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Research Article

Evaluating Spatial Patterns of Urban Green Spaces in Karachi, Pakistan through Satellite Remote Sensing Techniques

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Abstract: Urban ecology is a field of multiple disciplines and its practical applications has been rapidly growing. Changes in vegetation pattern and shift also defines climatic conditions of an area along with the urbanization. This research article deals with the temporal analysis of identification and classification of urban green spaces in Karachi for year 2000 and 2016. Supervised classification and Normalized Difference Vegetation Index (NDVI) was applied to access identification and discrimination of increased urban area and elimination of green areas from Karachi. Data was acquired from LANDSAT satellite image data, analysis of vegetation cover was accessed by Normalized Difference Vegetation Index (NDVI) by using ArcGIS 10.1 and ERDAS 2014 software. From analysis it has been observed that in previous sixteen years of research vegetation has increased but shifted from urban centers or city centers to suburbs of city. Area of vegetation shift is 4%, Barren land has been reduced to 14% and Build up has been increased to 3% over 16 years in Karachi.

Keywords: Urban Green Spaces, Normalized Difference Vegetation Index, Satellite Remote Sensing and Urban Ecology.

1. INTRODUCTION

Techniques of Satellite Remote Sensing (SRS) are adequately used in monitoring and evaluating urban green spaces. Spatial and temporal monitoring is effectively useful in monitoring and mapping changes of an area. Urban green spaces have note worthiness and pros in our daily life. However, these breathing spaces of relief, peace and amusement are being ignored and under rate due to urban development. Extensive augmentation of urban areas is frequently changing local climate and detreating environment, fast growing urbanization has caused plenty of environmental impacts connected with loss of green spaces [1]. After developing urban areas greenery has been eliminated. Therefore, it is significant to conserve green are as that will ultimately protect biodiversity. Major cities are experiencing bad air quality, traffic noise and congestion and rise in temperature that has turned cities into heat is land, this effect in known as Urban Heat Island (UHI) [2].

Green areas have probable prospective to mitigate the unfavorable effects of urbanization in a sustainable way that includes reduction of air and noise pollution, cooling effect for UHI, fresh air supply and CO_2 manager hence they are helpful in making cities alluring and attractive to live [3]. Urban Green Spaces (UGS) contributes to sustainable development of urban ecosystem thus researchers are presenting theories and models by using SRS. The ability of mapping these environmental challenges SRS has shown utility for informing the state of pressures on biodiversity at landscape, ecosystems, continental and global spatial scales [3]. Mc Phearson, et al., (2016) has explained that urbanization is also associated with new species habitat introduced by ecosystem these species have higher proportion in urban areas than rural areas, because urban ecology is a man induced disturbance which initiates the colonization of new habitat. The global urban population is increasing day by day and will reach to certain limit in few decades. Resultantly, cities are expanding particularly in developing countries. Urbanization has changed the landscape within

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and around the city. Other than benefits have been bought to society from economic perspective or development, Urbanization has also caused serious negative ecological issues that includes Urban Heat Island (UHI), Pollution (air and water), vegetation loss due to infrastructures and loss of habitat of several species [4]. Many researchers have related that to maintain urban sustainability is the most challenging task because of cities rapid growth, in recent past years' urban ecology has been examined and contrast are being mapped to get results and future recommendation are narrated. A landscape ecology perspective integrates elements of sustainability they view human as "ecosystem engineer" they are prior for developing urban sustainability [5]. This study reveals the spatial difference of urban green spaces in Karachi city by comparing year 2000 with year 2016. Chaudhry et al., (2015) explained temporal studies reveal the elimination of greenness and their replacement with buildings or making them part of urban area. Similarly, Karachi has been drastically changed its ecology and growth pattern from year 2000 to year 2016. These ecological disturbances react to produce new disasters of climate change like heat wave or heat stroke and urban heat island. Impacts of heat waves are not only driving human morbidity and mortality but also causing stress in animals, crops, vegetation and infrastructures [6]. Karachi city follows complex land use due to excessive population that is day by day increasing further more in future. Due to population excess amount of greenery has been fell from city center and buildings are replacing them. Therefore, urban dwellers should focus cons of green areas removal. On the other side Karachi city has created ecological problems that include ecological consequences, urban green space shrinkage, and urbanization expansion in last 16 years of development. Problems due to climate change has emerged globally in past decades [7]. Green spaces are unevenly distributed in to build up areas and are not preserved as ecological frames [8].

Mahboob et al., (2015) has narrated about identification and classification of urbangreen spaces becomes easier and technically perfect after using SRS and GIS techniques. Remote sensing is profitable and technically used for analyzing variables in urban development spatially and temporally. Statistical techniques along with vast applications of GIS and RS urban development can be easily mapped and graphed to show the trend line [9]. Rafiee et al., (2009) described classification is the easiest way to compare and identify variable, as in this study green areas has been classified from LANDSAT 5 TM and LANDSAT 8 OLI and then discriminations, analysis and results have been made. Satellite remote sensing (SRS) provides an important expert source of data about land cover and land use, this data can be used for monitoring classification and identification of changes in green areas in past sixteen years [10].

2. MATERIALS AND METHODS

2.1. Study Area

Karachi is located in Sindh on the beautiful coast of Arabian Sea, the map for study area is shown in Fig. 1. Geography of this city is amalgamated with rocky hills, coast, marshy lands, mangroves, rivers, coastal plains and large Kirthar range. Its geographical coordinates are 24°45′ N to25°37′ N and 66°42′ E to 67°34′ E with total area of 3,600 km^2. City is populated with 16 million people comprising of 18 administrative towns and 178 union councils almost 95% of population lives in urban center [2]. It has its own noteworthy and idiosyncratic values. Karachi as a megacity, has modified economic values of not only Sindh rather all of the Pakistan [12]. Karachi being Pakistan's largest business city and trading capital produces almost 60% of the total Pakistan's revenue. It is the major patron and correspondent of various greenhouse gases like CO_2 in the atmosphere that produces imbalance uncontrolled climate change [13, 11].

2.2. Data Analysis

World's population is increasing and accelerating urban development that leads to environmental habitat loss, degradation, climate change and transition in biodiversity. In order to analyze and understand dynamic phenomena of removal or changes in UGS from urban center different steps were taken down before the analysis. After the data collection (LANDSAT 30 m) image pre-processing for image extraction and rectification was done on both images of LAND SAT5 (TM) for year 2000 and LANDSAT8 OLI (TIRS) for year

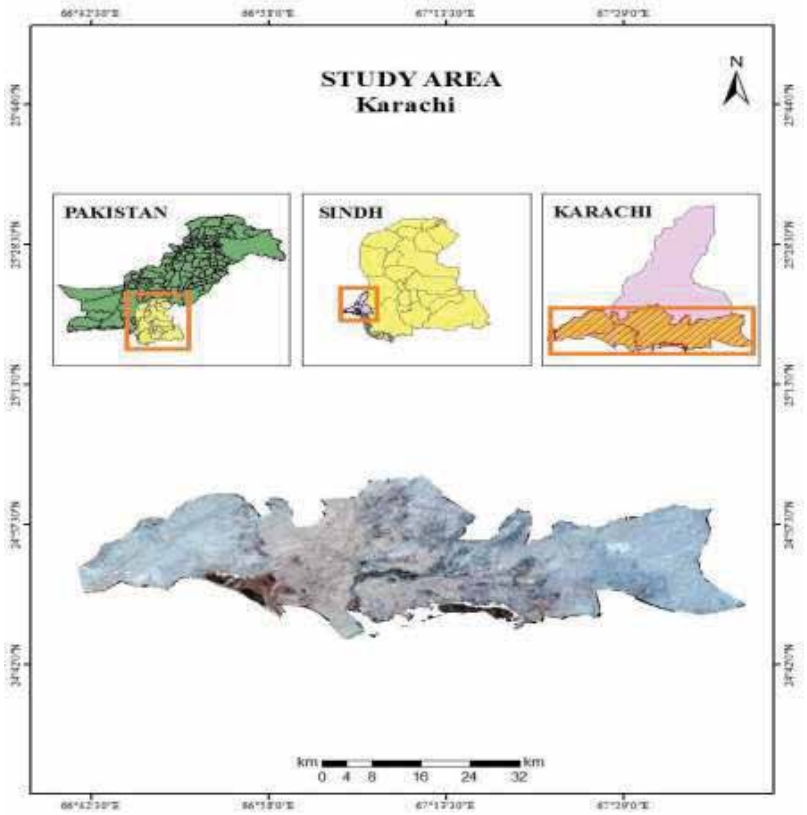

Fig. 1. Map showing Study Area of Karachi, Sindh, Pakistan)

2016. ERDAS 2014 and ArcGIS10.3 were used for data processing, data analysis, data comparisons and generation of thematic map layouts. After the process of image processing, image data has been stacked by Image Stacking, High Resolution Merge was applied on images for vivid visualization. Both images were further studied and undergoes with analysis of Supervised Classification (maximum likelihood) were performed and major classes urban green spaces, urban areas, mangroves, agricultural lands, waterbodies and barren land were created with ERDAS 2014. For the justification of objective vegetation index (NDVI) for calculating vegetation cover was also analyzed for both images, these steps are best analyzed under the techniques of GIS environment. Finally, results were defined and discussions were made, and final thematic layers inform of map layouts were exported by using ArcGIS 10.1.

3. RESULTS AND DISCUSSION

3.1. UGS Supervised Classification (year 2000)

In supervised classification, numerical discriminators are made up of those data sets already assigned as a class and have their own identity to get easily identify with larger cover on land. This should have training sites or representative areas in image before allocating classes of image [14].

For the analysis of Urban Green Spaces (UGS) first of all training sites were identified for pixels inside and outside the training areas. These training sites are evaluated and assigned to the similar class of maximum likelihood member. After selection of training sites, spectral class was assigned to similar pixels as maximum likelihood and several algorithms includes Minimum distance to mean classification, Gaussian Max likelihood method and parallelepiped classification were applied. The main purpose of classifying image data is to separately identify each class, which includes major classes of UGS and urban center whereas minor classes includes mangroves, agricultural land, barren land, waterbodies.

Results as also shown in Fig. 2 elaborates that most of green spaces area round agricultural lands of Malir River, some of them are spaced within urban areas and few of them are found in north barren areas of Karachi while dark green areas are

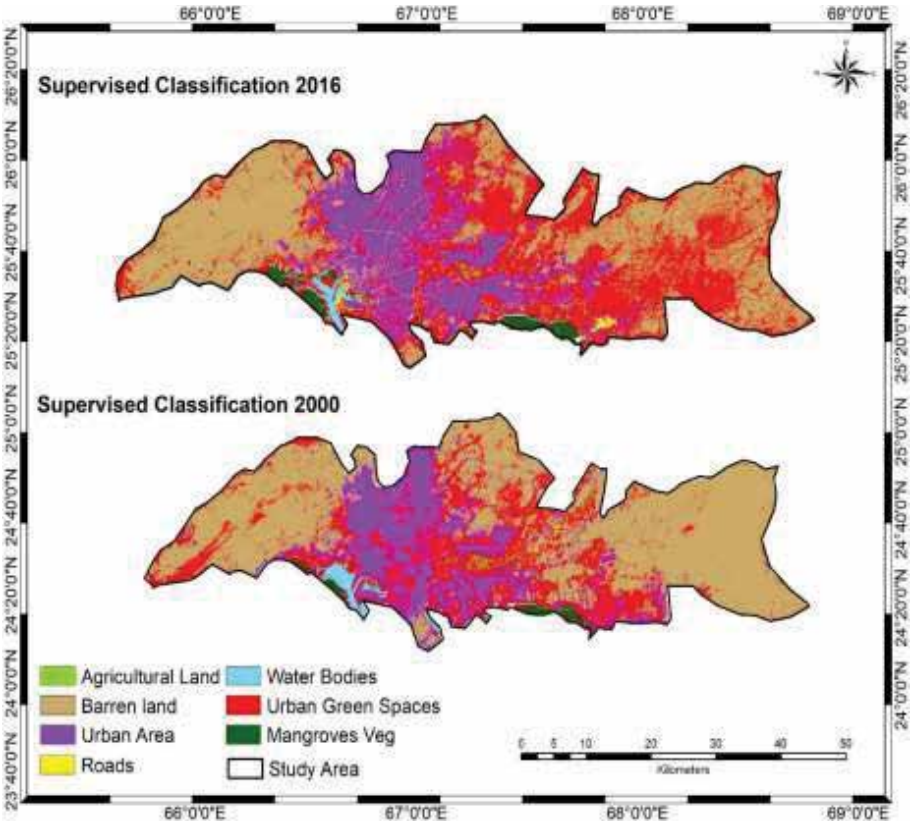

Fig. 2. Map showing Supervised Classification of Urban Green Spaces in Karachi for year 2000 & 2016

of mangroves located in South along sea side.

3.2. UGS Supervised Classification (year 2016)

Temporal analysis discriminates changes over period, supervised classification on this image shows changes in major classes UGS and urban center. Both classes have increased their values from year 2000 to 2016 as shown in Fig. 2. Urban areas are expanded towards northern and eastern as well as western sides of urban center. Maximum urban development has raised value of Population density in Karachi therefore, ultimate results shows the removal of green areas from main urban center. Comparative results clearly elaborate the shift of green spaces towards barren areas in north and north eastern sides of Karachi. Greenery in Karachi has been increased but drastically removed from urban areas due to building and city development phenomena. In Table. 1 calculated area for both years shows the differences in values while the graphical representation of area for year 2000 and 2016 is shown in Fig. 2. Calculations shows that the Build-up area has been increased from 330.49 Sq km to 349.13 Sq km which is 3%, Barren Land has decreased its value from 1016.59 Sq km to 760.03 Sq km which is 14% and vegetation has been increased 4% from 43.73 Sq km to 48.23 Sq km. Findings of this analysis shows that vegetation presently are taking over barren areas of Karachi but main centers of Karachi is now diminishing greenery or breathing spaces. Therefore, urban dwellers or urban developer's needs to focus removal of greenery from main city center as those areas are already enriched with pollution. For the reduction of pollution and safe environment green spaces are always recommended.

In Fig.5 comparison of year 2000 and 2016 describes that vegetation in year 2000 was found in main urban city whereas shifted to north eastern of Karachi in year 2016. The zones referred as Zone 1 (Z1) and Zone 2 (Z2) in Fig.4. explains how changes were identified and classified with supervised classification. As shown from analysis it has been analyzed that UGS from Z1 in year 2000 is enriched and after sixteen years it has been removed due to urban areas development as shown in Z1 of year 2016. On the other side, analysis also proves that in Z2 of year 2000 barren land has very

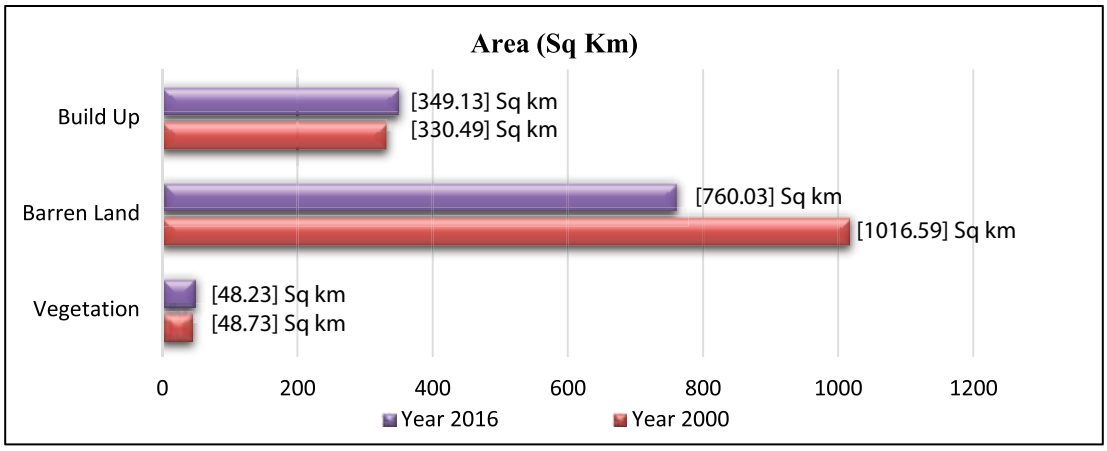

Fig. 3. Chart showing Area in Sq Km (Build-up, Barren Land and Vegetation) for year 2000 and 2016

Table 1. Area in Sq Km (Build-up, Barren Land & Vegetation) Year 2000 and 2016

Class	Area (Sq Km) Year 2000	Area (Sq Km) 2 Year 2016
Build-Up	330.49	349.13
Barren Land	1016.59	760.03
Vegetation	43.73	48.23

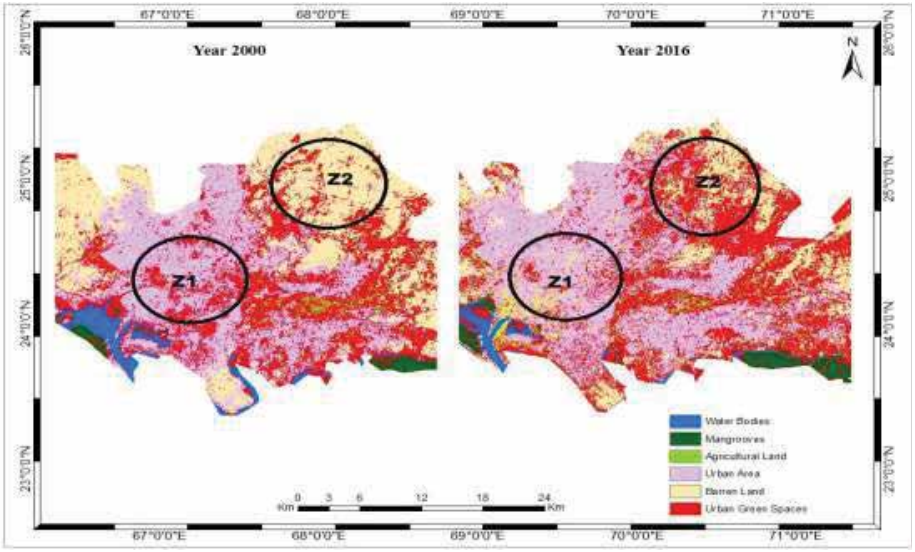

Fig. 4. Map showing Supervised Classification of Urban Green Spaces in Karachi for year 2000 and 2016

less vegetation whereas in year 2016 the ultimate shift of vegetation has been revealed as clearly shown in Z2 of year 2016 in Fig. 4.

3.3. Normalized Difference Vegetation Index (NDVI)

NDVI green plants absorb solar radiation (UV-Rays) for photosynthesis from spectral region and it is calculated from the visible (VIS) and near infrared (NIR) reflected by vegetation [15]. It is calculated from individual measurements as shown in equation (Eq. 1)

$$NDVI=(NIR–Red)/ (NIR+Red) \quad \text{Eq. 1}$$

Badamasi M.M et al., (2010) has calculated that anthropogenic activities are highly affecting ecosystems and great stress is on vegetation, globally. Disturbing vegetation cover is not only disturbing land cover pattern but also it comes with the shortage of food and agricultural facilities of a country. Monitoring of vegetation cover, to maintain and sustaining for healthy life should be supreme. Vegetation cover, greenery or open spaces are the playing chief role in maintaining ecosystems of the Earth. Remote Sensing has made things easier for the detection and monitoring of vegetation on larger scales. With the passage of time, land covers are changing some of them are naturally and mostly are due to the development of human power and transforming open places into populated areas. NDVI is one of the important key factor to calculate the presence of vegetation in a particular area of interest, NDVI has many applications and is most used indices among all and mostly used for vegetation cover monitoring, moisture detection in crops and also crops stress. Values of NDVI ranges from -1 to +1, that ranges for different scales and levels of vegetation and their classes [16].

Less green leaves give values close to zero (0), Values close to (+1) indicates dense green vegetation and Values (-1) show up with no vegetation or very less vegetation. In Table. 2 years 2000 was analyzed with -0.368 to -0.1220 for vegetation while same table shows the discrimination in value from (-0.1165 to -0.0172) in Karachi for vegetation in year 2016. Fig. 5. of NDVI discriminates two important points that has to be noted one that dead vegetation or no vegetation has lowered down its value from (-0.1220 to 0.0172) as figured in Table. 2 and shown in Fig. 5. But vegetative portions in Karachi has been grown up with its value because of the green spaces or greenery shift in barren areas, these values are from (0.0444 to 0.0982). Pastures and crop lands have raised their values in Karachi as compared to before as they were identified in barren areas or suburban areas of city. This analysis helps to show that greenery from urban area Karachi has been shifted towards suburbs and barren areas.

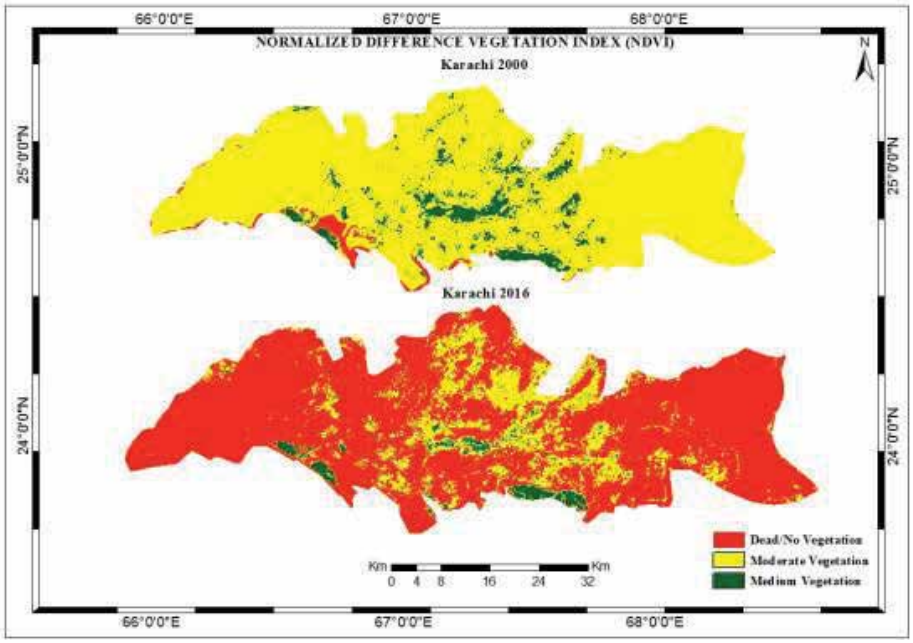

Fig. 5. Normalized Difference Vegetation Index (NDVI) Year 2000 and 2016

Table 2. Normalized Difference Vegetation Index (NDVI) Year 2000 and 2016

Land Cover type	Year 2000	Year 2016
Water/ No Vegetation	-0.3684 –-0.1220	-0.1165 –-0.0172
BarrenRock/Sand	-0.1220 – 0.0444	0.0172–0.0982
Pastures/Crop land	0.0444– 0.4806	0.0982–0.3638

4. CONCLUSION

Main achievement of this study was to analyze and calculate how much greenery has been lost and shifted towards barren areas of Karachi in comparison of these 16 years. It has been observed from the study that Karachi is more vulnerable to the environmental changes due to the greenery decrease. Findings of this contrast and comparative study reveals that Karachi is a megalopolis city with immense population that requires development. Urban development is a major concern that is not only effecting greenery of city but also disturbing ecological cycle for several species of city. On the other side, urban development intrusion has also put ecological disturbance, the temperature of the city has raised its value hence, and most of the Urban Heat Island effects are experienced. This study was aimed to analyze and evaluate spatial patterns of green spaces over the period of sixteen years. Spatial and temporal changes in urban areas and their green areas has been identified and classified by using technique of supervised classification and for evaluation Normalized Difference Vegetation Index (NDVI) was applied. Raised values of crop land, pastures and greenery has explained better condition of Karachi environment in suburbs but removal of green areas from city center sounds dangerous and alarming. Remote sensing is essential for evaluating spatial patterns and identification of an area of interest, without techniques of SRS observations and theories cannot be analyzed or mapped.

5. RECOMMENDATIONS

In future, urban dwellers or planners should focus ecological environment before planning more infrastructures. Karachi has vast area of barren land greenery should be planned therefor, maintaining ecology of species and climate of city.

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