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Research Article

3D Analysis of Graveyard Trees in the Wake of COVID-19

Shazia Pervaiz[1*], Filza Zafar Khan[2], and Kanwal Javid[3]

[1]Environmental Protection Agency, Lahore, Pakistan
[2]Pakistan Council of Scientific and Industrial Research Laboratories Complex, Lahore, Pakistan
[3]Department of Geography, Government College University Lahore, Pakistan

Abstract: Covid-19 presented the new perspective of urban green space to battle the pandemic crisis globally. The havoc of Coronavirus became more deadly with the combination of foul air which is one of the urban challenges birthed by the shrinkage of green cover. Significantly, urban trees are valuable and cost-effective solutions to gobble up the concentration of air-borne particulates from the environment. Thus, by keeping in view the importance of trees in the era of COVID-19, the 3D (density, diversity and durability) analysis has been carried out for the first time in the smog prone city (Lahore) with the objective to examine the potential of green cover in the urban graveyards. The current research consists of two data sources. The first source is a Muslim Graveyard and the second one is a Non-Muslim (Christian) Graveyard. Field assessment was carried out in graveyards using a global positioning system. The observation data of trees assessment was used in terms of tree cover, diversity and their physical condition. Results of the study showed that both of the graveyards are deficient in tree cover. Thus, it was concluded from the findings that the unsatisfactory state of tree health and diversity could neither maintain the surrounding environment by absorbing carbon dioxide nor defeat the particulate pollutants. Moreover, the present study will prove to be a valuable source of information for government departments such as forest and urban planning to realign strategies to provide healthy air to breathe, mitigate the risk of pandemic and minimize environmental pollution i.e., smog.

Keywords: COVID-19 and air, Miani Sahib,Smog, Tree Diversity, Urban Environment, UNFCCC.

1. INTRODUCTION

Urban green spaces are the hotspot of biodiversity [1], habitat of plants [2] and animals [3]. In cities, urban green spaces provide healthy ecosystem services [4] to conserve and protect environment, maintain and regulate the climate to achieve sustainable development goals (SDGs). From the perspective of environment [5], green cover of urban areas has a significant importance to protect and increase the quality [6] and health of environment judiciously [7] by decreasing high temperature [8], reducing air pollution [9], absorbing carbon dioxide [10], accumulating the large concentration of carbon dioxide (CO2) as biomass [11], abating toxic pollutants [12], particulate matter (PM2.5) [13, 14], PM10 [15], controlling smog [16], purify water [17], and to achieve SDG's 11 and 13 [18, 19].

Besides, UGS from an economic point of view, provides amenity value [20, 21] by providing several economic services [5, 22-24] to generate income [25] and reduce energy consumption by providing shade [23]. Urban green space (UGS) increases the commercial and residential real estate economic values [26, 27]. Furthermore, UGS trees have monetary value in terms of carbon trading [28] and storage [29, 30] which is addressed in United Nations Framework Convention on Climate Change (UNFCCC) and required for reporting under Kyoto Protocol treaty [31, 32]. Furthermore, it is tradable commodity under Clean Development Mechanism [33] to alleviate global warming [34]. Further, UGS encourages employment [35] and benefit economically to strengthen the physical and mental health [36, 37] of urban dwellers.

In addition to economic benefits, urban trees

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*Corresponding Author: Shazia Pervaiz < shaziapervaiz@gmail.com>

also offer important and significant ecological [37], social [38], cultural [39] and spiritual services. Moreover, UGS contributes significantly in reducing stress [40], improving mental [41] and public health from a social point of view [42] and can mitigate the risk of Coronavirus [43].

Despite the importance of green space, transformation of UGS is one of the major threats for dwellers of urban cities worldwide [44] which is reported in several studies [45 - 48] including cemeteries [49]. Urban sprawl [50], land-use change [51], construction plans [6], industrial expansion and exacerbating development projects [52] elevate tremendous pressure on UGS which diminishes the dense vegetation cover drastically [53] including parks and graveyards. In addition, metropolitan cities are facing numerous environmental challenges such as insufficient green space gives birth to excessive air [54, 55] and water pollution [56], scorching summer heatwave [57, 58], high concentration of greenhouse gas emissions [59], the rising threat of smog [60, 61], inevitable climate change [62, 63] and polluted air increased the risk of Coronavirus [64].

Similarly, the urban city, Lahore is confronted with the shrinkage of green space and losing vegetation cover drastically [65]. In recent times, graveyard land has been encroached by private as well as for government interest [49]. As a result of green cover depletion, winter smog is engulfing the city at a faster rate and polluting the urban environment. Despite the importance of graveyards, they have always remained little researched in Punjab, Pakistan. So, to overcome the environmental pollution challenge, the development of UGS is the need of the day [66] in residential areas [67]. To improve UGS health, trees are considered a valuable green asset [68] and carbon reservoir [69, 70] and cost-effective approach to reducing carbon emissions [71 - 75] and to battle with terrible pandemic [63]. Considering the above facts, this research has been designed for the first time to examine the available diversity of trees and their health with special reference to graveyards to mitigate the conflict with the urban environment. The objectives of the present research are the following:

- To identify and evaluate the available tree diversity of selected research sites.
- To evaluate the physical health of trees.
- To propose indigenous trees having maximum carbon storage capacity for effective Nature Based Solution (NBS) to achieve sustainable development goals.

1.1. Significance of the Study

The present research would provide the latest and updated information about the available tree cover and their health condition in the study sites in the wake of COVID-19. Moreover, this information can be used to prepare strategies and alternative plans to reduce the air pollutants by planting trees in the graveyards.

2. MATERIALS AND METHODS

2.1 Selection of Research Sites

According to Irvin [76], the first step of the research was to select the study site. So, the present research has been conducted in the populated city of Pakistan (Lahore) [49]. It is an ancient and cultural city [77] dealing with urban sprawl and vehicular growth [78] issues. The city is ranked at the top of the list in Coronavirus [79] and smog issue [80]. To analyze the state of vegetation cover, two renowned graveyards of Lahore had been selected for research.

2.2. Study Sites

In order to carry out a study, the first graveyard has been chosen from Muslim community and the second one has been selected from the Christian community (Figure 1).

2.2.1. Gora Graveyard

'Gora' is derived from the Urdu word and is used for the fair skinned white people [81]. It is one of the oldest Christian graveyards in Lahore [49] which was established in the British Raj. The location of the study area (Gora Graveyard) is shown below in (Figure 2).

2.2.2. Miani Sahib Graveyard

Miani Sahib is the largest and oldest Muslim

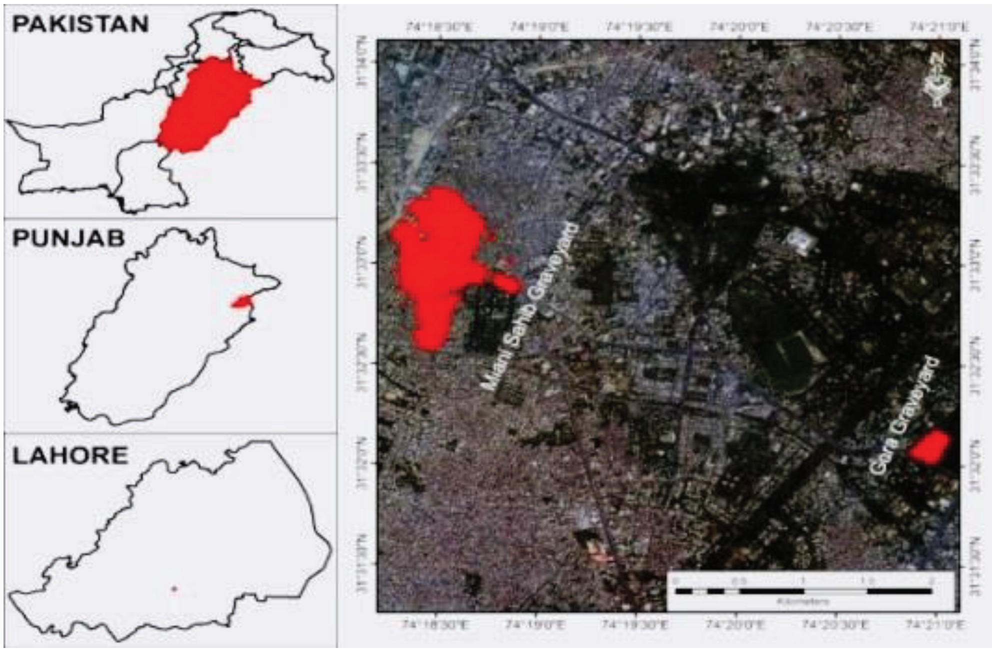

Fig. 1. Map of the study site

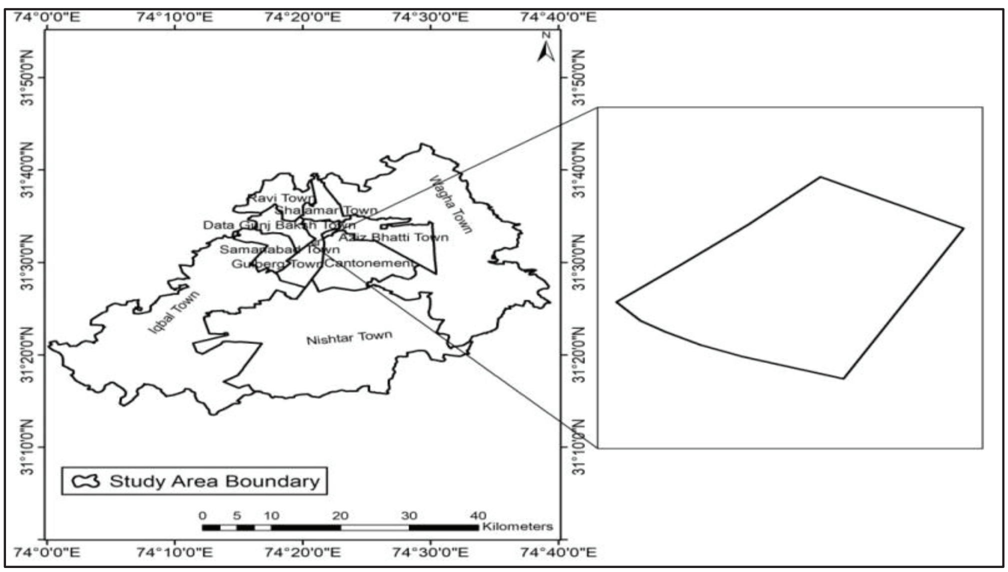

Fig. 2. Spatial location of Gora Graveyard in Lahore

Graveyard established in the 19th century of Mughal reign. It consists of A to H blocks [6, 82] locally known as Titar Saeen, Takiya Kamaran, Bara Makan, Nizam Shah, Huq Saeen, Sarki Banda, Daya Hamoon Shah and Goto Saeen. The graveyard occupies an area of 1,206 kanals and has the capacity of 0.3 Million graves which is being managed by the Miani Sahib Graveyard committee constituted in 1962.

At present, Miani Sahib is facing an acute shortage of new burials as most land of the graveyard has been encroached and confiscated by land mafia. Moreover, land grabbers have also delineated and fixed fences and boundary walls around encroached land. On this grave issue, Honorable Lahore High Court (LHC) has taken notice and 52 illegal kanal has been retrieved from the land grabbers [83, 84] and special attention is being given to upgrading the land cover of graveyard for a clean environment [85] by planting trees under passed orders of Honorable Lahore High Court (LHC). The location map of Miani Sahib is presented in the following

(Figure 3).

2.3. Global Positioning System

Global positioning system (GPS) is a handheld [86], geospatial tool [87] which was frequently used during site visits to collect coordinates from plotting tree locations. For this, the Garmin unit was used to collect data.

2.4. Crayons and Spray Paint

In order to mark trees, crayons and spray paint were used [88, 89].

2.5. Zipper Bags

Tree specimens were packed in plastic [90] bags and brought to the laboratory.

2.6 . Plant Presser

Trees specimens were pressed, dried and voucher specimen were submitted for identification [49] to the Lahore College for Women University, Lahore.

2.7. METHODS

2.7.1. Tree Identification

The specimens of plants were cut, collected, stored in a zipper bag and then preserved. The voucher specimens were deposited in the Herbarium of the Department of Botany, Lahore College for Women University (LCWU) and were identified by Prof. Dr. Tahira Aziz Mughal [49].

2.7.2. Visual Assessment of Tree Condition

Tree health was assessed visually during the field survey. The tree health was detected by visualizing trees' different categories such as decayed wood, cankers, poor roots, weak branches, cracks, dead tree tops and branches, poor tree architecture, hollow, diseased and canopy less [91].

2.7.3. Spatial Data

The spatial location of Miani Sahib and the Gora Cemetery was carried out through remote sensed data which is a renowned reported tool used in several studies to accurately detect and analyze UGS [49, 92-95].

3. RESULTS AND DISCUSSION

3.1. Gora Graveyard

3.1.1. Visual Assessment of Tree Condition

Gora Graveyard consists of ten different types of tree species (Table 1). During the field visit, a visual assessment revealed the actual condition of trees. Healthy trees occupy the maximum area of the

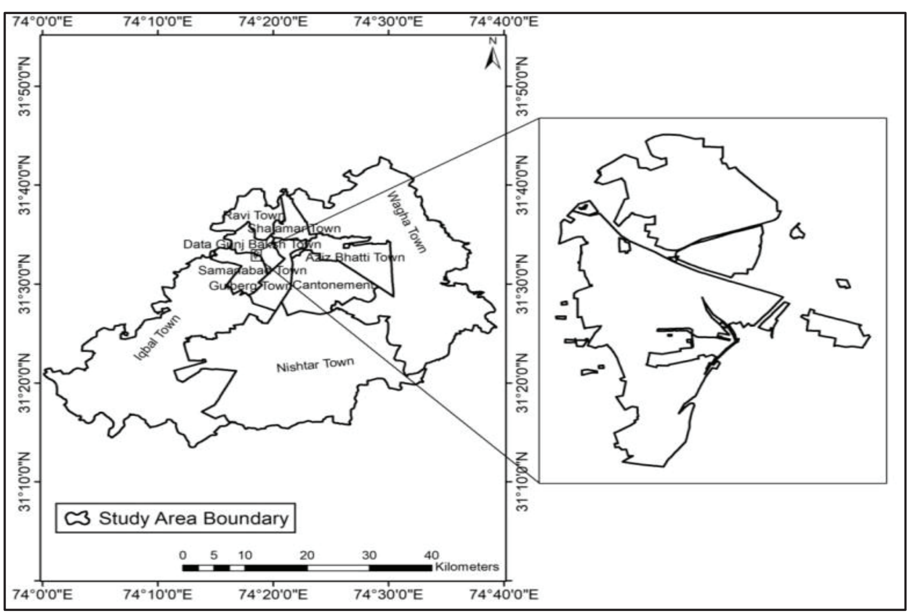

Fig. 3. Spatial location of Miani Sahib in Lahore

Table 1. Available tree species in the Gora Graveyard

Sr. No.	Local Name	Botanical Name
1	Aam	*Mangifera indica* L
2	Arjun	*Terminalia arjuna* (Roxb.) Wt & Arn.
3	Dhraik	*Melia azedarach*
4	Kikar	*Acacia nilotica*
5	Neem	*Azadirachta indica* J. Juss
6	Peepal	*Ficus relgiosa* L
7	Putajan	*Putranjiva roxburghii*
8	Sheesham	*Dalbergia sissoo* Roxb. ex A.P.DC
9	Simal	*Bombax ceiba*
10	Sufaida	*Eucalyptus camaldulensis* Hook

graveyard i.e. 59%, whereas 10% of the graveyard trees were recorded unhealthy as 'cankers'. Basically, this situation exists due to lack of tree maintenance which may weak the physical strength of the trees and results in tree mortality. The obtained values support the results reported in the study of Assaye et al. [96]. Moreover, analyzing the results of Figure 4, it is evident that the unhealthy trees can create threat for other trees and damage their healthy structure and similar results are reported by Clark and Matheny [97]. In addition, the basal decay and weak crotch and defective branches are the major causes of tree death. Findings like the current study are also reported in the study of Smiley and Kane [98]. However, Figure 5 exhibits the spatial location and provides the complete overview of trees condition in the Gora Graveyard.

3.2. Visual Assessment of Tree Condition in Miani Sahib Graveyard

3.2.1. Block A

Trees were evaluated using categories such as decayed wood, cankers, poor roots, weak branches, cracks, dead tree tops & branches and poor tree architecture [9]. Block A was recorded with 49% of healthy trees, whereas 27% trees were found to be lean. In the Miani Sahib, Block A demonstrated the highest level of healthy trees i.e., 77%, whereas 4% trees of Block A were found to be diseased (Figure 6). Evaluating results, it was found that unplanned vegetation and tree cover in the graveyard have inadequate room for their growth. Similar analysis has also been reported in the study by Kane et al [99].

3.2.2. Block B

Examining Figure 7, it has been noticed that Block B consists of maximum number of healthy trees i.e. 57%. During field survey, 17% cankers were recorded in Bara Makan which was associated with the stem of trees [99] with the apparent reason of water deficiency and poor nutrient movement which support the findings of the study carried out by Paap et al [100].

3.2.3. Block C

Tree health is a key component for the healthier built urban environment. Analyzing results of Block C, it can be clearly seen that 74% of trees were healthy whereas 15% trees of 'Block C' were visualized in a hollow stage including dead branches (Figure 8). The Lorenzini and Nali [23] study results support findings of the present study that the presence of unhealthy trees shows their short life expectancy and can lower the quality of the surrounding environment.

3.2.4. Block D

Block D values of Miani Sahib show the maximum number of tress in healthy state. Like Block C results, it is also evident that unhealthy trees can reduce the quality of environment after decay as reported by Lorenzini and Nali [23] and support results of the current study. Moreover, it is noticeable from the data that hollow trees occupy 6% of the block and lack of trees surveillance can increase the number of dead trees (Figure 9).

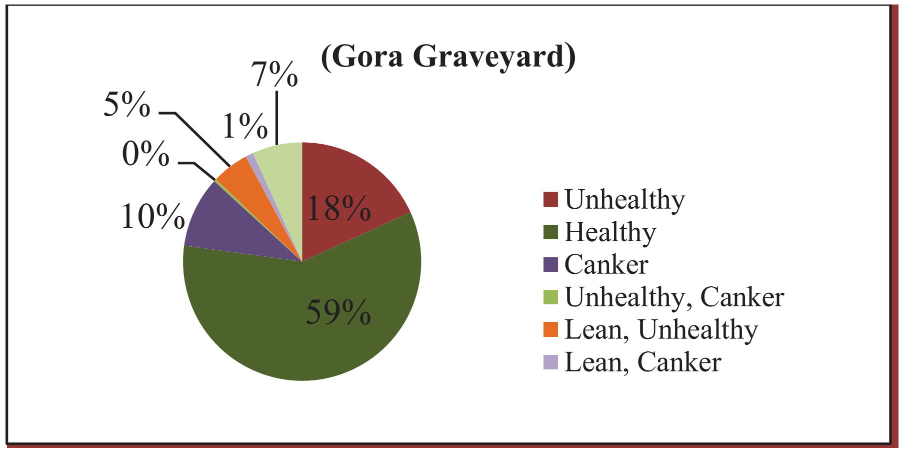

Fig. 4. Distribution of trees condition in the Gora Graveyard

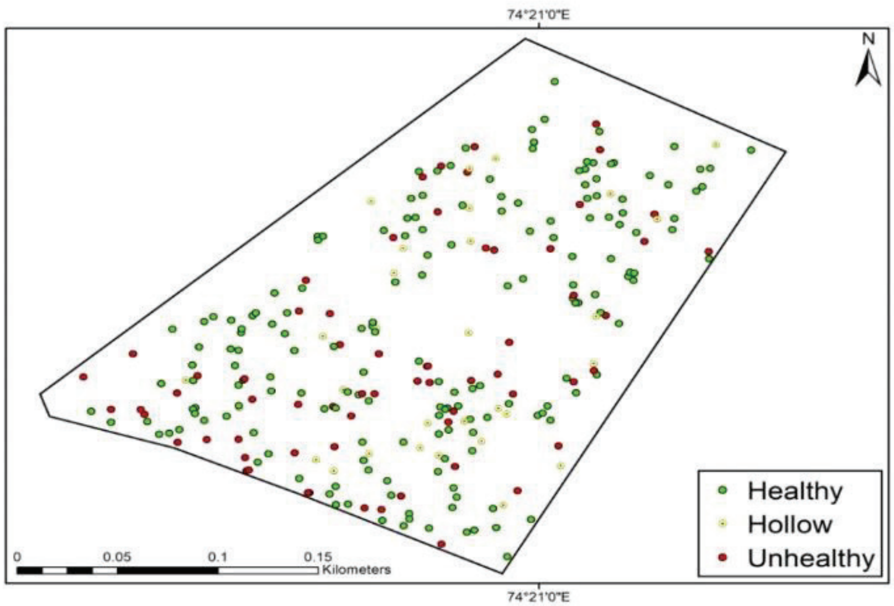

Fig. 5. Spatial distribution of tree condition in the Gora Graveyard

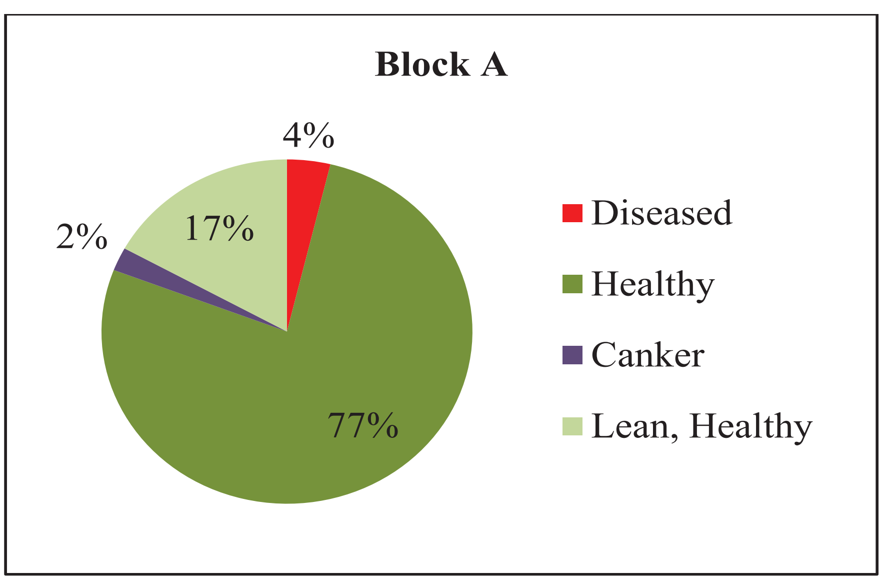

Fig. 6. Distribution of trees condition in Block A

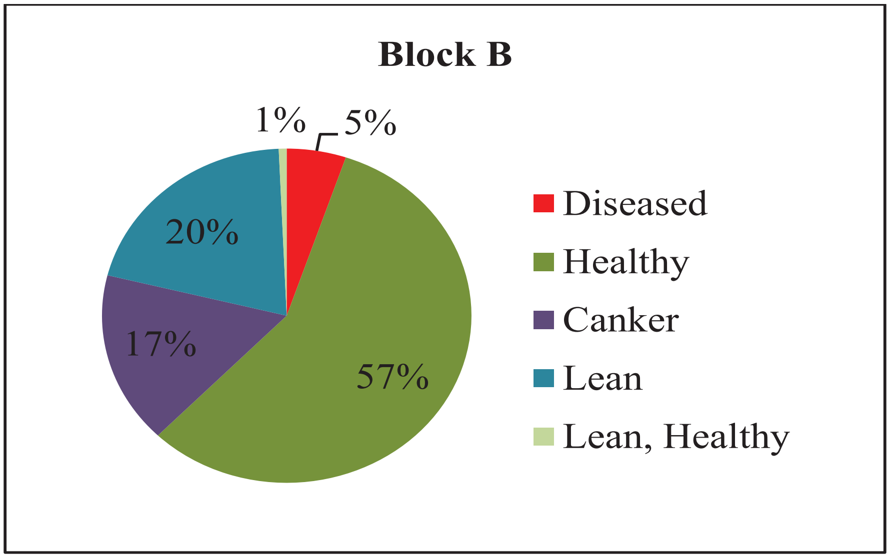

Fig. 7. Distribution of trees condition in Block B

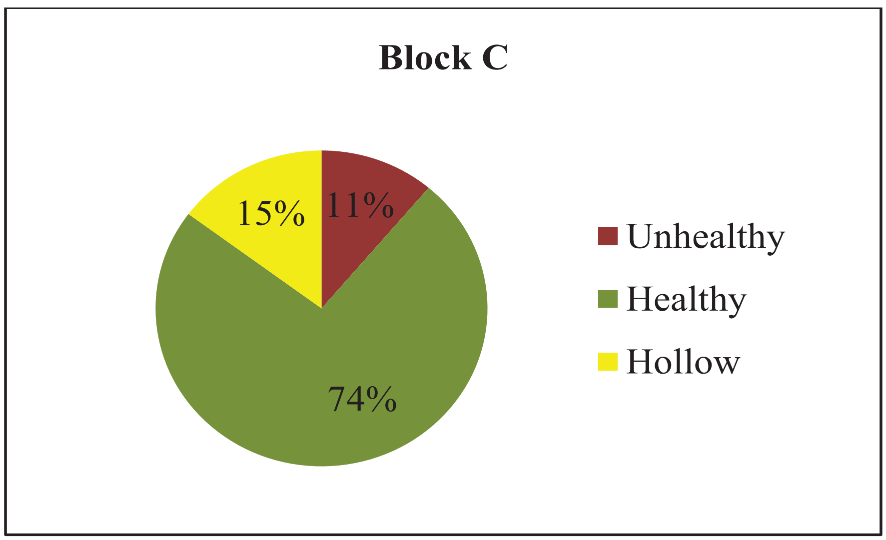

Fig. 8. Distribution of trees condition in Block C

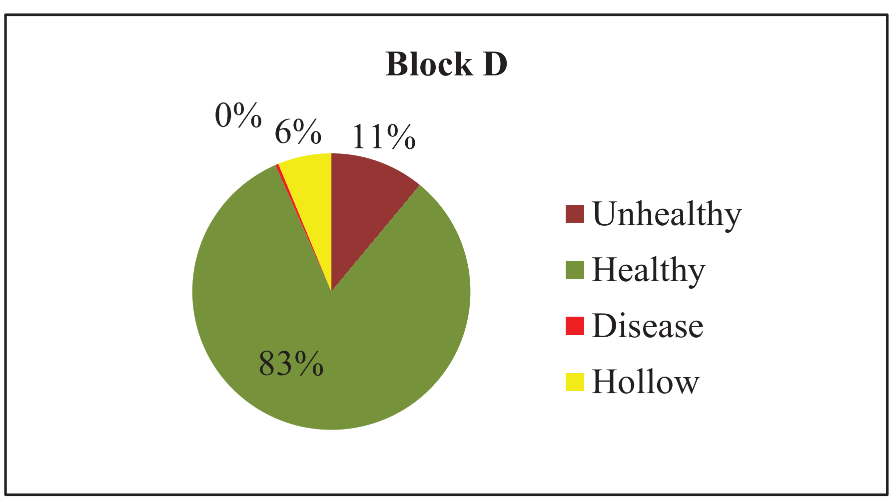

Fig. 9. Distribution of trees condition in Block D

3.2.5. Block E

Under the prevailing environmental conditions, Miani Sahib has great influence and contribution in defense against impure air. Block E exhibits the satisfactory state of trees but on the other hand, the block is also encountered with hollow and unhealthy trees which may weaken the trees and cause serious problems for other trees in the block. Hollow and weak trees are also discussed and reported in earlier study of Lorenzini and Nali [23] which support results of the present research (Figure10).

3.2.6. Block F

Visual interpretation of trees' health describes the highest value of healthy trees in Block F, i.e. 73% (Figure 11) which has the broad benefit for the urban environment reported in the study of Pearce and Tattar [101]. Further, Fig. 11 demonstrates the highest percentage of hollow trees comparing to other blocks of Miani Sahib. Simultaneously, data in Figure 8 interprets that poor state and health of trees can reduce their life span which is reported in the study of Magasi [102] and support the findings

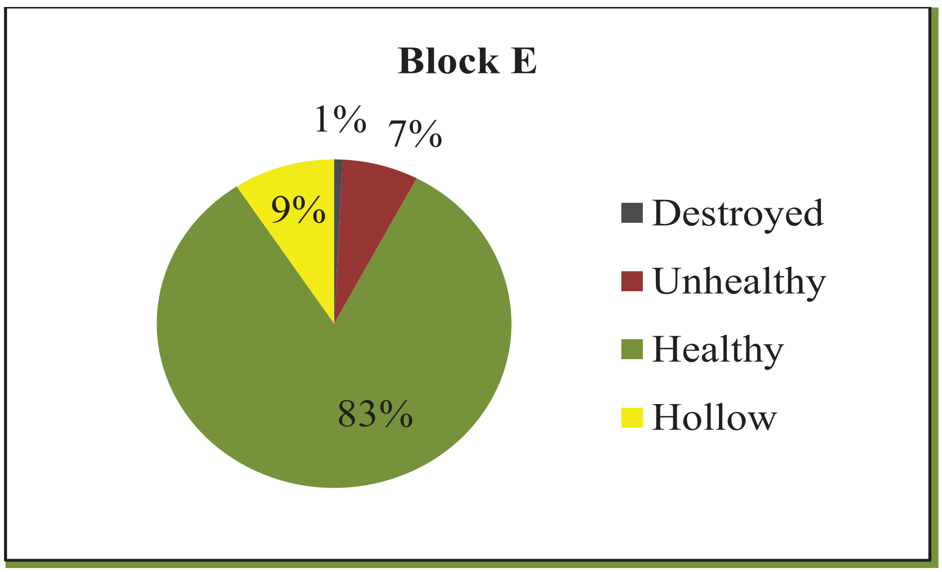

Fig. 10. Distribution of trees condition in Block E

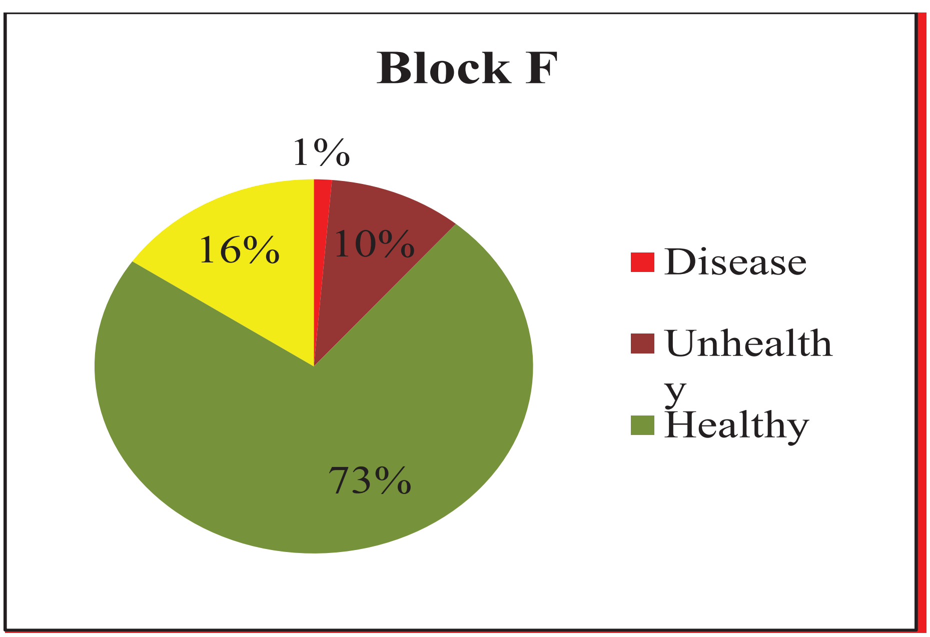

Fig. 11. Distribution of trees condition in Block F

of the current data too.

3.2.7. Block G

Trees are assets of the community [103] and healthy trees are an important component to boast up urban green environment which support results of the previous study conducted by Pearce and Tattar [101]. From Figure 12 results, it is evident that 13% of trees are decaying due to environmental stress reported in the earlier study of Wargo et al [103] and support the analysis of present results. Furthermore, results also illustrate the physical health of Block G trees. The visual results interpret the percentage of the healthy trees i.e., 82% [104, 105] which produce healthier air and indicate the Block G dynamic green infrastructure. Moreover, healthy trees are capable of accumulating and absorb particulate and gas pollutants as reported by Salmond et al. [106]. On the other hand, healthy structure of trees provides an opportunity to achieve directly or indirectly 15 out of 17 United Nations Sustainable Development Goals (UN SDGs). So, trees are well known and reported nature-based solution (NBS) to improve the environmental conditions. In the earlier study, trees are acknowledged by their various benefits by Pearce and Tattar [101] and support the recent research. While Figure 13 represents the overall spatial location of trees condition from A to G Block of Miani Sahib Graveyard.

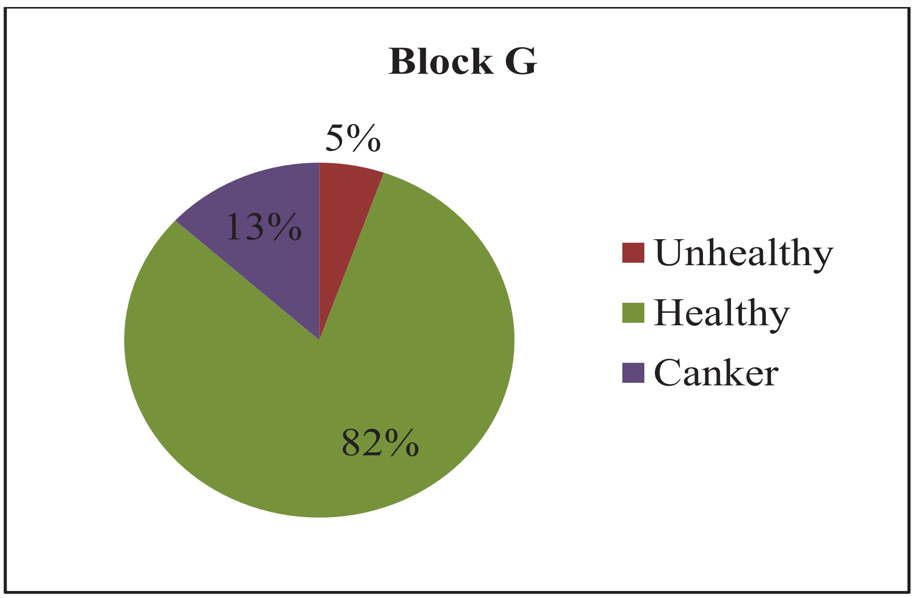

Fig. 12. Distribution of trees condition in Block G

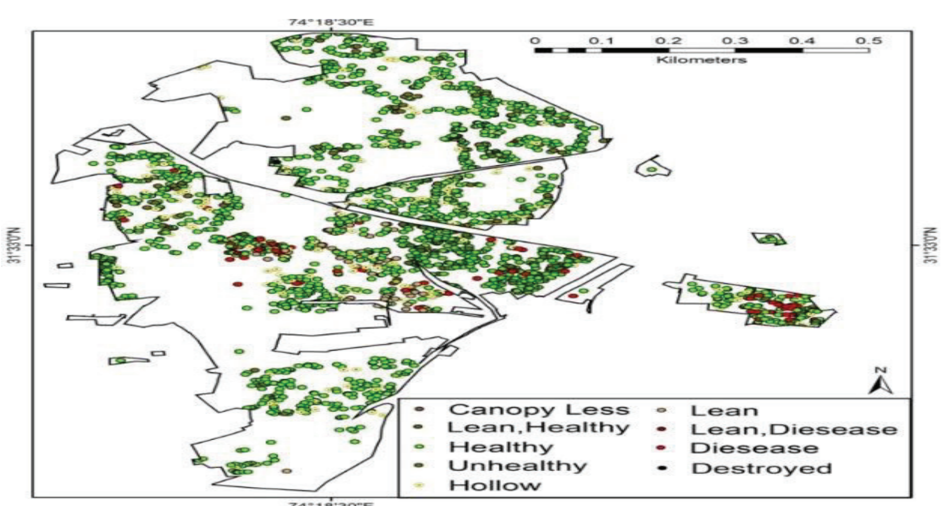

Fig. 13. Spatial distribution of trees condition in Miani Sahib Graveyard

4. CONCLUSION AND RECOMMENDATION

Trees play vital role in human life from the cradle to the grave. Technically, they are proven significant natural sources to store carbon and reduce airborne pollutants. From the perspective of environment and economic development, they have tremendous potential to meet the UN SDGs Goals. Therefore, to evaluate the green infrastructure, the current study presents the density, diversity and durability of Lahore's graveyards' trees such as Miani Sahib and Gora. By examining and reviewing the surveyed data, it was noticed that both graveyards lack in tree cover which can hardly tackle harsh summer and winter smog. Monitoring results of trees species indicated that Gora Graveyards lack in tree diversity as compared to Miani Sahib (Table 1 and 2). Regardless, the high percentage of healthy trees is identified and evaluated in both graveyards and needs to increase tree cover to purify air. In order to receive the environmental and economic benefits, there is a dire need to plant most suitable tree species to overcome airborne pollutants. The right species will not only improve the air quality but will also knock down the risk of a pandemic as there is scientific consensus that Coronavirus is most dreadful with particulate pollutants. For this reason, the following reported tree species are recommended to plant in graveyards for ecosystem restoration such as Neem *(Azadirchta indica)*, Indian laburnum (*Cassia fistula*), Gulmohar (*Delonix regia*), Pipal (*Ficus religiosa*), Java plum (*Syzygiumcumini*), Jacaranda (*Jacaranda mimosifolia*), Indian lilac (*Lagerstroemia indica*) and Temple tree (*Plumeria rubra*) which are most suitable in urban environment [107] and viable nature-based solution [108] to overcome the pandemic crisis [109, 110].

5. ACKNOWLEDGMENT

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