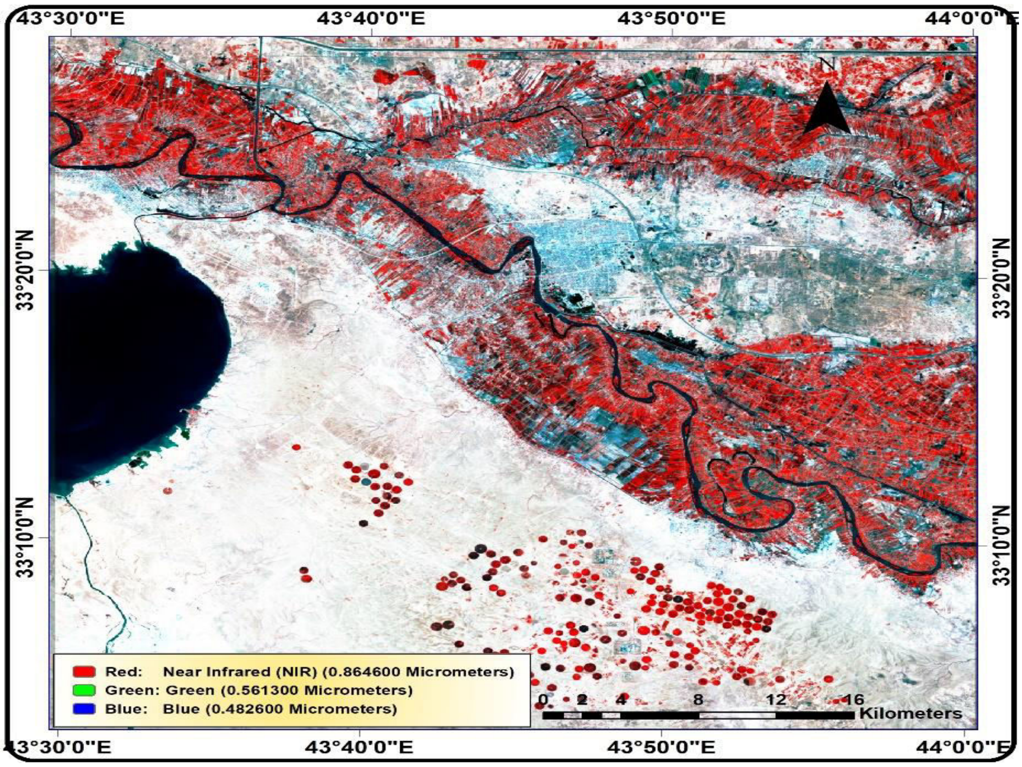

Figure 3. Spectral reflectivity of the Fallujah region
Source: Satellite imagery of the Landsat 8 type OLI based on 5.3ENVI

2. Digital Processing of Satellite Visuals: The Digital Method was Carried out According to the following

To determine and identify the land cover of the Fallujah region, the digital analysis method was used, to determine the spectral patterns by using the electronic calculator, and the special ERDAS Ver2015 program was adopted to analyze, interpret and improve satellite images of the selected sites and vary in reflectivity values, the land covers with different spectral behavior were determined by using OLI sensors. Multiple methods for dealing with increasing its spatial accuracy to 15 m with the eighth band (Figure 4).

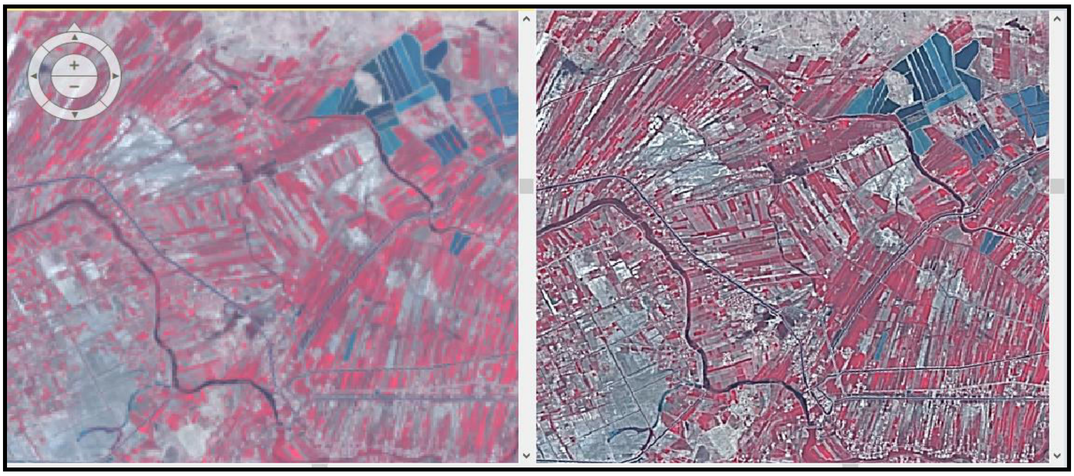

Figure 4. Increasing the discriminative accuracy using the Pan Sharpen application
Source: Based on ERDAS IMAGINE 2015

Clip deduction and Enhancement of the study region by using the histogram equalization method, which Converts the range and brightness values of the entered visual to a range and brightness values approximating the reference visual, i.e. the reflectivity values are approximating to 255, so this method distributes the reflectivity values again (Paul M. Mather, 2004, p.104), which leads to a clear variance between the phenomena and helps to improve in distinguishing the manifestations of the land cover of the study region (Figure 5).

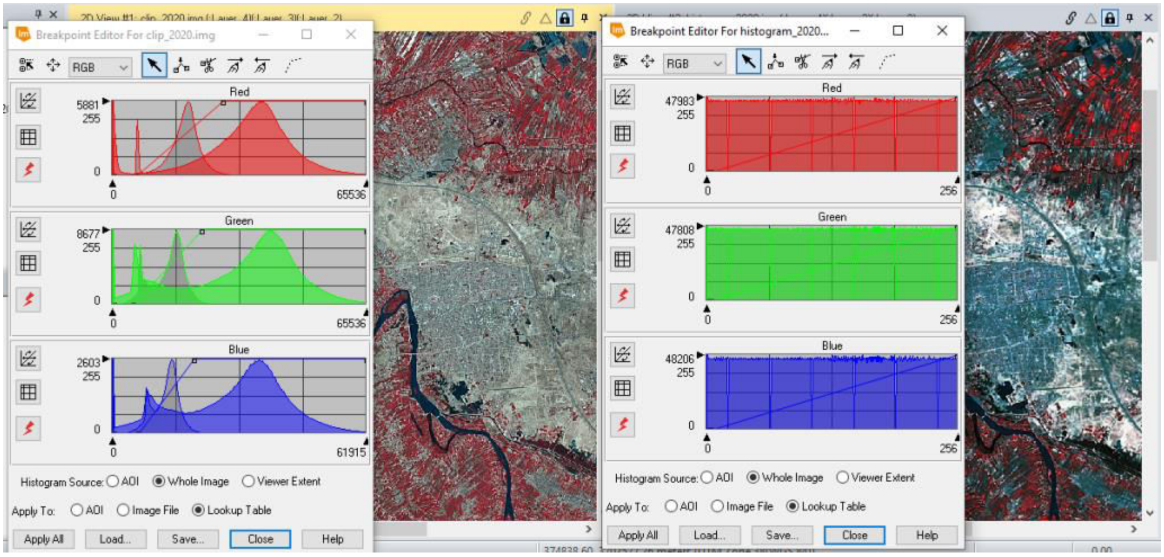

Figure 5. Radmetric improvement by using the histogram equalization method
Source: Based on ERDAS IMAGINE 2015

After it, the stage of evaluating the quality of the training region and choosing the spectral fingerprint. At this stage, the quantitative expression of the spectral intervals between the training samples is done by calculating the spectral interval between each pair of training samples and the samples evaluation test by using the averages curve (Figure 6), and the numerical spacing scale by Jefferies Matusita style, as the value of the spacing between fingerprints approaches to 1414 (Table 1).

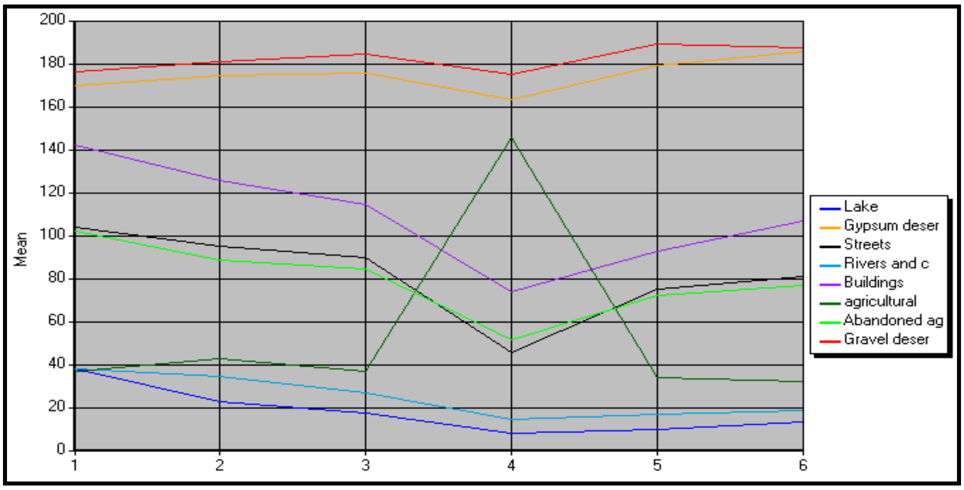

Figure 6. Evaluation of the quality of training region by using the Mean plot method application
Source: Based on ERDAS IMAGINE 2015

Table 1. Consistency matrix of training region by using Jefferies Matusita method

Best Minimum Separability

Bands	AVE	MIN	Class Pairs:						
			1: 2	1: 3	1: 4	1: 5	1: 6	1: 7	1: 8
			2: 3	2: 4	2: 5	2: 6	2: 7	2: 8	3: 4
			3: 5	3: 6	3: 7	3: 8	4: 5	4: 6	4: 7
			4: 8	5: 6	5: 7	5: 8	6: 7	6: 8	7: 8
1 2 3 4 5 6	1329	802	1414	1414	1408	1414	1414	1414	1414
			1400	1413	1309	1414	1379	802	1388
			1200	1408	1001	1349	1364	1333	1311
			1409	1391	1082	1216	1389	1413	1338

Best Average Separability

Bands	AVE	MIN	Class Pairs:						
			1: 2	1: 3	1: 4	1: 5	1: 6	1: 7	1: 8
			2: 3	2: 4	2: 5	2: 6	2: 7	2: 8	3: 4
			3: 5	3: 6	3: 7	3: 8	4: 5	4: 6	4: 7
			4: 8	5: 6	5: 7	5: 8	6: 7	6: 8	7: 8
1 2 3 4 5 6	1329	802	1414	1414	1408	1414	1414	1414	1414
			1400	1413	1309	1414	1379	802	1388
			1200	1408	1001	1349	1364	1333	1311
			1409	1391	1082	1216	1389	1413	1338

Source: Based on ERDAS IMAGINE 2015

Results and Discussion

1. Supervised Classification

The supervised classification is built on the basis of prior information about the spectral reflectivity characteristics of the land cover features of the study region, by choosing the classification method with maximum likelihood, as this method is one of the best statistical methods for classification and is the most widely used in spectral classification processes. The results of the spectral analysis of the selected patterns indicate that there are eight secondary spectral classes derived from the main classes of urban, vegetal, rocky, and water land covers (Figure 7 and Table 2), which included secondary units that differ in spectral behavior in the same class. The spectral groups were classified into (A) urban cover (B) vegetative cover (C) desert land (D) water cover.

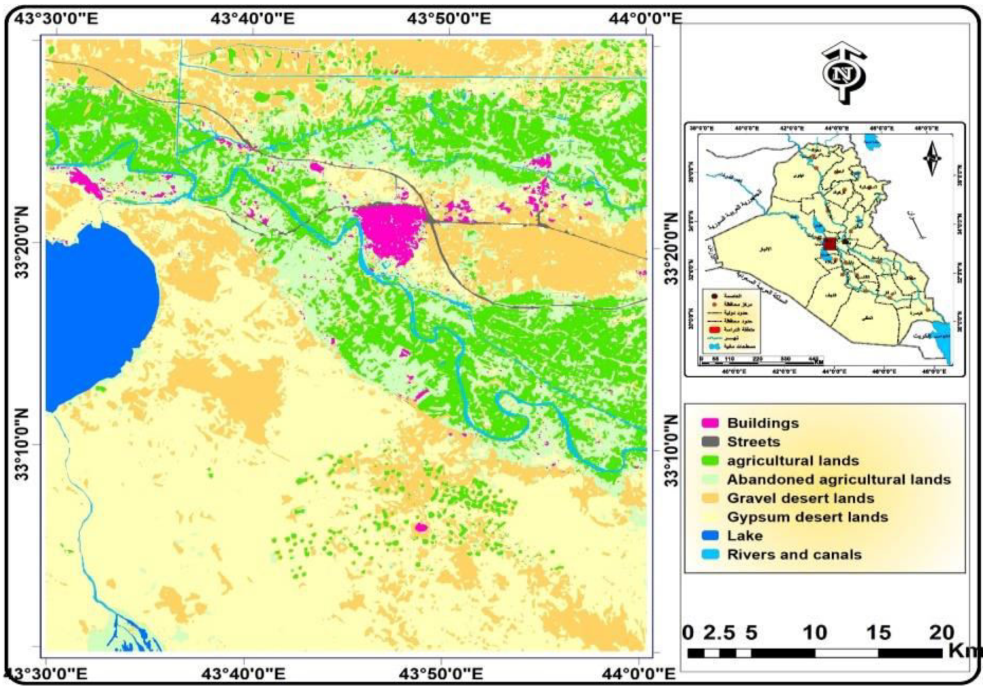

Figure 7. The land coverings of the Fallujah region for the 2020
Source: Satellite imagery of the Landsat 8 type OLI based on 5.3ENVI

Table 2. The areas of the land covers of the Fallujah region for the 2020

No.	Level 1	Level 2	Area (km2)	Proportion ()
1	A-Urban Cover	Buildings	40.4	1.6
2		Streets	11.8	0.5
3	B-Agricultural Cover	agricultural lands	386.9	15.5
4		Abandoned agricultural lands	384.0	15.4
5	C-Desert lands	Gravel desert lands	511.7	20.5
6		Gypsum desert lands	1015.8	40.6
7	D-Water cover	Rivers and canals	41.6	1.7
8		Lake	107.9	4.3
		Total	2500	100

Source: The areas were calculated by using the ArcGIS 10.8.1 program

2. Relationship of Spectral Reflectivity with Land Cover

The land covers showed different values of reflectivity and different spectral behavior as a result of the different chemical, physical, mineral and physiological characteristics of the land surfaces, as 40 GPS samples were taken (Figure 8 and Table 3).

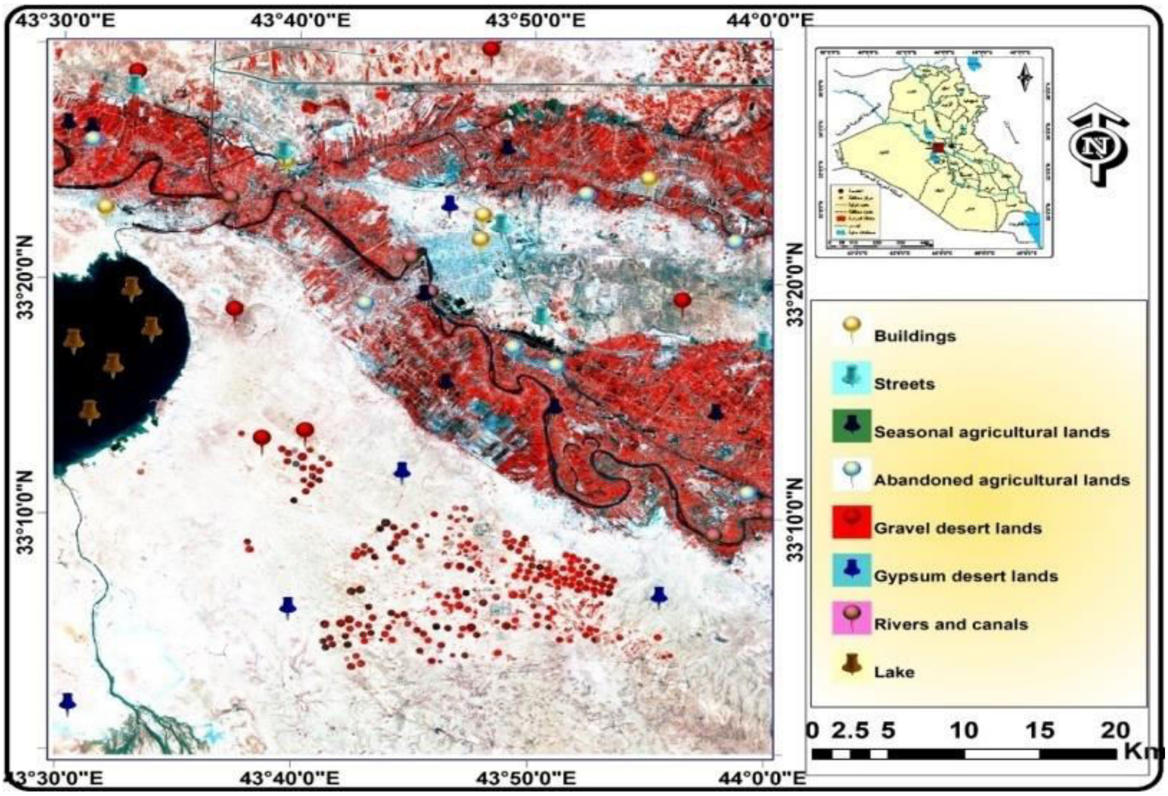

Figure 8. Spectral reflectivity coefficient for coordinate points according to ground covers for the 2020
Source: Satellite imagery of the Landsat 8 type OLI based on 5.3ENVI

The spectral reflectivity value ranges from 0 to 1, as the characteristics of spectral reflectivity depend on the wavelength of electromagnetic energy, quality and condition of the objects on the earth's surface, which allows the possibility of distinguishing the various visible objects in the Satellite visual, the final results of the reflectivity values were presented as follows in Table 4 and Figure 9.

The rock cover of the desert regions represented the highest reflectivity values, represented by the gypsum desert regions with the highest 0.327 and lowest 0.255, followed by the gravel desert regions with the highest 0.281 and the lowest 0.231, where the dark-colored coarse soil surfaces and the light-colored soft soil surface High reflectivity.

Table 3. Spectral reflectivity values of land covers according to coordinate points for the 2020

No.	Classification type	Long.(λ)	Lat. (ϕ)	Reflectance()
1	Buildings	43.80	33.36	0.277
2	Buildings	43.80	33.38	0.289
3	Buildings	43.92	33.40	0.212
4	Buildings	43.53	33.38	0.219
5	Buildings	43.66	33.41	0.244
6	Streets	44.00	33.29	0.207
7	Streets	43.84	33.31	0.256
8	Streets	43.81	33.37	0.225
9	Streets	43.66	33.42	0.279
10	Streets	43.55	33.47	0.204
11	agricultural lands	43.76	33.32	0.154

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12	**agricultural lands**	43.77	33.26	0.132
13	**agricultural lands**	43.85	33.24	0.162
14	**agricultural lands**	43.50	33.44	0.145
15	**agricultural lands**	43.81	33.43	0.140
16	**Abandoned agricultural lands**	43.87	33.39	0.231
17	**Abandoned agricultural lands**	43.98	33.36	0.259
18	**Abandoned agricultural lands**	43.85	33.27	0.173
19	**Abandoned agricultural lands**	43.82	33.28	0.208
20	**Abandoned agricultural lands**	43.72	33.31	0.168
21	**Gravel desert lands**	43.67	33.22	0.261
22	**Gravel desert lands**	43.64	33.22	0.281
23	**Gravel desert lands**	43.62	33.31	0.258
24	**Gravel desert lands**	43.80	33.49	0.254
25	**Gravel desert lands**	43.55	33.48	0.254
26	**Gypsum desert lands**	43.77	33.39	0.314
27	**Gypsum desert lands**	43.74	33.20	0.264
28	**Gypsum desert lands**	43.66	33.10	0.286
29	**Gypsum desert lands**	43.51	33.03	0.303
30	**Gypsum desert lands**	43.93	33.11	0.275
31	**Rivers and canals**	44.00	33.17	0.092
32	**Rivers and canals**	43.96	33.15	0.076
33	**Rivers and canals**	43.62	33.39	0.069
34	**Rivers and canals**	43.67	33.39	0.066
35	**Rivers and canals**	43.76	33.32	0.074
36	**Lake**	43.54	33.27	0.056
37	**Lake**	43.55	33.33	0.058
38	**Lake**	43.52	33.24	0.061
39	**Lake**	43.51	33.29	0.054
40	**Lake**	43.56	33.30	0.057

Source: The reflectivity values were extracted from Figures 8 and 9 based on the Arc GIS 10.8.1 program.

Followed by the urban cover represented by the urban buildings that recorded the highest reflectivity values 0.289 and the lowest 0.210, followed by the streets with the highest 0.279 and the lowest 0.198, as the absorption factor represented a change in the percentage of reflectivity, the color contrast factor and the type of surface had an effect on the high coefficient of spectral reflectivity.

Followed by vegetation, as the spectral reflectivity of agricultural lands represented the highest 0.180 and lowest 0.126, followed by the abandoned agricultural lands with the highest reflectivity values 0.259 and the lowest 0.163. The type and state of vegetation have a strong influence on the spectral reflectivity, the reflection and absorption coefficient of electromagnetic radiation is varying according to the state of the plant and its height.

While the lowest spectral reflectivity values were represented in the water cover, as the spectral reflectivity of the river and channels represented the highest 0.093 and the lowest 0.065, followed by the surface of Lake Habbaniyah the highest 0.061 and the lowest 0.054. The amount of electromagnetic radiation reflected by the water cover is less compared to other land coverings.

Table 4. Spectral reflectivity coefficient of the land covers of the Fallujah region for the 2020

No.	Classification type	Minimum	Maximum	Average	Std Dev

1	Buildings	0.210	0.289	0.248	0.034
2	Streets	0.198	0.279	0.234	0.033
3	agricultural lands	0.126	0.180	0.148	0.021
4	Abandoned agricultural lands	0.163	0.259	0.204	0.035
5	Gravel desert lands	0.231	0.281	0.257	0.017
6	Gypsum desert lands	0.255	0.327	0.288	0.028
7	Rivers and canals	0.065	0.093	0.077	0.012
8	Lake	0.054	0.061	0.057	0.002

source: the spectral reflectivity coefficients were extracted by using the arcgis 10.8.1 program.

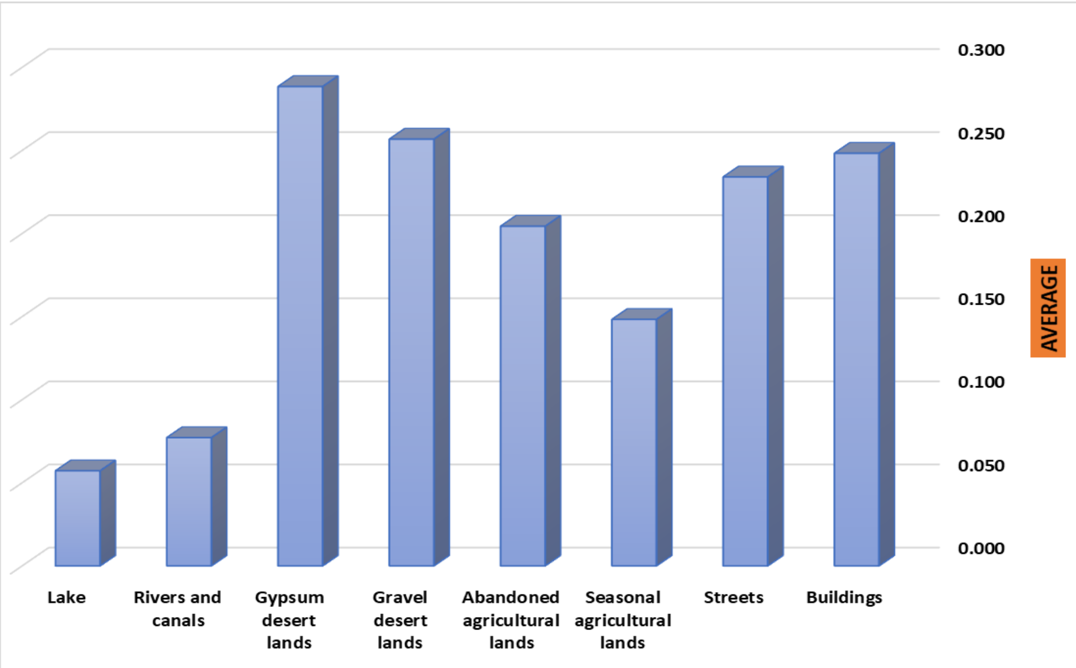

Figure 9. The rate of spectral reflectivity of the land covers of the Fallujah region for the 2020
Source: Based on Table 4.

Conclusions

Remote sensing data and its importance in studying the spectral reflectivity has an important role in determining the variation between land covers according to the characteristics of each use and the wavelength of the land reflectivity. The use of multiple methods in terms of the number of wavelengths used, methods of dealing and expressing the reflectivity through the use of multiple channels for the purpose of obtaining the best identification of the land covers. The reflectivity values showed a clear influence of the land covers and reflected a relationship between the characteristics of the land covers and the reflectivity values. Also, the varying levels of spectral reflectivity of the land covers that could be distinguished in this study help decision-makers in developing land uses for agricultural purposes in this vital area in the semi-arid regions.

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