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Spatial Analysis of Vegetation Cover in Urban Green Space under New Government Agenda of Clean and Green Pakistan to Tackle Climate Change

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ABSTRACT
Shrinkage of urban green space has led to the disruption of the ecological balance. Population growth, industrial expansion, development activities and land encroachment reduce the vegetation cover of metropolitan cities including Lahore, Pakistan. Presently, Lahore is on top of all metropolitan cities in the world having worst air quality index (AQI). Thus, monitoring of the vegetation cover in urban areas is the ultimate need of the day for the conservation and protection of environment which is also the agenda of new government (Clean and Green Pakistan). Besides, Honorable Lahore High Court has also passed an order to plant trees in the oldest and biggest graveyard of Lahore to tackle the climate change issue. Considering the above-mentioned facts, the current research was carried out for the first time in Lahore, Pakistan to analyze the vegetation cover using spatio-temporal technique. For vegetation cover assessment, spatial techniques were used in the present study viz. Normalized Difference Vegetation Index (NDVI), Transformed Normalized Vegetation Index (TNDVI), Difference Vegetation Index (DVI) and supervised classification. On the basis of high magnitude of smog and air pollution issue, four recent years were selected, i.e. 2015, 2016, 2017 and 2018 to observe ground reality. The results of the study revealed the depletion of vegetation cover in cemeteries at an alarming rate. Furthermore, the results of study revealed no significant change in green cover in Miani Sahib after the passing order of Lahore High Court of plantation in the graveyard.

Keywords: Clean and Green Pakistan, Gora Cemetery, Miani Sahib, NDVI.

INTRODUCTION

Green spaces in the urban areas play an essential role of maintaining the balance between the natural and built environment. Basically, green space is described as any type of vegetation surface such as urban forests, parks, gardens and cemeteries [Haq, 2011; Kabisch and Haase, 2013]. Moreover, "green cover" term refers to the aerial data of trees, shrubs and grasses which is identified and taken from an aerial source [Sexton et al., 2013].

From the perspective of environment, the green cover of urban areas has a significant importance in decreasing high temperature [Christian & Ugoyibo, 2013; Imam & Banerjee, 2016], reducing air pollution [Cavanagh et al., 2009; Selmi et al., 2016], absorbing carbon dioxide from the atmosphere (Davies et al., 2011; Nowak et al., 2013), abating particulate matter ($PM_{2.5}$) [Saebo et al., 2003; Alcock et al., 2017; Chen et al., 2017], PM_{10} [Nowak et al., 2014], controling smog [Rosenfeld et al., 1998]; it is also beneficial for sustainable development [Peng et al., 2008; Van de Voorde et al., 2008] and achieving sustainable development goal (SDG) 11 [Nero, 2017]. Moreover, urban green space (UGS) contributes significantly to stress reduction [Thompson et al., 2012] and improves public health from the social point of view [Mitchell, 2013].

Despite the importance of green space, the transformation of UGS is one of the major threats for the dwellers of urban cities worldwide [Kondo et al., 2018]. Urban sprawl [Gairola and Noresah, 2010; Önder, 2014; Kopecká et al., 2017; Naeem et al., 2018], land use change [Chen et al., 2006], industrial expansion and exacerbating development projects exert tremendous pressure on UGS, which not only diminishes the dense vegetation cover drastically [Bhaskar et al., 2012; Blaschke et al., 2014] but also creates serious environmental challenges such as loss of biodiversity [Morelli et al., 2017], climate change [Broto & Bulkeley, 2013], high temperature [Morris et al., 2015], air pollution [Banerjee et al., 2011; Kanniah et al., 2016] vehicular emissions [Essel, 2017] and winter smog. Several studies reported the depletion of green space in the urban areas [Hillsdon et al., 2006; Shahabi et al., 2012; Byomkesh et al., 2012; Narmada et al., 2017] including cemeteries [Pervaiz et al., 2018].

Cemeteries are considered as valuable green spaces (ShakerArdekani et al., 2015) having cultural and aesthetic values in urban environment, [Uslu, 2010]. Cemetery or graveyard is known as a sacred place [Ilyas et al., 2018] and a diverse habitat of flora [Molnár et al., 2017]. According to [Arffmann, 2000] cemetery has four major roles: to provide hygienic condition; place of sorrow; contact with eternity and social interaction. Furthermore, cemeteries have multiple valuable functions [Deering, 2014] and play the role of green lungs in heavy traffic area [Swensen et al., 2016]. Besides burying dead bodies on cemeteries, they may potential serve as city parks [Quamruzzaman, 2009], rich source of floral diversity [Rahman et al., 2007], hotspot of multiple taxa [Shah et al., 2016]. Despite the importance of cemeteries, they have always remained little researched in Pakistan. Therefore, this study was carried out for the first time in Lahore, Pakistan to assess the green cover of cemeteries. Lahore is a populated city and characterized by the fastest growth of vehicles [Sabar & Anjum, 2017]. It is an ancient, cultural city [Khattak et al., 2014; Ghaffar, 2015; Akhtar et al., 2017] and industrial hub of Punjab, Pakistan [Pervaiz et al., 2016]. Lahore has been known as the city of gardens [Shirazi, 2012] but currently it is confronted with the shrinkage of green space. In recent times, cemetery lands have been encroached by the private as well as governmental interest [Pervaiz et al., 2018]. As a result of green cover depletion, winter smog and hazardous air is engulfing the city on a fast rate. Hence, Lahore, is ranked 1st in the worst air quality index (AQI) in December, 2018 [DAWN, 2018]. Thus, tree plantation is the only solution collectively proposed by the Government of Punjab in Section 7 of Smog Policy, 2017 [GOP, 2017], Federal Government [Agenda of Clean and Green Pakistan] [DAWN, 2018] and Judiciary (Order passed by Lahore High Court) [Duniya New, 2018] to combat the air pollution and smog menace.

The specific objectives of the current research are: to assess the vegetation cover of cemeteries using spatio-temporal technique from 2015 to 2018 and to evaluate the change in green vegetation cover. Moreover, a comparative analysis was performed based on the researched data obtained from two famous cemeteries of Lahore, Pakistan. Findings of the present study will be helpful in conservation and utilization of green cover in cemeteries. Moreover, this study will provide significant information in terms of tree diversity to researchers and students (Nagendra and Gopal, 2010). In addition, it will also provide valuable and useful support to urban planners and environmental policy makers in the planning of further cemeteries in Lahore. This study will serve as a good guideline for tree plantation to fulfill the promise of "Clean and Green Pakistan" and improve the urban environment.

MATERIALS AND METHODS

Study sites

The present research was conducted on two renowned cemeteries of Lahore. The first graveyard chosen is of Muslim community and second one is of Christian community. Miani Sahib is the largest and oldest Muslim cemetery established in the 19^{th} century. It consists of A, B, C, D, E, F G, H blocks and rich with floral diversity [Shah et al., 2016]. On the other hand, the Gora Cemetery is one of the oldest Christian graveyards in Lahore. Both cemeteries were chosen for the assessment and comparison of vegetation cover. The Gora cemetery is situated on Jail Road, Lahore near canal and besides the Lahore Gymkhana Golf Course [Pervaiz et al., 2018]. The locations of study areas (Miani Sahib and Gora Cemetery) are shown below in Figure 1.

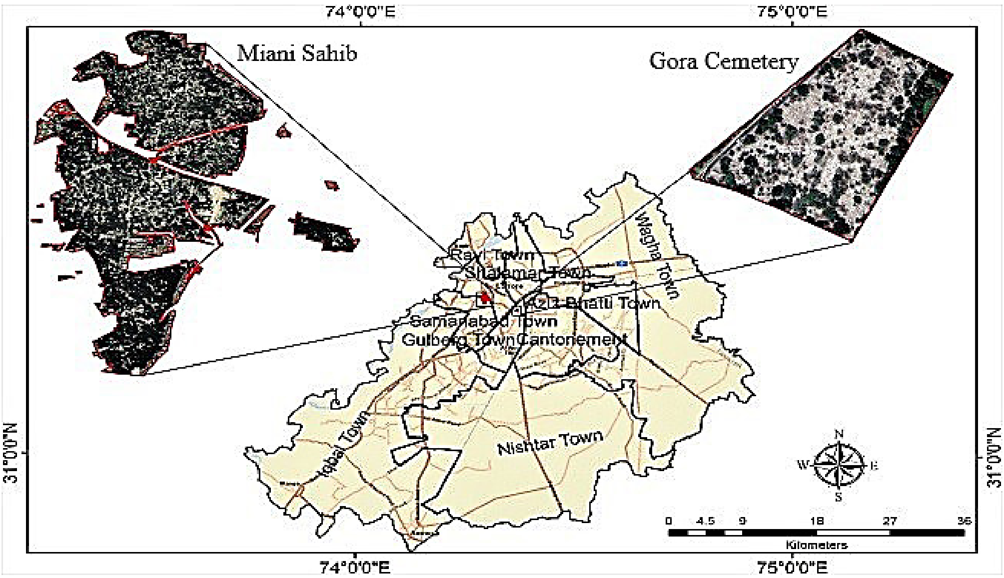

Figure 1. Spatial Location of Miani Sahib and Gora Cemetery in Lahore

Spatial Data

Vegetation cover identification of Miani Sahib and the Gora Cemetery was carried out through remote sensed data which is a famous reported tool used in several studies to accurately detect and analyze UGS [Saati et al., 2010; Bhandari et al., 2012; Trisakti, 2017; Assaye et al., 2017]. For this research, Sentinel-2 data from 2015 to 2018 was retrieved from USGS Earth Explorer. The Erdas Imagine 2015 and ArcGIS 10.5 software were used for the manipulation of Sentinel-2 data, Furthermore, description of the spatial data is given in the following Table 1.

Layer stacking is a process in which different bands of image stack with one another and make a single image including all bands in one image [Puletti et al., 2017]. Layer stacking was carried out in Erdas Imagine 2015.

IMAGE ANALYSIS

Different remote sensing techniques viz. Normalized Vegetation Index (NDVI), Transformed Normalized Vegetation Index (TNDVI), Difference Vegetation Index (DVI) and supervised classification were used in the study for change detection of vegetation cover.

Normalized Difference Vegetation Index (NDVI)

Normalized Difference Vegetation Index (NDVI) is the most commonly used technique (Ahmad et al., 2014) to identify and analyze the changes in green cover. The values of NDVI generally range between -1 to +1; the -1 value depicts the absence of vegetation and +1 value shows the presence of vegetation [Batool and Javid, 2017]. Moreover, NDVI values are suitable for the calculation of change detection analysis using the equation (NIR – RED) / (NIR + RED) [Pervaiz et al., 2018].

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

Transformed Normalized Difference Vegetation Index (TNDVI)

Transformed normalized difference vegetation index (TNDVI) is a symbol of vegetation

Table 1. Description of Sentinel Images Spatial Data

Satellite	Sensor Type	Band No	Data Acquisition Year	Spatial Resolution (meters)
Sentinel	S2A	4,3,2 (R,G,B)	2015	10
Sentinel	S2A	4,3,2 (R,G,B)	2016	10
Sentinel	S2A	4,3,2 (R,G,B)	2017	10
Sentinel	S2B	4,3,2 (R,G,B)	2018	10

biomass, and it is a ratio between near-IR and red reflection. The TNDVI is computed using the following equation 2:

$$TNDVI = \sqrt{(((Infrared-Red))/((Infrared+Red)))} + 0.5 \quad \text{(Eq. 2)}$$

According to Greenland (1994), TNDVI is an integrated function of photosynthesis, leaf area and evapo-transpiration. The total amount of biomass has indirect and direct relation with surface energy balance, surface temperature consistent with interference of sunlight, canopy cover ratio and with evapo-transpiration cooling effect [Friedl and Davis, 1994; Sandham and Zietsman, 1997; Yang et al., 2008; Siddiqui and Javid, 2018; Mazher et al., 2018].

Difference Vegetation index (DVI)

DVI is calculated simply as the difference between the NIR and the Red band (Equation 3).

$$DVI = NIR - Red \quad \text{(Eq. 3)}$$

Unlike the angular indices ratio, Vegetation Index, Normalized Vegetation Index, Perpendicular Vegetation Index and Difference Vegetation Index perform relatively well at low Leaf Area Index values, i.e. relatively sparse vegetation cover, but they become more sensitive to soil background reflectance as leaf area index increases [Jordan, 1969; Brogea and Leblanc, 2001].

Supervised Classification

The images were classified into three categories such as vegetation cover, graves and built-up area. The classification results of both sites were evaluated using the accuracy assessment process by comparing images with ground truthing points in ArcGIS 10.5. In addition, Google Earth imagery, false and true color composite images, and prior knowledge about the study area were used as the reference data. Vegetation cover of study sites were mapped using a combination of NIR and red band [Siddiqui and Javid, 2018; Mazher et al., 2018].

The initial phase in supervised classification consisted in opening the Signatures Editor from the Classifier Menu. In Signature Editor, the picture being ordered was opened utilizing the Viewer. When the record was opened in the watcher, territories were chosen that characterized the marks. The Polygon Tool from the Attributes Editor was utilized for this purpose. Utilizing the Polygon Tool and by zooming all through the picture, particular regions of the picture were chosen where the highlights were known. Once an area of known attributes was chosen, at that point it was added to the mark manager by utilizing the "add signature button". A few polygon signatures were included and blended afterwards to capture numerous areas known to have a similar component. At that point, the signature was named with the name of the element. After a few highlights were recognized, the signatures were spared as a signature document (*.sig). The picture was additionally saved as a picture file (*.img) with a similar name. With the end goal to see the classified picture, both the picture document and the signature file were opened in the viewer. Furthermore, the schematic diagram for data processing and analysis is presented in the following Figure 2.

RESULTS AND DISCUSSION

NDVI analysis presented in Table 2 represents the vegetation cover of Miani Sahib. The results of Table 2 show that 0.31 sq.km area out

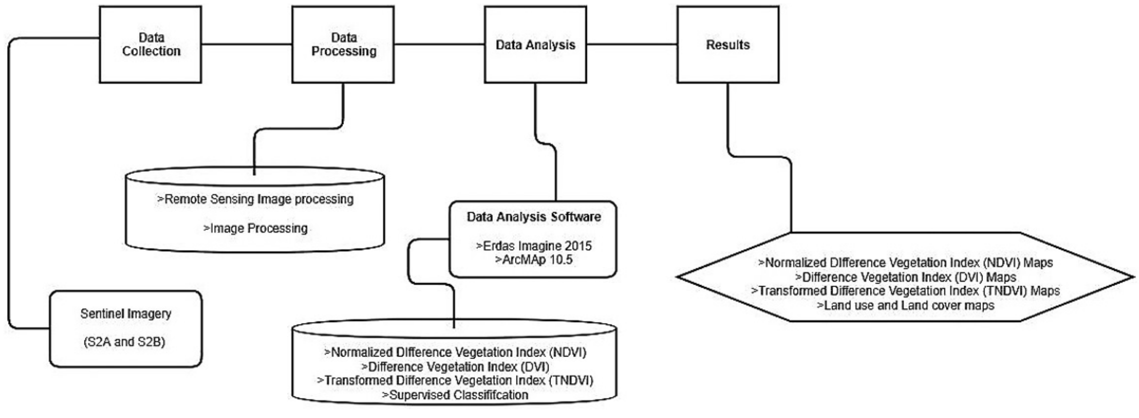

Figure 2. Schematic Diagram of Data Processing and Analysis

Table 2. NDVI Analysis of Miani Sahib

Vegetation Classes	2015		2016		2017		2018	
	Area (sq km)	Area (%)	Area (sq km)	Area (%)	Area (sq km)	Area (%)	Area (sq km)	Area (%)
Healthy	0.31	55.37	0.25	43.56	0.24	42.75	0.21	37.49
Medium	0.07	12.35	0.18	31.09	0.08	14.09	0.07	12.78
No	0.18	31.81	0.14	24.88	0.24	42.65	0.28	49.30

of 0.56 sq.km total area of graveyard decreased gradually from 2016 to 2018.

Figure 3 depicts the status of vegetation health in Miani Sahib. The data of Figure 3 show that healthy vegetation of graveyard has been depleting since 2015. In addition, in 2018 the healthy trees reduced to 37.49%. Similarly, the NDVI data of medium healthy vegetation revealed the sharp decline from 2016 to 2018.

Moreover, TNDVI and DVI analysis were also performed for the accuracy assessment of NDVI and supervised classification results. Thus, the results of TNDVI and DVI (Figure 4) gave the similar output by indicating the decrease in vegetation cover from 2015 to 2018. While analyzing the results of Miani Sahib, it can be clearly seen that the lack of tree cover in graveyard created negative impact on air quality of Lahore. Furthermore, fluctuation in built-up area and advance booking of land for graves is pushing the city towards unhealthy smoggy environment. It can also be predicted from the results that if depletion of vegetation cover persists in future, the air pollution level of the city will increase at an alarming rate.

In supervised classification of Miani Sahib (Table 3), three classes were chosen for the analysis such as built-up area, graves and vegetation. From results, it is evident that built- up area remained the same in three years i.e. 2015, 2017 and 2018. On the other hand, the area occupied by graves has increased from 2015 to 2018 i.e. 0.12 sq.km in 2015, 0.31 sq.km in 2016, 0.36 sq.km in 2017 and 0.38 sq.km in 2018 respectively. The results pertaining to the vegetation cover also indicate the depletion level of 69.74% to 25.08% from 2015 to 2018, while fluctuation was recorded in built-up and graves percentage areas from 2015 to 2018.

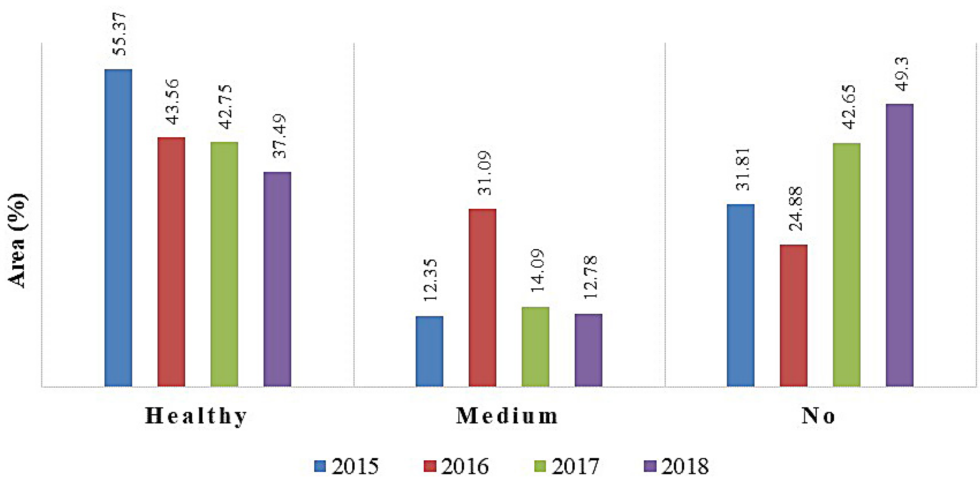

Figure 3. NDVI Classification of Vegetation Cover in Miani Sahib

Table 3. Supervised Classification of Miani Sahib

Classes	2015		2016		2017		2018	
	Area (sq km)	Area (%)	Area (sq km)	Area (%)	Area (sq km)	Area (%)	Area (sq km)	Area (%)
Built-up Area	0.04	7.71	0.03	5.56	0.04	6.37	0.04	7.39
Graves	0.12	22.11	0.31	55.64	0.36	63.31	0.38	67.19
Vegetation	0.39	69.74	0.22	38.36	0.17	29.83	0.14	25.08

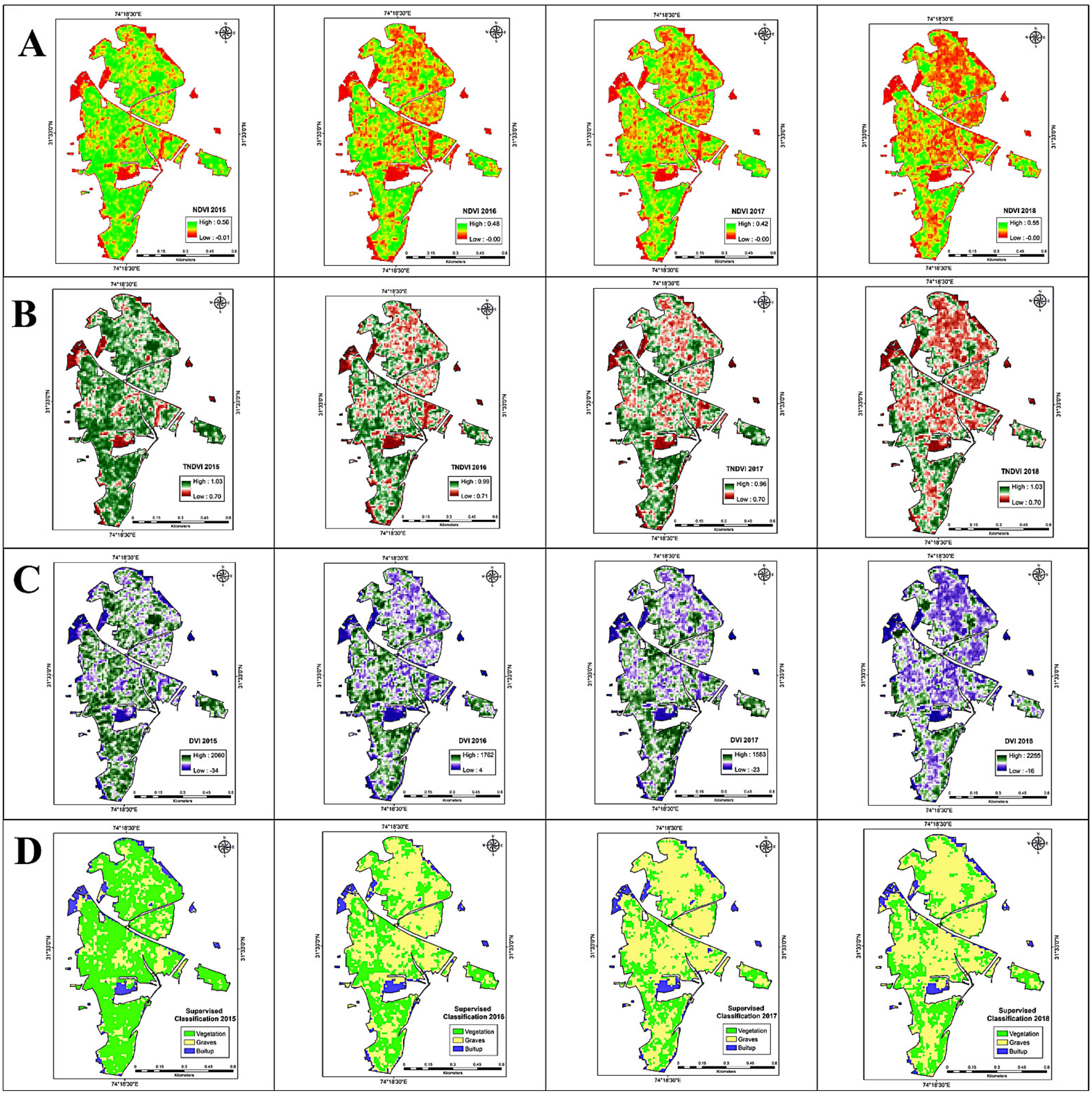

Figure 4. NDVI, TNDVI, DVI and Supervised Classification of Miani Sahib for Year 2015, 2016, 2017 and 2018

Land use and land cover (LULC) analysis of Miani Sahib is shown in Figure 5. Land cover of graveyard depleted from 69.74% to 25.08% from 2015 to 2018. The analysis of land use of graves area shows a large change in percentage i.e. 67.19%. Moreover, results of LULC show the reduction in vegetation cover which is polluting air and the health of environment in the study area as trees are known to filter and purify the air.

The Gora Cemetery

The data of Table 4 show the vegetation cover of the Gora Cemetery using NDVI. The results of vegetation cover indicate the decrease in healthy vegetation from 2015 to 2018 i.e. 44.71%, 42.42%, 41.02% and 33.13% respectively.

While analyzing the results of Figure 6, a change in healthy vegetation cover was observed. From 2015 to 2018, healthy vegetation reduced drastically. Furthermore, variation in average level of healthy vegetation was also recorded in 2015 and 2018. NDVI classification of the Gora Cemetery shows that healthy vegetation in cemetery was >50 % from 2015 to 2018.

Table 5 shows that vegetation area of cemetery consists of 0.04 sq.km out of 0.05 sq.km total area in 2015 which is reduced to 0.02% in

Table 4. NDVI Analysis of the Gora Cemetery

Vegetation Class	2015		2016		2017		2018	
	Area (sq km)	%	Area (sq km)	%	Area (sq km)	%	Area (sq km)	%
Healthy	0.02	44.71	0.02	42.42	0.02	41.02	0.02	33.13
Medium	0.01	14.38	0.00	9.79	0.00	9.68	0.01	11.96
No	0.02	40.12	0.02	47.01	0.02	48.74	0.03	54.08

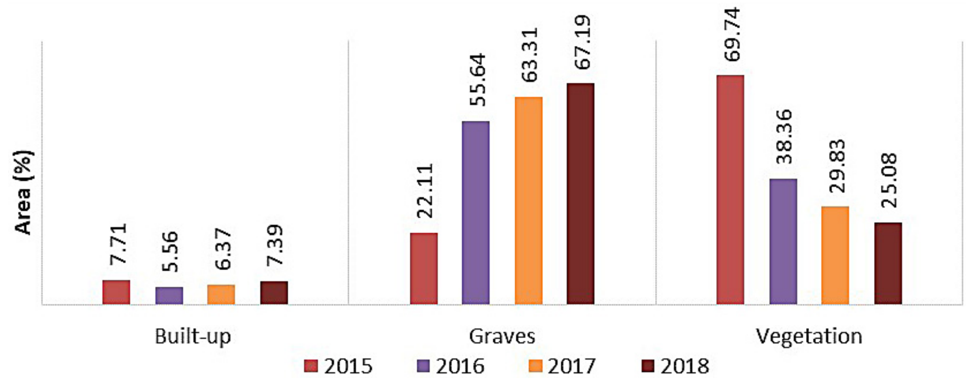

Figure 5. Land Use and Land Cover Supervised Classification of Miani Sahib

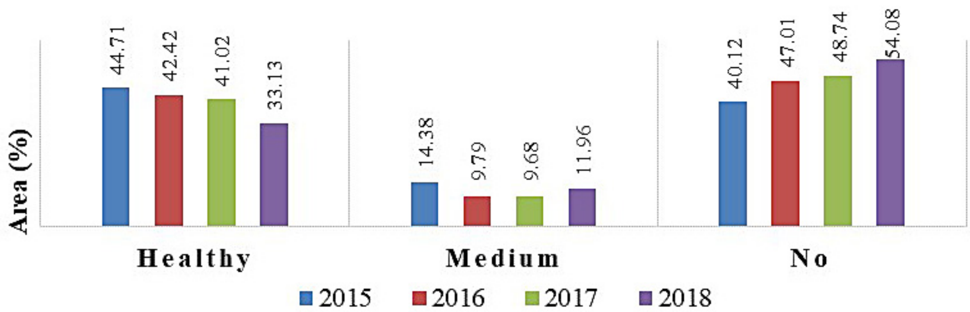

Figure 6. NDVI Classification of Vegetation Cover in the Gora Cemetry

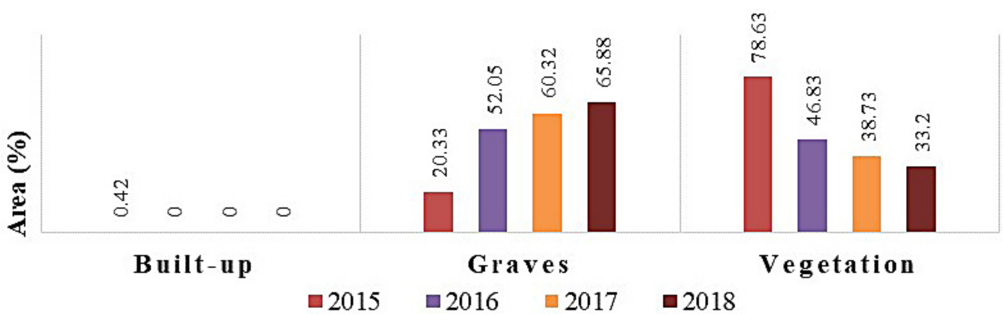

Figure 7. Land Use and Land Cover Supervised Classification of the Gora Cemetry

Table 5. Supervised Classification of the Gora Cemetery

Classes	2015		2016		2017		2018	
	Area (sq. km)	%	Area (sq. km)	%	Area (sq. km)	%	Area (sq. km)	%
Built up	0.00	0.42	0.00	0.00	No	No	No	No
Graves	0.01	20.33	0.02	52.05	0.03	60.32	0.03	65.88
Vegetation	0.04	78.63	0.02	46.83	0.02	38.73	0.02	33.20

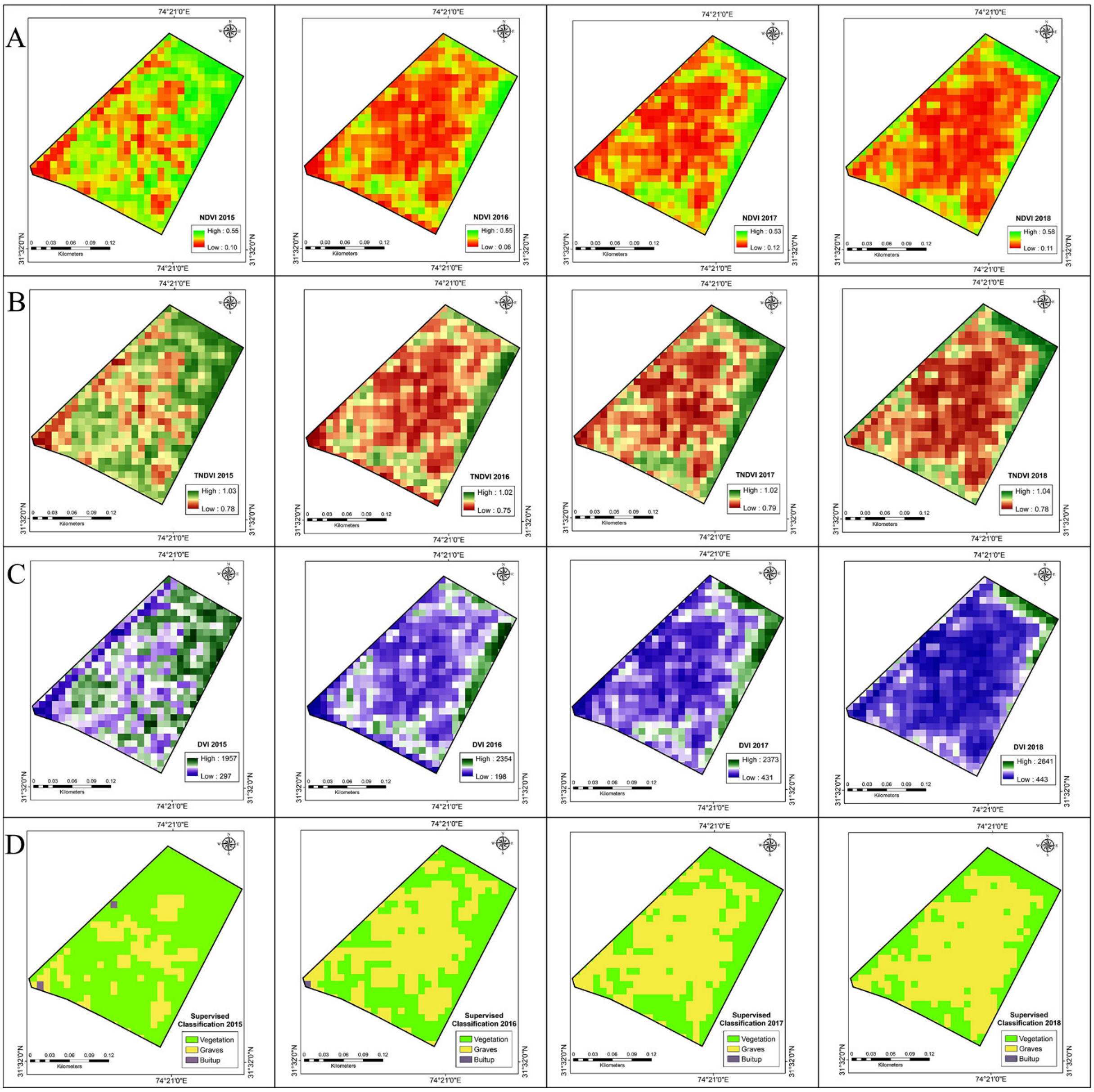

Figure 8. NDVI, TNDVI, DVI and Supervised Classification of the Gora Cemetery for Year 2015, 2016, 2017 and 2018

2016 and 2017. Furthermore, increased number of graves was also recorded in Gora cemetery from 2015 to 2018. Moreover, the results of supervised class of vegetation show the declining trend of green cover in the Gora Cemetery from 2015 to 2018 (Figure 7).

The results of Figure 8 reveal the same situation of LULC which was analyzed in Miani Sahib. The vegetation cover was reduced from 78.63% to 33.2% till 2018. Moreover, the graves area was recorded with high percentage i.e. 65.88%. No built-up area was found in the Gora Cemetery of Lahore from 2015 to 2018.

CONCLUSIONS

The cemeteries of urban areas play a key role in the protection of environment. In the current scenario, the vegetation cover of cemeteries was reducing at an alarming rate. In the light of Honorable Lahore High Court orders, no significant increase in vegetation cover has been witnessed yet according to the spatial analysis results. Furthermore, comparing results of Miani Sahib and the Gora Cemetery, it was noted that green cover of Miani Sahib is somewhat better than in the case of the Gora Cemetery. However, overall, the current situation of vegetation cover in both graveyards is not good and is the apparent reason for the high level of air pollution. Thus, in order to protect the environment, there is a dire need to plant indigenous pollution tolerant trees to attenuate the negative impacts of air pollution, particulate matter (PM) and vehicular emissions. Besides, the green promise of the newly elected government is yet to be fulfilled in the near future.

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