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Tree census of urban green space with special reference to Gora Cemetery of Lahore, Pakistan

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Abstract

The present study is carried out in the oldest Christian Gora Cemetery of Lahore, Pakistan. The main rationale of the research was to prepare the tree inventory of the study area. The inventoried data was analyzed to determine the diversity of growing trees species in the graveyard. In addition, spatial analysis of tree cover was also analyzed from 2000 to 2018 using NDVI technique. The results of field study showed that *Azadirachta indica* was the most dominant growing tree species of Gora Cemetery. Whereas, the least percentage was found with the fruit tree i.e. *Mangifera indica*. Moreover, the spatial results of study inferred the highest value of tree cover in 2000 whereas the least green cover was analyzed in 2013. Findings of the study showed that the significant fluctuation in green cover has the negative impacts on urban environment which ultimately creates hurdles in coping with global warming and curbing the climate change rising threat. So, the role of the government towards maintenance of green spaces in the graveyards for urban sustainability is very important. Hence, the present research would be helpful to provide baseline information for urban planners and foresters to plan appropriate composition of green space trees in the graveyards. In addition, the inventoried data would be valuable for city authorities for decision making about green cemeteries and also helpful for further research on urban ecosystem.

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Introduction

Metropolitan cities are facing numerous environmental challenges such as insufficient green space, excessive air and water pollution (Heather, 2012), scorching summer heat wave (Livesley *et al.*, 2016), high concentration of greenhouse gas emissions (Chavan and Rasal, 2010), rising threat of smog (Calfapietra *et al.*, 2013, Riaz and Hamid, 2018) and inevitable climate change (Karagiannis and Soldatos, 2010). The grave urban environmental issues are increasing rapidly due to industrial expansion, population growth (Ravindranath *et al.*, 1997; Gupta and Goyal, 2014; Haaland and van den Bosch, 2015) and development of construction plans (Siddiqui *et al.*, 2016). Moreover, encroachment of Urban Green Spaces (UGSs) by residential, commercial, industrial and extensive road plans pose serious threat (Qadeer, 1983) to the vegetation cover of cities including graveyards and parks (Rahman, 2014). Like other developing countries, Pakistan is also facing green space reduction and losing vegetation cover drastically (Alam *et al.*, 2014). Thus, to cope with the climate change to maintain UGSs, nature-based solutions (NBS) are direly needed to overcome global warming concerns. UGS support and guard the urban environment judiciously (Younis *et al.*, 2018) and consider well their environmental, economic and social benefits (Lyytimäki and Sipilä, 2009; Stoffberg *et al.*, 2010; Haq, 2011; Senanayake, 2013).

Furthermore, global challenge of climate change can be mitigated by green space development (Elmqvist *et al.*, 2015) of residential areas (Younis *et al.*, 2018). Trees are considered a valuable asset and carbon reservoir (Tripathi and Joshi, 2015) and cost effective approach to reduce carbon emissions (Ajani and Shams, 2016). They are not only help to remove the sulfur dioxide, nitrogen dioxide, carbon dioxide, ozone, particulate matter and carbon monoxide from the air (Nowak *et al.*, 2006; Chavan and Rasal, 2010) but also accumulate the large concentration of CO_2 as biomass (Yang *et al.*, 2005; Thangata and Hildebran, 2012; Vashum and Jayakumar, 2012; Mngrsquo and Beedy, 2013; Das *et al.*, 2017). They provide a wide range of services in terms of shade (Desai and Nandikar, 2012) shelter, timber, fuelwood (Crowther *et al.*, 2015), medicines Shah *et al.*, 2016), fruit and nuts (Raza and Ullah, 2015). In addition, they maintain ecological balance, provide habitat for faunal diversity (McPherson *et al.*, 2011; Mitra *et al.*, 2017) and beautify the landscape (Seamans, 2013). Moreover, carbon storage by urban forest is a significant component which is addressed in United Nation Framework Convention on Climate Change (UNFCCC) (Pasher *et al.*, 2014) and required for reporting under Kyoto Protocol treaty (Ravindranath *et al.*, 1997; Tom-Dery *et al.*, 2015). Furthermore, it is tradable commodity under Clean Development Mechanism (Kiran and Kinnary, 2011) to alleviate global warming (Srinivas *et al.*, 2014). Therefore, by keeping in view the above facts, the present study is carried out for the first time in Lahore, Pakistan to assess the tree diversity of green space with special reference to Christian Cemetery of Lahore. The specific objectives of the study are to prepare the tree inventory of cemetery and to analyze the spatial context of tree cover from 2000 to 2018 using Landsat 7, Landsat 8 and Digital Globe images imageries.

Materials and methods

Study site

The present study is carried out in the oldest Christian Gora (White) Cemetery located on Jail Road in Lahore which is the second largest metropolitan city of Pakistan (Pervaiz, 2015; Alam *et al.*, 2014; Malik and Wahid, 2014; Shirazi and Kazmi, 2016; Riaz and Hamid, 2018). Gora cemetery is situated nearby Lahore Gymkhana Club, in the East of Jail Road and intersection of Zafar Ali Road. The Cemetery lies on 31°32′5.93′′N and 74°20′58.69′′E (Fig.1).

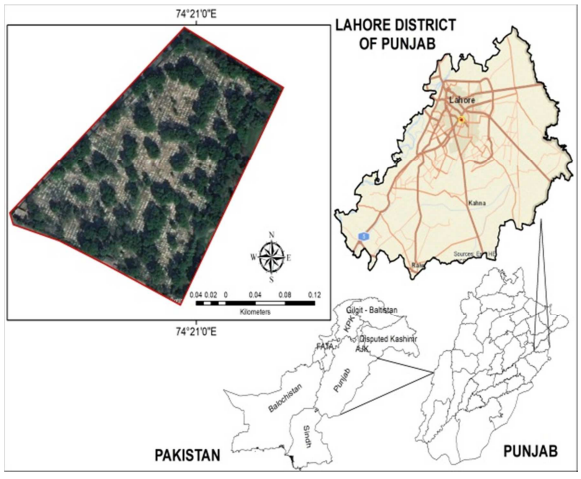

Fig. 1. Location map of Gora Cemetery, Lahore.

Data collection of trees

The field survey was carried out from April, 2018 to May, 2018 to collect data using the standard criteria of a tree (Chavan and Rasal, 2010; Hangarge *et al.*, 2012). In order to measure girth at the Diameter at Breast Height (DBH), the reported method of Brown (1997) was adopted. Moreover, only those trees were measured which were having 10cm and >10cm tree Girth at Breast Height (GBH) using a calibrated plastic measuring tape (Hangarge *et al.*, 2012).

Tree identification

The specimens of plants were collected, documented and preserved. The voucher specimens were deposited in the Herbarium of Department of Botany, Lahore College for Women University (LCWU) and identified by Dr. Tahira Aziz Mughal. The arrangement of trees in alphabetical order with their botanical, family and local names is tabulated in Table 1.

Spatial data acquisition and processing

Two types of multi-temporal satellite data (Landsat 7, Landsat 8 and Digital Globe images) were retrieved from the Earth Explorer in the summer months (Table 2) using the United States Geological Survey (USGS) website https://earthexplorer.usgs.gov/ (Ahmad and Goparaju, 2016).

Table 1. Spatial data of Gora Cemetery, Lahore.

Satellite	Sensor Type	Band No.	Data Acquisition Year	Spatial Resolution (metre)
Landsat 7	TM	4, 3, 2 (NIR, R, G)	2000	30
Landsat 7	TM	4, 3, 2 (NIR, R, G)	2008	30
Landsat 8	OLI	5, 4, 3 (NIR, R, G)	2013	15
Landsat 8	OLI	5, 4, 3 (NIR, R, G)	2018	14
DigitalGlobe	Quickbird	3, 1, 2 (NIR, R, G)	2000	0.6
DigitalGlobe	Quickbird	3, 1, 2 (NIR, R, G)	2008	0.6
DigitalGlobe	Quickbird	3, 1, 2 (NIR, R, G)	2013	0.6
DigitalGlobe	Quickbird	3, 1, 2 (NIR, R, G)	2018	0.6

Digital images were processed using Erdas Imagine 2014 software. Whereas vector data was manipulated using the ArcGIS (10.5) software to process, analyze and integrate the spatial data. The spatial images were downloaded and layer stacked as per band combination. Furthermore, the obtained images were geo referenced, mosaicked (Singh *et al.*, 2016) and subset by using a geo referenced shape files of the study area.

Afterwards, the tree cover was identified by using Normalized Difference Vegetation Index (NDVI). Thereafter, the obtained results were exported to shape files for further analysis in ArcGIS.

Data analysis

The Landsat imageries of study area were analyzed using Erdas software and converted to an NDVI output. Moreover, the vegetation cover change classification and intensity is listed in Table 2.

Table 2. Intensity classifications of vegetation cover in Gora Cemetery, Lahore.

Classes	Intensity
Dense Vegetation	More than 50%
No Vegetation	Less than 1%

Spatial analysis was classified on the basis of Normalized Difference Vegetation Index (NDVI) by taking images of 2000, 2008, 2013 and 2018. A vegetation index was calculated by using the formula i.e. NDVI= (NIR – Red)/(NIR + Red) where NIR exhibited values of near infrared and VIS described the values of visible red reflectance (Mustafa *et al.*, 2015; Agbelade *et al.*, 2016; Dimitrov *et al.*, 2018). Normalized difference vegetation index (NDVI) is an index which is based on the spectral reflectance of vegetation cover. Every feature has its own specific reflectance which varies with the wavelength and different analysis performed for different features of the ground. NDVI is an analysis for computing different types of vegetation, the values of NDVI range from positive to negative such as -1 to +1. A highest NDVI value exhibits the presence of dense vegetation in the area whereas lower value infers to the thin vegetation. Huang and Haung and Siegert (2006) and De Boer (2000) reported the NDVI technique for change detection of vegetation in their studies.

Results and discussion

Based on the filed survey results, most of the trees belong to the family of Anacardiaceae, Combretaceae, Fabaceae, Meliaceae, Myrtaceae. Whereas, recorded tree diversity of the study area consists of *Acacia nilotica*, *Azadirachta indica*, *Bombax ceiba, Dalbergia sissoo, Eucalyptus. camaldulensis, Ficus relgiosa, Mangifera indica*, *Melia azedarach*, *Putranjiva roxburghii* and *Terminalia arjuna* (Table 3).

Table 3. List of trees in Gora Cemetery, Lahore.

S. No.	Botanical Name	Family	Local Name	Average GBH (cm)
1	*Acacia nilotica*	Fabaceae	Kikar	104.03
2	*Azadirachta indica* J. Juss.	Anacardiaceae	Neem	102.66
3	*Bombax ceiba*	Bombacaceae	Simal	98.181
4	*Dalbergia sissoo* Roxb. ex A.P.DC.	Fabaceae	Sheesham	102.66
5	*Eucalyptus camaldulensis* Hook	Myrtaceae	Sufaida	105.61
6	*Ficus relgiosa* L.	Moraceae	Peepal	101.89
7	*Mangifera indica* L.	Anacardiaceae	Aam	91.12
8	*Melia azedarach*	Meliaceae	Dhraik	101.17
9	*Putranjiva roxburghii*	Euphorbiaceae	Putajan	102.68
10	*Terminalia arjuna (Roxb.)* Wt & Arn.	Combretaceae	Arjun	102.66

Further, analyzing the results, it has been revealed that *Azadirachta indica* is the most abundant tree species covering 47% of vegetation cover of study site. Whereas, fruit bearing trees *Mangifera indica* percentage is recorded very low i.e. 4% (Fig. 2). Moreover, results presented that most of the recorded trees were notable addition of exotic kind of tree i.e. *Eucalyptus camaldulensis* was also planted. Based on the results (Fig. 2), it was noted that maximum ten kinds of trees were having GBH ≥10cm. Estimating GBH of measured trees, the *E. camaldulensis* showed highest value of average GBH to squeeze CO_2 (Table 3). Moreover, evaluated indigenous species of study site including *B. ceiba* and *M. azedarach* found best suited for plantation being a good source of quality timber for fuelwood and plywood and also suggested for plantations (Rahman *et al.*, 2014).

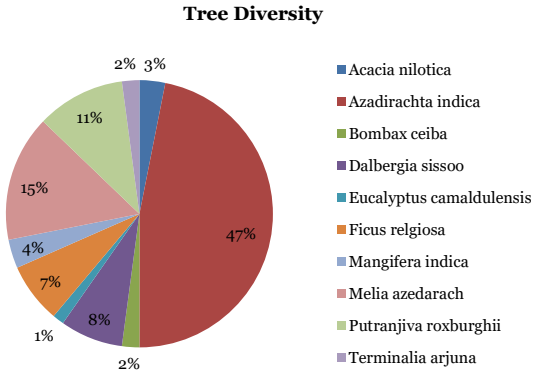

Fig. 2. Percentage of tree diversity in Gora Cemetery, Lahore.

So, analysis of tree diversity of cemetery exhibited that growing trees have great potential to decrease the impacts of global warming and urban air pollution.

Moreover, the tree diversity of graveyard is significantly viable in medicinal and commercial applications such as *A. nilotica* (Roozbeh *et al.*, 2017), *A. indica* (Pankaj *et al.*, 2011), *B. ceiba, D. sissoo* (Asif and Kumar, 2011) *E. camaldulensis* (Dhakad *et al.*, 2018), *F. relgiosa* (Gautam *et al.*, 2014), *M. indica*, *M. azedarach*, *P. roxburghii* (Abhimanyu *et al.*, 2015; Nilam *et al.*, 2018) and *T. arjuna* (Amalraj and Gopi, 2017). In addition, filed study observation analysis demonstrated that *A. indica*, *M. azedarach and E. camaldulensis* are fast growing tree species. Guarna (2012) reported that fast growing tree species are well known to sequester CO_2 (Table 1). In addition, Fig. 2 shows the location points (Latitude and Longitude) of two different trees species i.e. *A. indica* and *M. indica* in Gora Cemetery.

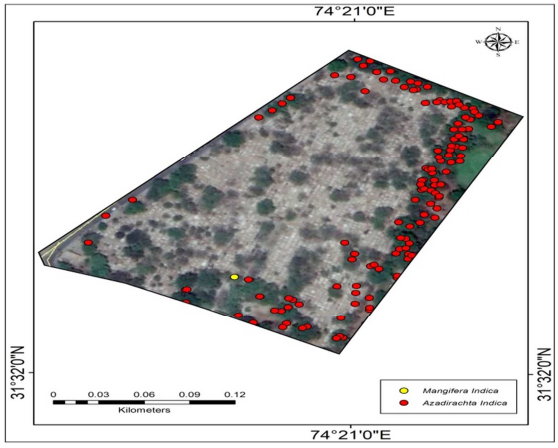

Fig. 3. Location points of *Azadirachta indica* and *Mangifera indica* in Gora Cemetery, Lahore.

NDVI assessment of Gora Cemetery showed the spatio-temporal pattern of green cover. The results of green colour showed the highest and maximum values of vegetation, yellow colour is exhibiting medium green cover while red is indicating missing trees. The NDVI values were calculated from Landsat satellite images of the year 2000 to 2018. The highest value of NDVI was found in the year 2013 and the lowest value of NDVI was assessed in the year 2018. In comparison to the year 2013, the NDVI values of the year 2018 showed decreased level of vegetation value ranging from 0.023938 (sqkm). Moreover, higher NDVI values in the study site were found in scattered patches.

The decrease level in NDVI values clearly indicates the tree cover fluctuation in the cemetery. From the results of study, it is evident that green vegetation percentage is less than 60 percent in selected years (Fig. 4).

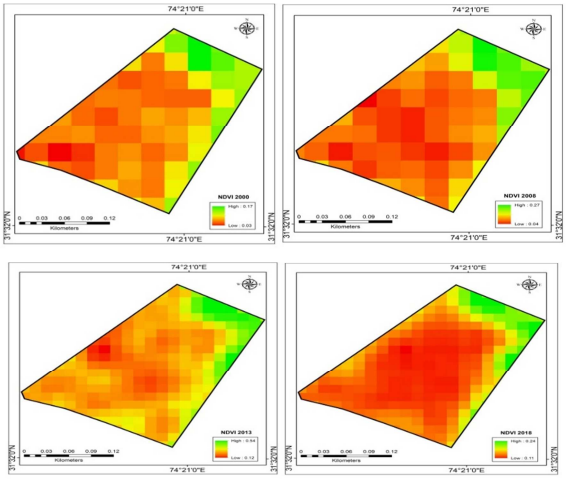

Fig. 4. NDVI variation analysis of tree cover from 2000 to 2018.

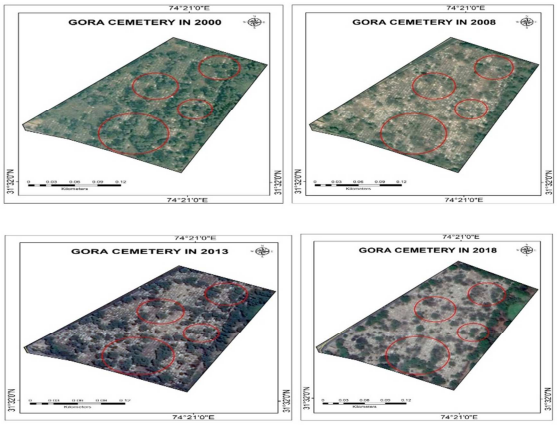

Fig. 5. Vegetation cover fluctuations in Gora Cemetery, Lahore.

From Fig. 5, the change in vegetation cover from 2000 to 2018 can be clearly seen. Furthermore, the percentage values of green cover of study area are listed in Table 4.

Table 4. Area covers by trees through NDVI.

2000		2008		2013		2018	
(Sqkm)	%	(Sqkm)	%	(Sqkm)	%	(Sqkm)	%
0.025113	52.16	0.024225	50.31	0.025113	52.16	0.024225	50.31

Conclusion

In Christianity, planting trees in burial place is considered sacred. Cultivation of trees in burial sites provides low cost solution to control carbon emissions. Thus, taking into consideration the trees importance, the vegetation cover should be increased in the green space to overcome atmospheric pollution. Moreover, plantations of woody trees in graveyards not only offer good environmental services but it is also a good opportunity to earn carbon credits. So, the role of the government is to sustain the natural resource of green space by planting suitable trees species to maximize carbon storage and to optimize livelihood of local people.

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