Measurement Albedo Coefficient for Land Cover (Lc) and Land Use (Lu), Using Remote Sensing Techniques, A Study Case: Fallujah City

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Abstract. Albedo tests the total surface reflectance, offering plenty of useful details on the environment and a deeper understanding of the balance of environment features. Yet usually different sunlight wavelengths are not reflected equally, resulting in a variable surface color and variations in the absorption of certain wavelengths due to changes in the surfaces physical or chemical characteristics. Surface albedo differences can be measured using radiometers, or by using the general equation to extract the value of the albedo for surfaces if all the variables are available. Every space agency uses this equation according to its measured wavelengths. So, the general equation of the satellite landsat was chosen to extract the values of albedo. Surface whiteness is a modulus, and it represents a portion of the incident sunlight reflected by the surface of any feature, and the surface absorbs radiation that is not reflected. The study examined the effect of albedo on the climate of Fallujah and the thermal composition of that urban area. The study used a method that combines remote sensing and geographic information systems to achieve this. Basic samples representing the ten landmarks of Fallujah were taken, the coordinates of these points were measured, and simulated with the satellite images of Landsat 7 and 8 and the sensor (ETM+, OLI) to find the wavelengths of reflectance of these features. When applying the general equation, the albedo values were shown as follows (Buildings with a value of 0.19, Streets with a value of 0.20, Rivers and canals with a value of 0.16, Sand plains with a value of 0.16, River islands with a value of 0.16, Low density arable land with a value of 0.18, High density arable land with a value of 0.15, Gravel land and its value. 0.23, Industrial areas with a value of 0.20, Abandoned land and saline, a value of 0.21).

Keywords: Albedo, Reflectance, Remote sensing, GIS, Satellite Landsat Imagery.
1. Introduction

The fraction of the incident radiation that is reflected from the surface is called the albedo. Albedo plays a major role in the energy balance of the earth’s surface, as it defines the rate of the absorbed portion of the incident solar radiation, [1]. Soil albedo is a complex feature, which is determined by many soil dependent and independent (environmental) characteristics. The process that results in the reflected radiation is called reflectance, whereby the energy of radiation is reradiated by the chemical constituents (e.g., atoms or molecules) of the surface layer approximately half the thickness of wavelength, [2].

The portion of solar radiation that the Earth's surface does not reflect is absorbed by the soil or vegetation that interacts with the radiation incident. The energy absorbed will increase the temperature of the soil or the rate of evapotranspiration from the soil-vegetation system surface. Some of the energy that is absorbed and transformed into heat is re-radiated at a wavelength that is longer than the radiation coming in. This is why the peak terrestrial radiation occurs in the infrared spectrum while the peak incident radiation occurs in the visible spectrum’s blue-green portion.

The value of the albedo ranges from 0 to 1. The value of 0 refers to a black body, a theoretical media which absorbs 100 per cent of the radiation incident, for example, Albedo ranging from 0.1–0.2 refers to dark-colored, rough soil surfaces, see Table 1.

The aim of the search is to find and monitoring the coefficient (Albedo) for different land uses (LU) in Fallujah city, and Matching and improving climatic factors by observing albedo values.

| Natural surface types                  | Approximated albedo |
|----------------------------------------|---------------------|
| Blackbody                              | 0                   |
| Forest                                 | 0.05–0.2            |
| Grassland and cropland                 | 0.1–0.25            |
| Dark-colored soil surfaces             | 0.1–0.2             |
| Dry sandy soil                         | 0.25–0.45           |
| Dry clay soil                          | 0.15–0.35           |
| Sand                                   | 0.2–0.4             |
| Mean albedo of the earth               | 0.36                |
| Granite                                | 0.3–0.35            |
| Glacial ice                            | 0.3–0.4             |
| Light-colored soil surfaces            | 0.4–0.5             |
| Dry salt cover                         | 0.5                 |
| Fresh, deep snow                       | 0.9                 |
| Water                                  | 0.1–1               |
| Absolute white surface                 | 1                   |

2. Study Area and Description

Fallujah is located in the middle widths of the northern hemisphere, between two latitudes (33° 21’ 09” – 33° 17’ 47”) North, and longitude (43° 44’ 58” – 43° 49’ 33”) East, [2].

It is located to the west of the city of Baghdad with a distance of (60) km and to the east of the city of Ramadi, the center of Anbar Governorate, at a distance of (47) km. It is the administrative center of the Fallujah district, which consists of two administrative units: Fallujah, the Judiciary Center, and the
Saqlawiyah sub district from the west and northwest, the average area of the district (635 km²) is dominated by the desert characteristic in most of the northern, western and southern parts and lacks most commercial, industrial and service establishments, which made these areas mainly dependent on the city of Fallujah (the center of the judiciary) in which these institutions are concentrated, unfold Not to fall on a knot of important transportation, which gained it regional and international importance.

Figure 1. The location of the study area, illustration the city of Fallujah, which is one of the districts of Anbar Province in the western part of Iraq.

3. Materials and Methods

3.1. Climate
The prevailing climatic conditions at the Fallujah site, as is the case in the central regions of Iraq, are characterized as dry desert, as the amount of solar radiation is very large, the daily and annual thermal range varies greatly up to extremes, Relative humidity varies according to the amount of precipitation and its variation between years and the amounts of water stored in the lakes near the city, [3].

Temperatures begin to rise gradually in the city of study with the arrival of the summer months, starting in April and May, as the average temperature for these two months is (22.4° C) and (27.9° C) respectively, and after that the temperature continues to rise to reach (35.4° C) in July, the highest temperature recorded during the year. The lowest temperatures were recorded in January (10° C).

Solar radiation is the main source of heating the Earth's surface, which is electromagnetic radiation, and then converted to chemical energy, which is the basis for the occurrence of chemical reaction in the life of the plant. The amount of solar radiation received by the Earth’s surface depends on the angle through which solar radiation falls on the Earth’s surface and is determined (by geographic location, Earth’s surface composition and time period), according to seasons, day and night, [4].

Through Table 2, it turns out that the average hours of sunshine in the city of Fallujah begins to increase from March to August, as daylight hours reach (463) and (688). calories/cm²/day, and it decreases from September to December, when it reaches (569) and (267) calories/cm²/day, and the highest value of solar radiation appears in June, July, August.

The results showed that the humidity is inversely proportional to the temperature. Through Table 1, The results showed that the humidity recorded its highest rate in December (72%) and lowest in July (25%).

The rain begins in the month of November and continues to May, and most of the precipitation comes in the months of December and the second, February and March, while the months of June,
July and August are characterized by being free of rain, and that the rain has little impact on the city's growth and expansion, either positively or negatively, [5].

**Table 2.** Values and rates of climate elements for AL-Ramadi station for the period (2000-2018).

| Climate Elements | temperature (°C) | Solar radiation (Calories/cm²/day) | Relative humidity (%) | Rain (mm) |
|------------------|------------------|----------------------------------|----------------------|-----------|
| January          | 10.0             | 323                              | 72                   | 16.3      |
| February         | 12.3             | 351                              | 62                   | 14.6      |
| March            | 16.6             | 463                              | 55                   | 13.4      |
| April            | 22.4             | 554                              | 46                   | 11.5      |
| May              | 27.9             | 644                              | 35                   | 6.4       |
| June             | 32.1             | 748                              | 20                   | 0         |
| July             | 35.4             | 753                              | 25                   | 0         |
| August           | 34.1             | 688                              | 27                   | 0         |
| September        | 33.1             | 569                              | 32                   | 9.3       |
| October          | 28.0             | 435                              | 50                   | 13.7      |
| November         | 21.7             | 338                              | 61                   | 17.5      |
| December         | 11.7             | 267                              | 73                   | 20.8      |

3.2. **Acquisition Data Source and Processing**

ArcGIS was adopted in this study, a program that collects, inserts, analyses, displays and output data. The Landsat satellite data series was used and images were taken from the website and the following operations were carried out: (clipping satellite images, composite bands to produce Visual images of city features and processing of satellite images). Bands (2, 3, 4) and (3, 4, 5) for Landsat 7 and Landsat 8 respectively were used to determine changes in land cover, in Table 3 describes the bands used in the production of classification maps [6].

**Table 3.** Composites bands of satellite image (RGB) of ETM+ and OLI.

| Resolution | ETM+ | OLI | Color  |
|------------|------|-----|--------|
| 30         | Band-2 | Band-3 | Green  |
| 30         | Band-3 | Band-4 | Red    |
| 30         | Band-4 | Band-5 | NIR    |

3.3. **Supervised Classification of Land Cover and Land Use**

The classification of land cover and land use was carried out in the ERDAS program where the ground cover information was extracted from the images. Groups with the same spectral signature were grouped into one category, [7]. The land cover was classified into ten categories, depending on the prior knowledge by the researcher of the study area within the image in order to be able to identify the training samples, and the training sample: is a well-known area, location and shape, so that it can be identified on the map and contains a homogeneous ground category, and prior knowledge is obtained through many sources such as field visits and identification Sites of training samples or the use of maps or previously classified images, (Abandoned land and saline, Buildings, Gravel land, High density arable land and permanently irrigated, Low density arable land mixed with fallow land, Industrial areas, River islands, Rivers and canals, Sand plains) Thus, we produced the maps of the land
cover classified for the years of the study, where Each category represents a certain color. The results of the classification showed that there was a change in the land cover in terms of area with the change in the time of the image taking effect due to seasonal and global climatic changes and the effects of the human, as shown in Figure 2 and Table 4, [8].

![Figure 2](image_url)

**Figure 2.** It describes a composite process for the period 2001 and 2019, as well as the controlled classification process for the same period.

| No. | Supervised Classification type                                      | 2001     | 2019     |
|-----|--------------------------------------------------------------------|----------|----------|
|     |                                                                    | Area (km²) | Proportion % | Area (km²) | Proportion % |
| 1   | Abandoned land and salines                                        | 30.0     | 23.2     | 31.8     | 24.5     |
| 2   | Buildings                                                          | 14.4     | 11.1     | 23.9     | 18.4     |
| 3   | Gravel land                                                        | 14.0     | 10.8     | 22.9     | 17.6     |
| 4   | High density arable land and permanently irrigated                | 12.9     | 10.0     | 10.4     | 8.1      |
| 5   | Industrial areas                                                   | 1.4      | 1.1      | 2.3      | 1.8      |
| 6   | Low density arable land mixed with fallow land                    | 18.3     | 14.1     | 5.1      | 4.0      |
| 7   | River islands                                                      | 2.0      | 1.6      | 1.6      | 1.2      |
| 8   | Rivers and canals                                                  | 3.9      | 3.0      | 3.5      | 2.7      |
| 9   | Sand plains                                                        | 29.8     | 23.0     | 24.4     | 18.8     |
| 10  | Streets                                                            | 2.8      | 2.2      | 3.6      | 2.8      |
|     | **Total**                                                          | **129.5**| **100**  | **129.5**| **100**  |

Table 4. Land covers areas measured (Km²).
3.4. Methods of measuring albedo

There are three methods of measuring albedo, the first method is using a special device called an electromagnetic spectrophotometer or a reflectivity scale, and this device exactly records the reflection of materials and metals, [2]. The second method is using equations, where equations 1, 2 and 3 (below) can be used to convert DNs in ETM+ Visuals to planetary reflectance or albedo, [14]. Equations 4 and 5 can be used to convert DN values to TOA reflectance, [15]. The third method using the titrations for the ENVI Standardization Program.

The advantage of the last method is that the estimation process can be completed automatically without the need to write the above equations that may result while writing unintended errors, [13]. Basic samples representing the ten landmarks of Fallujah were taken, the coordinates of these points were measured, and simulated with the satellite images of Landsat 7 and 8 and the sensor (ETM +, OLI) to find the wavelengths of reflectance of these features.

3.4.1. The reflectivity values. Reflectivity values can be found using the ENVI calibration program. This method has the ability to automatically complete the estimation process without having to write the above mentioned equations, which may result while writing unintended errors, [9]. Figures 2 and 3 illustrate the process of finding reflectivity using the ENVI program, as shown in Figures 3 and 4, [10] and [11].

![Figure 3. Reflection creation through the ENVI program of (2001).](image1)

![Figure 4. Reflection creation through the ENVI program of (2019).](image2)

3.4.2. Global Positioning System (GPS). The Global Positioning System (GPS) is a satellite based navigation system that was developed by the U.S Department of defense. GPS provides continuous positioning and timing information, GPS consists, nominally, of a constellation of 24 operational satellites. This constellation known as the initial operation capability (IOC). To insure continuous worldwide coverage, GPS satellites are arranged so that four satellites are placed in each of six orbital planes. The observer, which determined this constellation geometry positioning geographic coordinates latitude, longitude and height Universal Time Coordinate (UTC), four to ten GPS satellites will be visible anywhere in the world, if an elevation angle of 10° is considered. Only four satellites simultaneously are needed to receiving signals to
provide the positioning or placing and time information. This techniques will be depending available on all world today for positioning and time accuracy, [12].

The GPS device was used to determine the coordinates of ten selected sites representing the study area and in the form of points, to determine and simulate the spectral signature of Fallujah city features.

3.4.3. Extract Albedo values. For conversion to Radiance of ETM+ Visuals, The following equation is used to convert DNs in a Level 1 product back to radiance units:

\[ L_\lambda = \text{Grescale} \cdot \text{QCAL} + \text{Brescale} \]  

which is also expressed as:

\[ L_\lambda = \left( \frac{\text{LMAX}_{\lambda} - \text{LMIN}_{\lambda}}{\text{QCALMAX} - \text{QCALMIN}} \right) \cdot (\text{QCAL} - \text{QCALMIN}) + \text{LMAX}_{\lambda} \]  

Where,

- \( L_\lambda \) is spectral radiance at the sensor’s aperture in (Watts/(m² * sr * μm))
- Grescale, is rescaled gain (the data product “gain” contained in the Level 1 product header or ancillary data record) in (Watts/(m²*sr*μm))/DN
- Brescale, is rescaled bias (the data product “offset” contained in the Level 1 product header or ancillary data record) (Watts/(m² * sr * μm))/DN
- QCAL, is quantized calibrated pixel value in DN
- LMIN\( \lambda \), is spectral radiance scaled to QCALMIN in (Watts/(m² * sr * μm))
- LMAX\( \lambda \), is spectral radiance scaled to QCALMAX in (Watts/(m²*sr*μm))
- QCALMIN, is minimum quantized calibrated pixel value (corresponding to LMIN\( \lambda \)) in DN = 1 for LPGS products
- QCALMAX, is maximum quantized calibrated pixel value (corresponding to LMAX\( \lambda \)) in D = 255

For relatively clear Landsat scenes, a reduction in between-scene variability can be achieved through a normalization for solar irradiance by converting spectral radiance, as calculated above, to planetary reflectance or albedo. This combined surface and atmospheric reflectance of the Earth is computed with the following formula:

\[ \rho_P = \frac{\pi \cdot L_\lambda \cdot d^2}{\text{ESUN}_\lambda \cdot \cos \theta_s} \]  

\[ L_\lambda = M_L \cdot Q_{\text{cat}} + A_L \]  

Where,

- \( L_\lambda \) is spectral radiance (W/(m² * sr * μm))
- \( M_L \), is radiance multiplicative scaling factor for the band (RADIANCE_MULT_BAND_n from the metadata)
- \( A_L \), is radiance additive scaling factor for the band (RADIANCE_ADD_BAND_n from the metadata)
- \( Q_{\text{cat}} \), is level 1 pixel value in DN

Similar to the conversion to radiance, the 16-bit integer values in the Level 1 product can also be converted to Top of Atmosphere TOA reflectance. The following equation is used to convert Level 1 DN values to TOA reflectance:

\[ \rho_\lambda = M_\rho \cdot Q_{\text{cat}} + A_\rho \]
Where, 
\( \rho_{\lambda} \) is TOA Planetary Spectral Reflectance, without correction for solar angle. (Unitless) 
\( M_{\rho} \) is reflectance multiplicative scaling factor for the band (REFLECTANCEW_MULT_BAND_n from the metadata). 
\( A_{\rho} \) is reflectance additive scaling factor for the band (REFLECTANCE_ ADD_BAND_N from the metadata). 
\( Q_{cal} \), is level 1 pixel value in DN, [15].

4. Results and Discussion
The results of the classification in Table 4 showed that there was a change in the land cover in terms of area with the change in the time of the image taking effect due to seasonal and global climatic changes and the effects of the human.

The reflectivity values were found using the ENVI calibration software, as shown in Table 5 and Figure 5, [13].

Table 5. Albedo values for land covers according to the spectral signature coordinates points selected for the study area features.

| No. | Supervised Classification type | UTM / X-Axis Coordinate | UTM / Y-Axis Coordinate | Long.(\( \lambda \)) Degree Coordinate | Lat. (\( \phi \)) Degree Coordinate | Albedo Value |
|-----|-------------------------------|-------------------------|-------------------------|----------------------------------|----------------------------------|-------------|
| 1   | Buildings                      | 388339                  | 3691966                 | 43.80                            | 33.36                            | 0.19        |
| 2   | Streets                        | 389061                  | 3693821                 | 43.81                            | 33.38                            | 0.20        |
| 3   | Rivers and canals              | 388398                  | 3684529                 | 43.80                            | 33.29                            | 0.16        |
| 4   | Sand plains                    | 384948                  | 3688412                 | 43.76                            | 33.33                            | 0.16        |
| 5   | River islands                  | 386362                  | 3685267                 | 43.78                            | 33.30                            | 0.16        |
| 6   | Low density arable land        | 392771                  | 3686811                 | 43.85                            | 33.32                            | 0.18        |
| 7   | High density arable land       | 384342                  | 3688028                 | 43.76                            | 33.33                            | 0.15        |
| 8   | Gravel land                    | 386853                  | 3695038                 | 43.78                            | 33.39                            | 0.23        |
| 9   | Industrial areas               | 387756                  | 3690624                 | 43.79                            | 33.35                            | 0.20        |
| 10  | Abandoned land and salines     | 392101                  | 3693785                 | 43.84                            | 33.38                            | 0.21        |

Figure 5. Coefficient of albedo diagram for different land uses in the city of Fallujah.
By comparing the results in Table 5, we find a significant increase in buildings (14.4-18.4 km²), Gravel land (14-22.9 km²) and industrial areas (1.4-2.3 km²), while we find that there is a decrease in the area of Abandoned land and salines (30-31.8 km²). High density arable land and permanently irrigated (12.9-10.4 km²), and Low density arable land mixed with fallow land and River islands (18.3-5.1 km²), Rivers and canals (3.9-3.5 km²) and Sand plains (29.8-24.4 km²), while street space remains constant (2.8 km²).

The final results of albedo values were shown as follows (Buildings with a value of 0.19, Streets with a value of 0.20, Rivers and canals with a value of 0.16, Sand plains with a value of 0.16, River islands with a value of 0.16, Low density arable land with a value of 0.18, High density arable land with a value of 0.15, Gravel land and its value. 0.23, Industrial areas with a value of 0.20, Abandoned land and salines, a value of 0.21).

After comparing the results to the albedo values that we obtained with Table 1, which contains The approximated ranges of albedo of natural surfaces, we find that the results appeared almost identical, indicating the accuracy of the method used in this study, [1].

The arid lands are considered one of the hottest ground surfaces in the city of Fallujah during the day, its area is 24.5 km² where the value of albedo is 0.21, they represent the warming factor during the day and vice versa at night. Then the study suggests facing its role in reducing the temperature during the day by paving it with materials that reflect more solar radiation, which reduces its thermal effect during the day, while its palliative role continues during the night, to a greater and more clearer degree. Likewise, the same strategy can be adopted with paved roads, which have a value of the albedo is 0.20, as it occupies a good area of the study area, It is estimated at 3.6 km² as it is the most urban structure that absorbs solar radiation, Which is worth 753 Calories / cm² / day in July, [9].

The streets of Fallujah, which have an area of 3.6 km², while the value of the albedo is 0.20, should be exposed to the sky in a way that allows solar radiation to penetrate during the day as one of the environmental requirements. It allows at night to quickly leak and spread the ground radiation, and thus speed the cooling process. It is possible to overcome the high temperature during the day, which is associated with increasing the parameters of the visibility of the sky, through the implementation of other parallel measures, the most important of which is the spread of green spaces, whose area is currently estimated by 10.4 km², while the albedo is 0.15.

An analytical look at the climatic factors Table, we note that the months (June, July, August) are the highest in temperature and its value is (32.1, 35.4, 34.1) respectively, and the value of solar radiation is (748, 753, 688) respectively, which are inversely proportional to humidity. The relative amounts are (20, 25 and 27) respectively, and it has the lowest rates in these months throughout the year, in which there is no rain at all and its value is zero percent. We must adopt these months as a basic measure to monitor the values of albedo for the main features in the city, as well as monitoring the climate in the city and diligently working to soften the city’s atmosphere by reducing the albedo coefficient to the lowest value (0 to 0.2) by choosing the above proposals to increase green areas (lower and higher) density in the green area, its value from (0.18 to 0.15), and the construction of industrial aquatic spaces and the value of albedo is 0.16 and the choice of reflective materials with colors closest to whiteness, [9].

The high temperature in Fallujah, Which reaches (35.4° C) in July, can be reduced by increasing the albedo of the components of the urban environment through the use of cold materials with a light color and soft texture. With this method, the temperature can be reduced by approximately one and a half degrees for each increase in the albedo rate by 0.01. And the method of increasing the whiteness can be applied to the roofs of buildings without its sides to reduce the cost by a very large percentage.

5. Conclusion
The study used a method that combines remote sensing and geographic information systems to examine the effect of albedo on the climate of Fallujah. The results of albedo values obtained almost identical with the approximated ranges of albedo of natural surfaces indicating the accuracy of the method used in this study. The study area was classified into ten categories: Buildings, Streets, Rivers, Sand plains, River islands, Low density arable land, High density arable land, Gravel land, Industrial areas and Abandoned land and salines.
Albedo tests the total surface reflectance, offering plenty of useful details on the soil environment and a deeper understanding of the balance of soil resources. Yet usually different sunlight wavelengths are not reflected equally, resulting in a variable surface color and variations in the absorption of certain wavelengths due to changes in the soil surface's physical or chemical characteristics.

By increasing the albedo of the components of the urban environment the high temperature in Fallujah can be reduced, through the Afforestation methods should be applied to the roofs of buildings, before the facades, because the roofs are exposed to sunlight almost all day long, so their role in lowering the temperature is greater. The expansion of parks and gardens is considered one of the most important strategies for a moderate urban climate. As these green spaces in the city are not sufficient, so they must be afforested as much as possible in order to contribute effectively to reduce the intensity of temperatures.

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