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ANALYSIS THE POTENTIAL OF VEGETATION INDICES (NDVI) FOR LAND USE / COVER CLASSIFRICATION IN KARACHI BY LANDSAT 8 DATA

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ABSTRACT

Vegetation is a crucial and essential element of an ecosystem. The urban ecosystem can also not be completed without the presences of urban flora. Assessment of urban vegetation and its classification is a difficult task with the traditional method. Several techniques have been used for vegetation and environmental assessment nowadays, including remote sensing. The Normalized Difference Vegetation Index (NDVI) is well-known techniques in remote sensing which is used to classify and quantifying vegetation. The main objective of this paper is the classification of urban vegetation with the help of NDVI Index using Remote Sensing and Geographical Information System for Karachi and its neighbourhood. In this study we used Landsat 8 satellite images for monitoring and assessing vegetation. We classified vegetation types and land categories including cropping, farming, orchard, urban parks, playgrounds, built-up areas and transportation corridors.

Key-words: NDVI, Karachi vegetation, Vegetation classification, remote sensing of vegetation

INTRODUCTION

The biosphere is a composition of fauna and flora on the earth surface. It is associated and functional due to the presence of lithospheric soil, hydrospheric water, and atmospheric climatic conditions. These elements serve to keep the life ongoing on this planet. Soil and vegetation serve numerous critical functions in the environment, at all possible spatial scales. These are the main component of the ecosystem. They contribute to regulating many cycles such as bio-geochemical, water, carbon and nitrogen cycles. As we know the vegetation converts sun energy into the primary production. The biomass as a result act base of the food chain for any living organism. Many classifications of the regions for vegetation and biodiversity have developed by the bio-scientist such as biomes. These regions have specific plants, soil, and climatic conditions. They can also classify into grassland, forest, rangeland vegetation and cropping.

Vegetation mapping based on remote sensing:

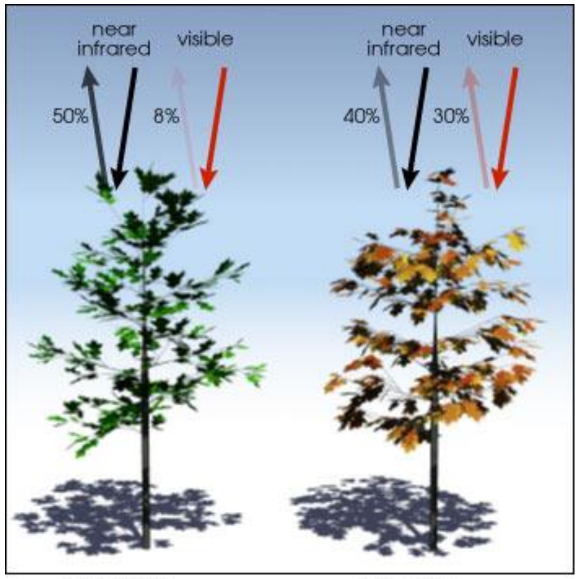
Remote sensing technology has been functional for analysis of vegetation cover. This technology has many advantages. It has repetitive and extensive area coverage that is useful for agriculture, forestry, urban and rural environmental management and ecology. The scientist has developed several band combinations and algorithms for vegetation assessment. Several allied factors and characteristics like soil and soil moisture, drainage pattern and environmental factors can also examine and monitor with vegetation assessment. Vegetation threshold values can be used for classification from fallow land, sparse to dense vegetation and forest types. The prime advantage of the satellite remote sensing system is to monitor the earth resources and processes regularly. As sensitive ecological indicator vegetation influencing climate, energy balance, hydrology and biogeochemical cycle.

There are many vegetation indices and measures are available for vegetation assessment through remotely mounted sensors. The normalised difference vegetation index (NDVI) is one of them. This has been extensively used to map spatial and temporal variations of almost all vegetation types. Figure 1 illustrates the use of a spectral vegetation index (NDVI) for differentiating the level of chlorophyll in different kinds of plant.

NDVI appraisal by Landsat data

With the availability of satellite images, many regional and global studies on vegetation mapping have become possible. NASA's multiple satellite programs are providing continuous digital data for regular monitoring of vegetation cover and other earth resources on different spatial resolutions such as NOAA, Terra/Aqua and Landsat. Out of these programs, the Landsat system constitutes the longest record of global-scale medium spatial resolution earth observation data (Tatem *et al.,* 2008). Landsat program revolutionised the moderate-resolution Earth remote sensing in the 1970s. With eight successful missions over 50 years, Landsat has documented and recorded the digital earth on a continuous interval (Roy *et al.*, 2014; Wulder *et al.*, 2016). The Landsat missions and sensors have developed with the technology from a demonstration project with visual interpretation to an advanced operational mission. It grew with the incremental improvements along the way in terms of spectral, spatial, radiometric, and geometric performance as well as a data acquisition strategy, availability, and products (Table 1).

The NDVI is a normalised ratio of the NIR and red spectral bands. There are many applications for using NDVI such as climate change, agricultural production, desertification, forest fire assessment, land cover change detection, vegetation assessment and vegetation health monitoring (Jeevalakshmi *et al*., 2016; Shao *et al*., 2016; Kong *et al*., 2016).



$$\frac{(0.50 - 0.08)}{(0.50 + 0.08)} = 0.72 \qquad \frac{(0.4 - 0.30)}{(0.4 + 0.30)} = 0.14$$

Fig. 1. NDVI (source NASA earth observatory).

In this study, several questions are conversing, like how satellite remote sensing is useful in the assessment of vegetation, how the variation of NDVI shows the variety of vegetation and plants and how remote sensing is beneficial for required scale vegetation monitoring, its classification and spatial resolution. The objectives of this research included i) examining the spatial patterns of vegetation, ii) classifying the vegetation with NDVI values and iii) Observing the zonal area of each vegetation cover.

Table 1. Landsat 8 OLI Spectral Characteristics.

Spectral Band	Wavelength	Resolution
Band 1 - Coastal / Aerosol	0.433 – 0.453 µm	30 m
Band 2 - Blue	0.450 – 0.515 µm	30 m
Band 3 - Green	0.525 – 0.600 µm	30 m
Band 4 - Red	0.630 – 0.680 µm	30 m
Band 5 - Near Infrared	0.845 – 0.885 µm	30 m
Band 6 - Short Wavelength Infrared	1.560 – 1.660 µm	30 m
Band 7 - Short Wavelength Infrared	2.100 – 2.300 µm	30 m
Band 8 - Panchromatic	0.500 – 0.680 µm	15 m
Band 9 - Cirrus	1.360 – 1.390 µm	30 m

MATERIALS AND METHODS

Study Area

The administrative Karachi Division is the study area. It is a coastal arid region lies as the southern part of Sindh Province (Fig. 2). The climate of the region is sub-tropical, which is characterized by hot summer and mild-winter and overall moderate climate. The average annual rainfall of the region is around 250 mm with very scarce water resources (Khan *et al*., 2018). Karachi, a city of more than 20 million population, is considered as the backbone of Pakistan's economy. It imports a major proportion of water for domestic usage from the Indus River (Irfan *et al*., 2018). However, the northern part of the study area (Gadap plain) is irrigated with groundwater and practice agriculture on a sustainable basis (Arsalan *et al*., 2006). It is true that water is the main ingredient of healthy vegetation cover, that is why the natural drainage of the local rivers are the agrarian related activities including agriculture and farming.

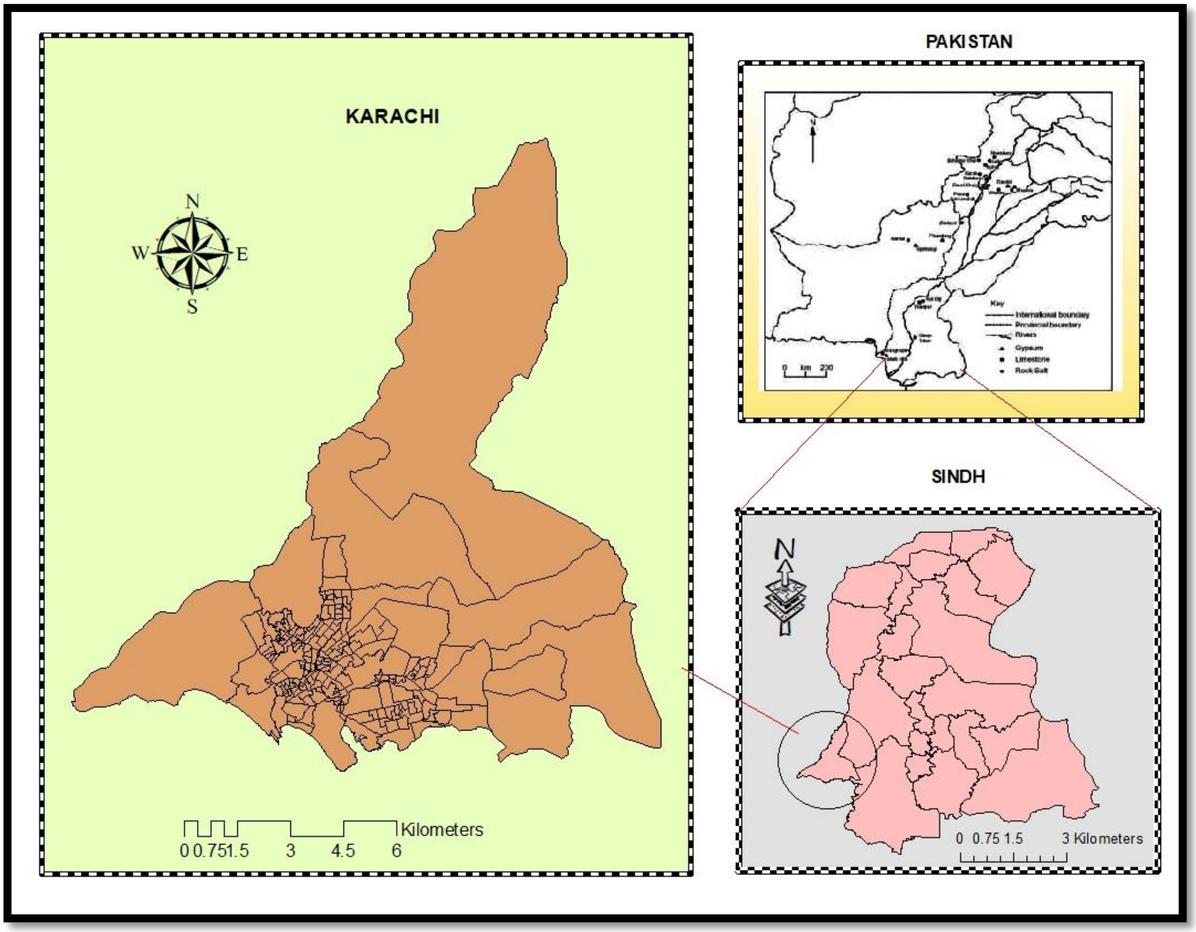


Fig. 2. Karachi administrative towns.

Vegetation assessment by NDVI through Landsat-8 Data and ArcGIS:

Landsat-8 satellite (Dec, 2019) data sets were obtained from the USGS website and further research proceeded on ArcGIS. NDVI and unsupervised classification were operated on ArcGIS after that compare each other. In order to find out the best repercussion of both techniques. NDVI is essentially operating on the basis of red and infrared bands combination. In Landsat 8 bands 4 and 5 are red and infrared bands so by the help of these combinations, NDVI is obtained (NDVI is used for identification of vegetation on the region of interest. By the help of bands combination, NDVI is performed on the satellite image. NDVI is calculated with the following equation.

NDVI= NIR-RED/ NIR+RED…… (eq. 1)

Where: RED is visible reflectance of the red band of the electromagnetic spectrum (600-700 nm), NIR is near-infrared reflectance of the electromagnetic spectrum (750-1300 nm) The NDVI is absorbed by the reflection of vegetation, which is the difference between the NIR and red band (Carlson *et al.*, 1994, Candiago *et al.*, 2015; Birtwistle *et al.,* 2016).

Radiometric Correction: DN conversion to reflectance with OLI Landsat data

Before putting these bands into equation, another process is required that is the radiometric correction. The radiometric correction is necessary as two different Landsat Images (with different path and rows) are being used and all are with different sun angles, so for bridging the gaps in data this process is needed. The radiometric correction has been done with the following steps (Table 2).

Table 2. Methodological steps.

1	Acquiring Images	USGS: https://earthexplorer.usgs.gov/
2	DN to Reflectance	Level-1 (uncorrected DN product) to convert the DN values to TOA Radiance or Reflectance. (https://www.usgs.gov/land-resources/nli/landsat/landsat-8-data-users-handbook) λ' = M ρQcal + A ρ ρλ' = TOA planetary reflectance, without correction for solar angle. Note that ρλ' does not contain a correction for the sun angle. M ρ = Band-specific multiplicative rescaling factor from the metadata (Reflectance_Mult_Band_x, where x is the band number) A ρ = Band-specific additive rescaling factor from the metadata (Reflectance_Add_Band_x, where x is the band number) Q cal = Quantized and calibrated standard product pixel values (DN).
3	Sun Elevation Angle	ρλ = ρλ '/cosθSZ = ρλ '/sin θSE ρλ = TOA planetary reflectance θSE = Local sun elevation angle. The scene center sun elevation angle in degrees is provided in the metadata (Sun Elevation). θSZ = Local solar zenith angle; θSZ = 90° – θSE. MR *BAND 4 + ADR / Sin(Sun elevation angle)
4	Reflectance Equation: Raster calculator(Using ArcGIS 10.3)	For example 2.0000E-05 * band 4 + -0.100000 / sin 68.68920046 2.0000E-05 * band 5 + -0.100000 / sin 68.68920046
5	NDVI	NDVI=(NIR-RED)/ =(NIR+RED) * NIR = (Band 5), RED = (Band 4)
6	NDVI threshold	NDVI Index/ Pixel Value -0.13, -0.11, 0.05, 0.07,0.11,0.15,0.19,0.17,0.32,0.37,>0.44,
7	Urban Classification	Land classification/ Tabulate areas

NDVI values + 1 represent that vegetation is available similarly the class closer to -1 illustrate that no vegetation cover. It may be a water body or bare soil area. Subsequently for second dataset all multispectral bands of Landsat 8 associated with the region of interest are merged by using mosaicking tool on ArcGIS. Later, with the help of **Iso cluster unsupervised classification** tool, image classification was performed on the mosaicked image.

The results were categorized into 11 unsupervised clusters. Each category shows its relevant region. The categories were labelled according to the visual interpretation of the region and ground knowledge. GoogleEarth was also used for land use/land cover result interpretation, as it provides a very high-resolution visual picture of the ground. Finally, two outcomes were prepared for further analysis and presentation viz. i) vegetation index, and ii.) Land use /land cover (Fig. 3 and 4).

RESULTS AND DISCUSSION

Figure 3 demonstrates eleven categories of different land use/ land cover. These categories are interpreted as Turbid Water, Clear Water, Built-up Land, Open Space (rural), Open Space (urban), Fallow Land (not used to raise a crop), Sparse Vegetation, Natural Vegetation, Orchards (plantation farming) and Parks, Crop Land (Mixed, Ready Crop/ Healthy Vegetation) and Mangroves in marshy and coastal belts.

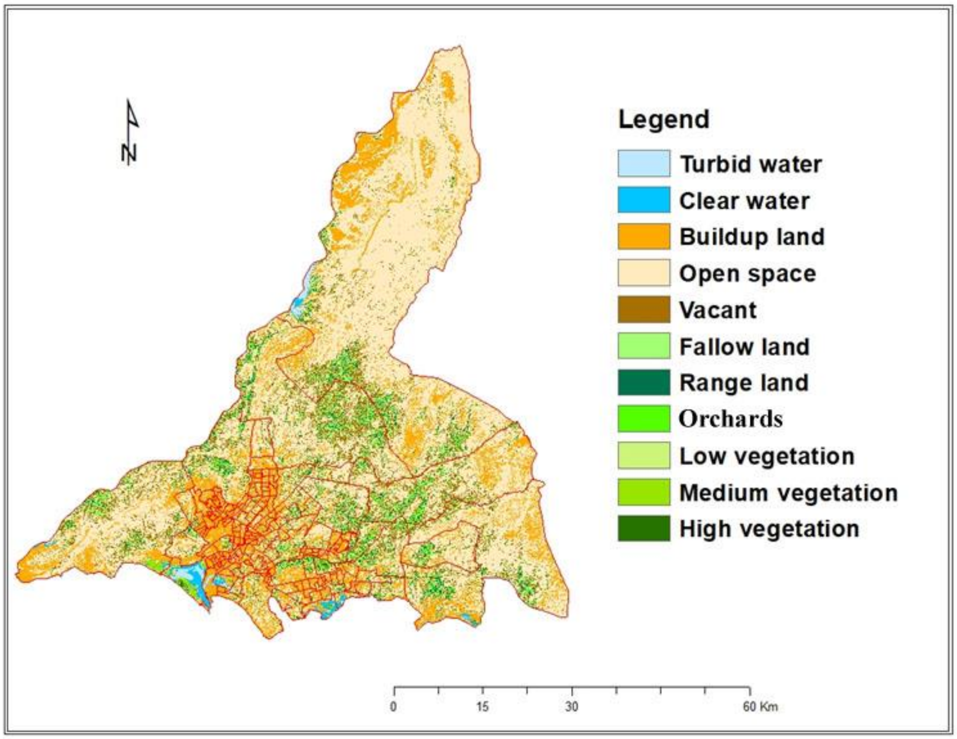


Fig. 3. Classification of land cover and land use by NDVI.

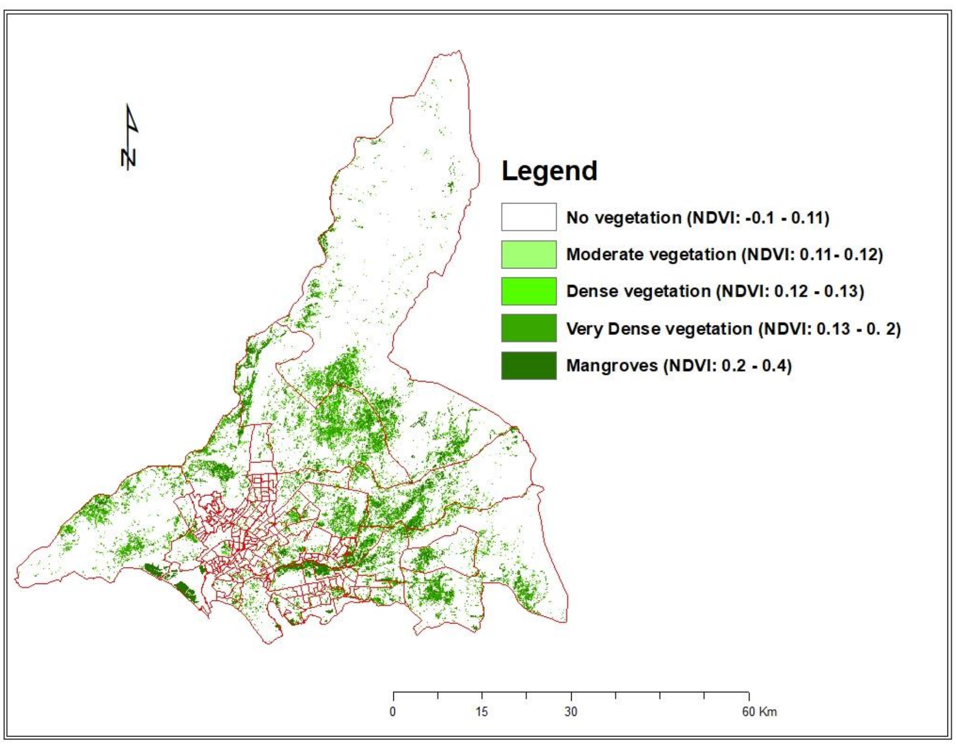


Fig. 4. Spatial variation of vegetation in Karachi.

Figure 4 provides the five clusters of vegetation cover according to the density, type and health of plants. These categories are identified as Very Low / No Vegetation (NDVI: 0.1 - -0.11), Moderate Vegetation (NDVI: 0.11 –

0.12), Dense Vegetation (NDVI: 0.12 – 0.13), Very Dense Vegetation (NDVI: 0.13 – 0.21) and Mangroves (NDVI: 0.2 – 0.4).

The boxplot of NDVI data shows that the maximum portion of the study area lies between moderate to very low vegetation cover (Fig. 5). The median value (0.01) is part of very low/no vegetation. There is a small proportion coved in Mangroves and very dense vegetation areas.

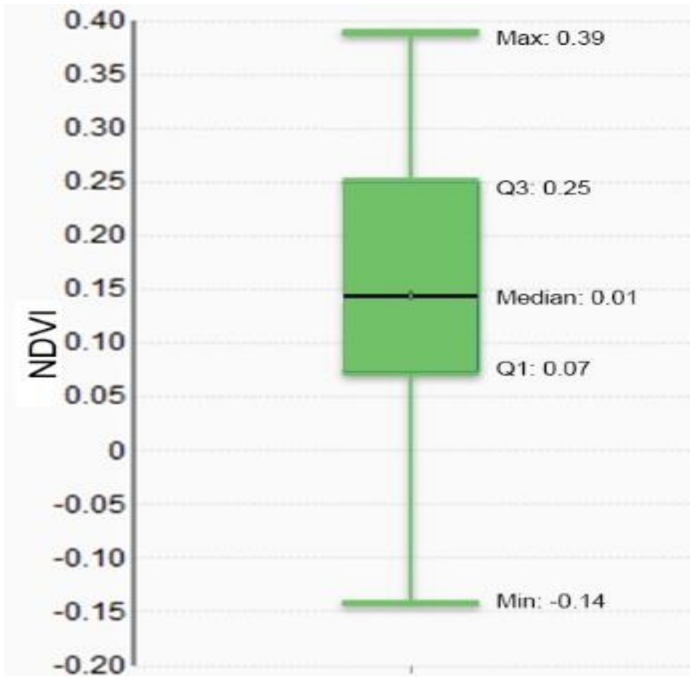


Fig. 5. Box plot by NDVI.

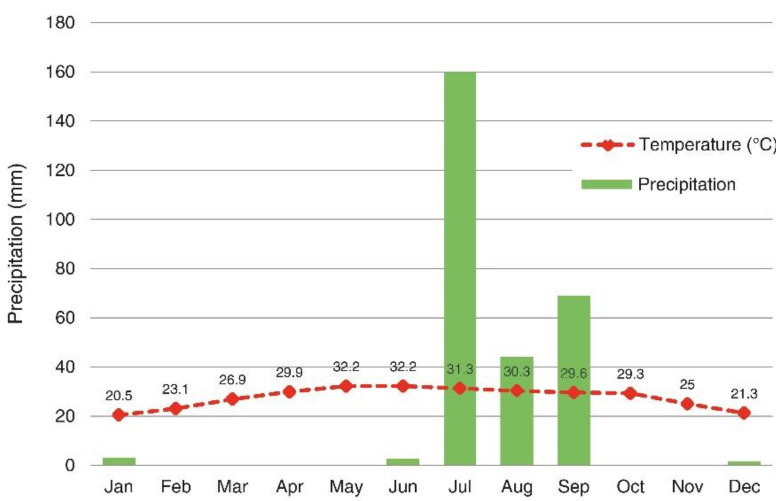


Fig. 6. Average monthly temperature and precipitation of Karachi (Source: Shaikh *et al*., 2014).

The study area is spread over around 3633 km^2 and generally with low and sparse vegetation. Out of that almost 5 % is under some kind of green space from Mangroves to Moderate Vegetation. The major part of the study area attributed to very low or no vegetation zone. It is mainly due to its climatic conditions. Karachi region receives very low precipitation (around 250mm annual average). Most of the rainfall occurs during monsoonal season from July to September (Fig. 6). The annual distribution of rainfall however, indicates that the pattern is highly inconsistent from total drought to 470mm (Fig. 7). As a result, the natural growth of vegetation follows the pattern of rainfall and shows similar inconsistent erratic patterns. In some years after monsoon vegetation cover increases more than 50% of the total area. However, on an average it remains very low as up to 5% of the total study area.

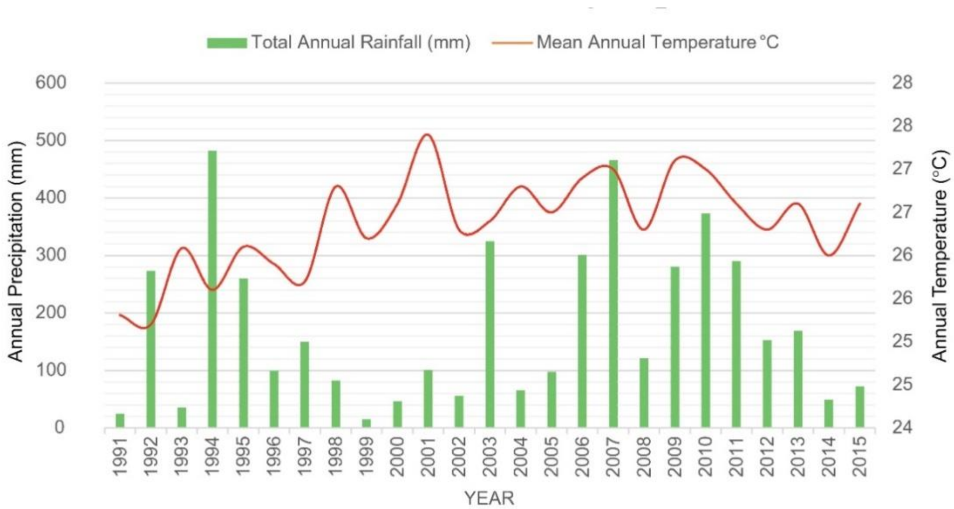


Fig. 7. Average temperature and precipitation of Karachi (Source: Irfan *et al*., 2018).

Table 3 shows the distribution of land use/landcover of the study area. Out of 3633 km^2 only 186 km^2 is covered under some type of vegetated land. Most of the region is open space with no vegetation. In urban open spaces mainly developed or partly constructed areas are included. These areas however, are not completed built-up. On the other side rural open spaces are vast barani (rainy) areas mostly comprises rocky outcrop and bare soil patches. However, fallow land is open but with some remnants of vegetation due to regular cultivation or grazing land.

Utilizing remote sensing NDVI could be convenient, as it can detect and identify surface features. This ability can be beneficial in city planning, its management and environmental assessment. The NDVI based vegetation analysis can be used further in disaster, drought and flooding. New construction and unplanned activities in cities, make them as urban heat island. New plants and vegetation expansions can reduce this phenomenon. Once vegetation pattern can identify and classification of land use, landcover and vegetation type have been done, change detection in vegetation type and other landscapes would be helpful to gain understanding into the adapting mechanism of the fragile ecosystems especially in arid areas to changing environmental conditions.

Table 3. Land cover and Vegetation classification.

Classes/ NDVI Thresholds	Land Cover / Vegetation Type	Features	NDVI Index/ Pixel Value	Area (km^2)	Area Percentages	Total Vegetation Area
1		Turbid Water	-0.13	19.07	0.50	3448 km^2 95 % total area
2		Clear Water	-0.11	33.66	0.89	
3		Built Up Land	0.05	713.30	18.87	
4		Open Space	0.07	2024.87	53.57	
5		Vacant Area (Urban)	0.11	409.82	10.84	
6		Fallow Land	0.15	246.94	6.53	
7	Very Low	Sparse Vegetation	0.19	98.38	2.60	186. km^2 5 % of the total area
8	Low	Natural Vegetation	0.17	45.08	1.19	
9	Medium	Orchards and Parks	0.32	21.47	0.57	
10	High	Crop Land (Mixed)	0.37	16.14	0.43	
11	Very High	Ready Crop/ Healthy Vegetation/ Mangroves Forest	>0.44	4.94	0.13	
			Total Area	3633.67	100.00	

CONCLUSION

This study shows that the remote sensing provides strong tools for assessing vegetation and vegetation-based land use /land cover classification. The study fully utilized the strength of remote sensing and image processing for assessing the NDVI and unsupervised classification. This study presents the methodology for quantification of vegetation cover areas and their by-product in form of land use / land cover maps of the study area. It is assessed that the 5% of the total study area (3633 km^2) is vegetated. The climate of Karachi does not support the dense vegetation in and around the city. Therefore, very minor proportion is under dense vegetation cover or mangroves (0.13%). The study however, depicts the scarcity of vegetation especially within urban built-up areas. For better urban ecosystem urban plantation and green areas development for the study area is direly needed.

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