Assessing spatial distribution and residents satisfaction for urban green spaces in Lahore city, Pakistan

Amna Shoaib · **Kinza Nadeem** · **Hafiza Saba Islam** · **Atia Saleemi**

Abstract Urban green spaces are an essential element of development planning which provides multiple benefits to society. This study was carried out in an explorative manner to examine the spatial distribution of urban green spaces and develop an air quality index map in Lahore, Pakistan. It also investigates the satisfaction level among residents of ten administrative zones for maintenance, security, plantation, cleanliness, and availability of parks. For this purpose, a total of 1110 questionnaires, 111 from each zone were filled by people residing in the respective sector for more than 5 years. The results showed that green spaces had acquired 5% (88 sq. km) of the total space of Lahore, with the most land area (27.22 sq. km) available in the Iqbal zone and the least (1.22 sq. km) in the Wagha zone. The analysis revealed that 35% area of the Gulberg zone includes green spaces. There is a positive correlation between green spaces and air quality in different zones of Lahore. Walking is the most preferred mode to visit green spaces, as 57% indicated that nearest parks are within 10 min walking radius. People residing in Gulberg and Cantonment had overall high satisfaction and those living in Ravi and Shalamar zone were least satisfied with all services. Recommendations include improvement in the park management system, design of new planning standards, ensuring accessibility, and enhanced security mechanisms.

Keywords Green infrastructure · Lahore · Livability · Parks · Spatial planning

Introduction

Cities are growing at an unprecedented rate, 55% of the world population is living in urban areas, and it will further increase to 68% by the year 2050 (United Nations, 2018). This rapid growth impacts sustainable development and reduces green space areas for residents in cities on varying levels and intensities (Jim et al., 2018; Krefis et al., 2018). It increases the visitor pressure in available green spaces and impacts infrastructure and quality of life (Peterson, 2017). Urban green spaces are an essential element of green infrastructure, which enhances local resilience and promotes sustainable living by improving the health and prosperity of residents (Orr et al., 2014).

Social equity in the cities can be achieved by distributing green spaces in a way that all residents should have accessible parks within the same distance

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(Cartier, 2021). The World Health Organization (WHO) suggests that 0.5 hectares of green space area should be available for people within 300 m of their houses (WHO, 2016). Similarly, WHO also recommended that every city should devote a minimum of 9 square meters to a maximum of 50 square meters area per person for green space (WHO, 2010; Morar et al., 2014). Globally, five kinds of standard approaches are used to provide green spaces within the cities which include area percentage, population ratio, specifications for facilities, catchment area, and local standards (Veal, 2013). This entirely depends on local authorities to select particular standards and provide accessible, safe, and functional green spaces for the wellbeing of citizens.

Developed countries are more focused on green development and cities like Singapore, Dublin, Nottingham, Sydney, Melbourne, and Hanover have revolutionized their existing infrastructure facilities to accommodate more green spaces (Harris, 2021). The global data reveals Oslo has the highest percentage (68%), Singapore (47%), Sydney (46%), Vienna (45.5%), Zurich (41%), Stockholm, Helsinki, and Hongkong (40%) of the total city area allocated for green spaces (World Cities Culture Forum, 2021; Manikikar, 2020). These are far more than the minimum area percentage standard of 15 percent for green spaces in the cities (Scruggs, 2015; Veal, 2013). But the situation is very different in crowded Asian cities where public green spaces are still considered as luxury (Nigam et al., 2020) and most of the cities have less than 10 percent green area. Istanbul (2.2%), Mumbai (2.5%), Shanghai (2.8%), and Taipei (3.6%) are some of the Asian cities with the least green space allocation in the world (Lawler, 2018).

In recent years, the quality and quantity of urban green spaces have reduced (Mass et al., 2006) which resulted in more environmental hazards in cities. Housing developers focus on increasing saleable areas and allocate a lesser range to green spaces in development (Fruth et al., 2019). The planning process is unclear about the factors that develop good quality green areas, and the blame is on planners for following outdated standards for allocating fewer green spaces (Jim et al., 2018; (Haaland & Van Den Bosch, 2015). The quality and accessibility of urban green spaces are subjective which vary between users and are difficult to measure as compared to quantity (Sturm & Cohen, 2014).

Despite the rich literature on the importance of green spaces, limited research is available in the context of developing countries (Rigolon et al., 2018) that focus on the current provision and satisfaction of green spaces in the cities. Pakistan is the fifth most populous country in the world with 225.5 million people, equivalent to 2.83% of the overall world population (Worldometers, 2021). Pakistan is a developing country with the worst record in air pollution and quality of life. It is the 7th most vulnerable county for climate change even though Pakistan contributes very little to the atmospheric greenhouse gases (UNDP, 2017). It is on 135th rank in producing the total quantity of greenhouse gases (GHG's) globally (Government of Pakistan, 2010). Realizing the importance of greenery and its positive impact on the environment, the Government of Pakistan has initiated a national level project in 2018 named *"Plantation of 10 billion trees"* within 5 years to improve the environment and fight climate change (Constable, 2018).

Urban areas of Pakistan lack planned green spaces and already established areas are developed in such a way that there is not enough space to create parks. The green infrastructure facilities available in Karachi and Lahore are declining and cannot integrate the green space requirement of its residents (Rayan et al., 2021). Lahore is the second most populated city in Pakistan. In the past, Lahore city was famous as the 'city of gardens' in Pakistan, but today, it is among the most polluted cities in the world (WWF, 2018; Ghani, 2018). Instead of planting more trees, Lahore is losing its green cover fast in an account of development projects that demand cutting down trees. Tree cover went down by 75% from 2007 to 2015 in the city, and if unplanned and uncontrolled urban expansion continues, it will further decrease (Ghani, 2018; Hassan, 2017). This trend of cutting trees and depletion of green spaces in Lahore is giving rise to environmental issues, like smog which spreads rapidly and is becoming out of control. The smog season is affecting Lahore for the last 5 years, but every year its intensity increases from previous ones (Shabbir, 2018). It impacts public health as people face asthma, allergies, eye infections, and other respiratory and cardiac problems due to smog (Riaz & Hamid, 2018).

By keeping into consideration, the importance of urban green spaces in improving the city environment and individual well-being this research investigates

the spatial distribution of urban green spaces in administrative zones of Lahore, the capital city of Punjab Province in Pakistan. The paper aims to assess the percentage distribution of green spaces in Lahore; analyze the air quality index with green spaces, obtain the satisfaction level of users for the available services in the parks, and to devise recommendations for enhanced user facilities of urban green spaces in Lahore.

Literature review

Green spaces refer to public and private open spaces in urban and rural areas, primarily covered by vegetation, which are directly (active or passive recreation) or indirectly (positive influence on the urban environment) available to a variety of users and communities (Cilliers, 2015). Green spaces are an integral part of urban areas which helps in maintaining sustainability and environmental quality. The integration of urban green spaces in land use planning improves health and contributes positively towards environmental sustainability (Kolavalli, 2018). The harmony between green spaces and architectural elements of buildings can create more functional, and sustainable communities. Therefore, green spaces develop livable communities and ensure effective urban planning to achieve sustainable cities by formulating new policies and tools to support livability (Garau & Pavan, 2018; Zuniga-Teran et al., 2020).

Different cities around the world have started development on green planning and formulated policies to ensure green communities by 2050. Cities in Sweden, Denmark, Netherlands, Austria, and Canada are trying to incorporate nature into landscapes to improve the quality of life for urban residents (Xiao, 2018). It also incorporates effective strategies to maximize urban nature by promoting green roofs and protecting existing park spaces (Law et al., 2017). It is easier for new or less developed cities to adopt green policies as compared to established cities which face multiple challenges to create space for green infrastructure within existing land-uses. It requires careful and innovative planning techniques to include green spaces in limited areas within well-settled cities (Parker, 2017).

Benefits of green spaces

Green spaces usually present as public open spaces, parks, and other nature-based settings bring multiple social, economic, health, and environmental benefits to the given area (Shoaib, 2021). Green areas should be easily accessible for all population groups and distributed equitably within the city (WHO, 2017). They serve as a place of social interaction for people and promote sustainable development, urban resilience, and quality of life in residential communities. The most measurable benefits of green spaces are in the environmental sector which reduces stormwater runoff, urban heat islands, and carbon emissions. It helps in promoting a healthy environment with improved air quality, climate change adaptation, and biodiversity options (Burley, 2018; Kim & Song, 2019).

Green spaces are also known to improve the air quality index in zones where parks and green settings are in abundance. Urban green and blue areas enhance air quality by reducing pollution and greenhouse gas emissions in the air (WHO, 2016). The green spaces regulate temperatures and offset the urban heat island effect in the cities with shading and other physical processes. The increase in infrastructural development, car ownership rate, and industrial emissions with the decline in green spaces has resulted in poor air quality in cities (Suppakittpaisarn et al., 2017).

The presence of green spaces attracts business and economic opportunities by increasing property prices of adjacent commercial or residential areas, creating tourism prospects, and establishing profitability in local area markets (Kim & Song, 2019; Xiao, 2018). Visiting greenspaces boosts cognitive and mental well-being, improves productivity, promotes psychological health, and improves the physical activity of the users which helps in a healthy lifestyle (Burley, 2018; Law et al., 2017). Access to green spaces has proved to be highly effective in enhancing the quality of life for residents. An epidemiological study conducted in the Netherlands reported a positive relationship between perception of health and the quantity of urban green spaces in neighborhoods (Braubach et al., 2017). The social benefits of green spaces are non-profitable which serve as a place of social interaction for people, improve aesthetic value, and improvise housing and public facilities (Suppakittpaisarn et al., 2017; Xiao, 2018). These green areas help build new

social connections and enhance neighborhood ties by serving as a gathering space for residents. Mental health, frequency of park use, and probability of weekly exercise decrease when park distance increase (Chawla, 2015; Sturm & Cohen, 2014). Thus, efficient planning is necessary for designing and placement urban green spaces to improvise user experience.

Users satisfaction with green spaces

The urban livability and quality of life can be improved significantly by understanding user perception towards available green areas (Krajter Ostoi´c et al., 2017; Ray Gozalo et al., 2018). It is an important measure to assess the efficiency and usability of parks for effective urban design and management. The utilization of facilities in the green spaces impacts individual choice for visiting certain parks and their decision to visit again in the future (Tsurumi & Managi, 2015). Resident satisfaction and perception towards planning and management of parks can be used in developing future policy decisions for the betterment of the area (Zhang et al., 2017). It will assist urban developers to deliver better facilities and incorporate possible changes pointed out by users to create a sense of attachment and association for people (Krajter Ostoi´c et al., 2017).

Different researches include resident satisfaction with urban parks and the factors that contribute to influencing their experiences. The size of the park, location, quality of the landscape, availability of public facilities is the physical features that impact individual choice for visiting parks (Akpinar, 2016; Evenson et al., 2016). Individual perception varies towards the different facilities like availability of benches for elder populations, presence of playgrounds for parents with children, and bicycle paths for bicyclists can change their opinion for certain green spaces. (Adinolfi et al., 2014; Ives, 2017). Proper maintenance of the provided facilities is the core element of green spaces to build a positive image for the users (Adinolfi et al., 2014; Wan & Shen, 2015). The absence of cleanliness, security, and maintenance creates negative experiences (Wang et al., 2015), henceforth, the physical features, management, and facilities in parks directly impact people's satisfaction and perception (Ives, 2017; Parker, 2017). Some external variables like crowded areas, frequency of organized events, and

socioeconomic aspects of users in parks like gender, age, education, and income can also affect user opinion (Jim & Shan, 2013; Sang et al., 2016).

Materials and methods

Case study

Lahore is the capital city of Punjab Province extended upon a total area of 1772 square kilometers (684 sq. mi) located on the bank of River Ravi (Government of Pakistan, 2000a). Lahore is the second most populated city of Pakistan with an annual growth rate of 4%. It is home to more than 12 million people (Khawar, 2017; Worldometer, 2021). On the global scale, the city is ranked as the 33rd most populated city in the world with a density of about 13,083 people per square kilometers (Demographia, 2021). Lahore has the country's best transport infrastructural facilities with easy access from every region of Pakistan via railway network, roads, and air service.

Lahore is famous as the city of gardens in Pakistan, but infrastructural development had reduced the green cover of the city and made it among the most polluted cities in the world (Ghani, 2018). The residents are concerned about reducing green spaces in the city and blames the authorities for diminishing green areas. The urban green spaces in Lahore are mostly used as parks for social gatherings and recreation by the citizens (Shirazi & Kazmi, 2016). The most famous city parks include Hazuri Bagh, Shalamar Garden, Gulshan-e-Iqbal Park, Nasir Bagh, Jilani Park, Jallo Park, Bagh-e-Jinnah, Model Town Park, Greater Iqbal Park (Jahan et al., 2019). Apart from recreation, these parks are also used for community meetings, political campaigns, and social awareness workshops in the city.

The city is subdivided into ten administrative zones namely Ravi, Shalamar, Data Gunj Baksh, Gulberg, Samanabad, Cantonment, Nishtar, Wagha, and Iqbal zone (Fig. 1). These administrative zones are controlled by Lahore Development Authority (LDA), Cantonment Board, Defense Housing Authority (DHA), and Local Government & Community Development Department (LG&CDD). Parks and Horticulture Authority (PHA) is mainly responsible for maintaining and managing urban green space and parks in Lahore. Green belts or other natural settings
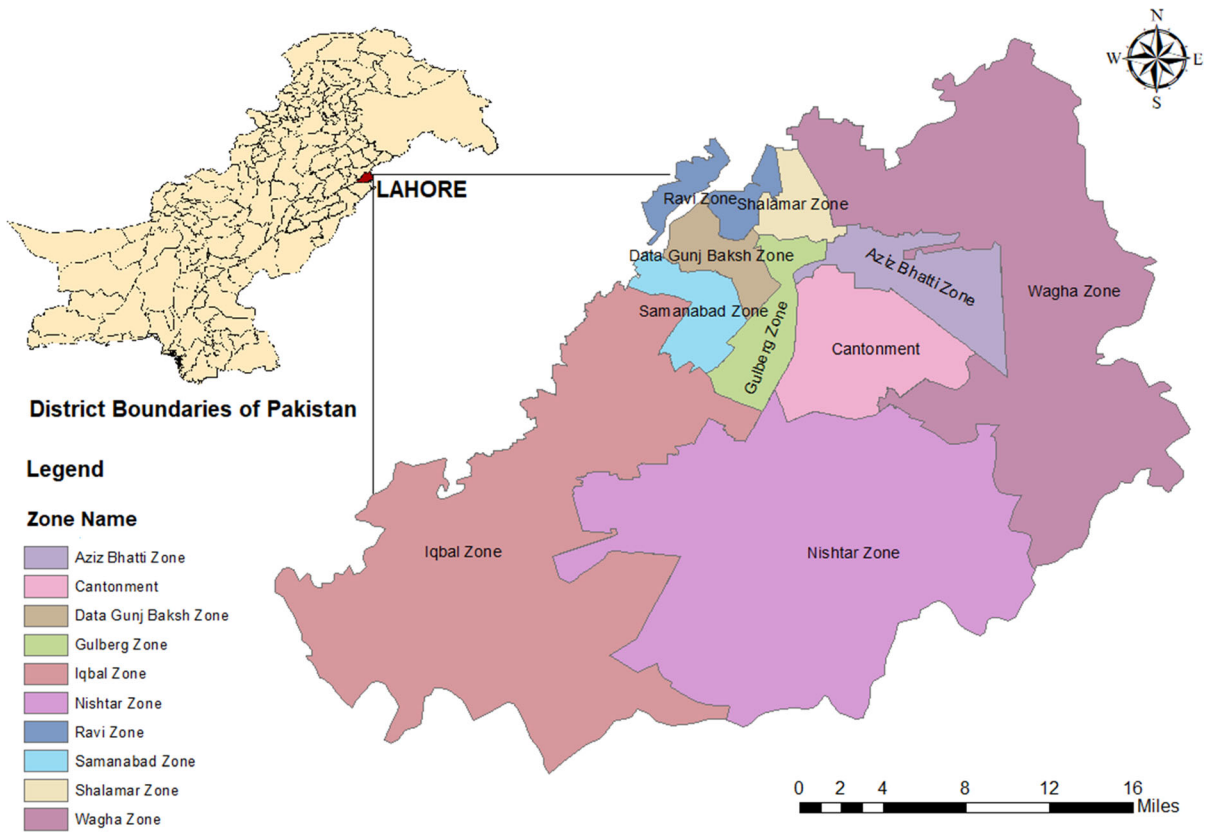
Fig. 1 Case study-administrative zones of Lahore *Source*: (Authors Own Work, 2021)

along the major roads and traffic junctions are under the jurisdiction of PHA. In the case of private housing schemes, maintaining parks and green spaces comes under the responsibility of the concerned authority.

The jurisdiction of PHA includes the management and maintenance of 828 parks in different areas of Lahore covering an area of about 88 square kilometers. Green spaces constitute about 5% of the total city area with the majority of green spaces in the Gulberg zone. Green spaces data is organized at the union council level which can be sub-categorized under zones based on their locations. Table 1 shows detail of all zones with their present distribution of green spaces.

Data collection

This study was conducted in an explorative and comparative manner to examine the distribution of urban green spaces in different zones of Lahore and resident satisfaction with the facilities. The research

data was gathered from primary as well as secondary sources. The data for present urban green spaces was collected from the Parks and Horticulture Authority (PHA) and analyzed in terms of administrative zones of Lahore.

The data for Air Quality was extracted from IQ Air Visual website and Punjab Meteorological Department for the year 2019. To analyze the impact of urban green spaces on air quality in different zones of Lahore ten locations with preinstalled air quality monitors were selected to develop an air quality index map. For this purpose, air quality monitors were installed at Misri Shah, Daroghwala, Bandh Road, Raiwind Road, Mozang, Canal Road Mughal Pura, Lahore US Embassy, Cantonment, Jail Road, and Thokar Niaz Baig were assessed.

Furthermore, to analyze the usability and condition of green spaces, people living in ten administrative areas of Lahore (Fig. 1) were surveyed from June to December 2020 through questionnaire analysis. For questionnaire analysis, a stratified random sampling

Table 1 Area and green space distribution in Lahore *Source*: (Parks and Horticulture Authority, 2020)

Name of zones	Total area (sq. km)	Total green space area (sq. km)	Percentage (%)
Ravi	64.71	4.55	7
Shalamar	26.44	4.24	16
Aziz Bhatti	68.65	0.95	1
Data Gunj Baksh	34.01	6.73	20
Samanabad	38.34	5.68	15
Gulberg	43.54	15	34
Wagha	470.7	1.22	0.3
Iqbal	445.1	27.22	6
Nishtar	394.46	6.78	2
Cantonment	186.05	15.32	8.2
Total	**1772**	**88**	**5**

technique was used and different areas within the geography of administrative zones were selected. Table 2 shows the selected areas within each zone from which questionnaire surveys were randomly conducted to analyze resident satisfaction for urban green spaces. Figure 2 depicts the geographical location of the selected survey areas in the relevant administrative zones of Lahore.

The sample size for the questionnaire survey was determined using the **Solvin method,** as it provides easy computation solely based on population data. Therefore, the sample size for research was calculated by taking the population of Lahore (N) as 12,642,000 and the margin of error (e) as 3% in the formula below:

$$n = \frac{N}{1 + Ne^2}$$

$$n = 12{,}642{,}000/1 + \left(12{,}642{,}000 * (0.03)^2\right)$$

$$n = 12{,}642{,}000/1 + (11377.8)$$

$$n = 1110$$

A total of 1110 respondents were surveyed to inquire about the satisfaction level of available urban green spaces in Lahore. The sample size was equally distributed in ten selected zones, and **111** respondents from each zone were selected randomly for this research work. People living in the given location for more than 5 years were included, as they would be in a better position to evaluate the facilities and services in the zone over the years.

The questionnaire included multiple open and close-ended questions related to the socio-economic characteristics of respondents and their preferred time,

Table 2 Survey locations for questionnaire analysis *Source*: (Authors Own Work, 2021)

Zone name	Survey areas
Ravi	Muslim Park, Qila Lachman Singh, Begum Kot
Shalamar	Chah Miran, Shadbagh, Wassanpura
Wagha	Barki, Daroghawala
Aziz Bhatti	Mughalpura, Tajpura, Harbanspura
Data Gunj Buksh	Rewaz Garden, Shadman, Islampura
Gulberg	Model Town, Gulberg, Faisal Town
Samanabad	Samanabad, Ichhara, Gulshan-e-Ravi
Iqbal	Johar Town, DHA EME Society, Township
Nishtar	Kahna Nau, Green Town, Kamahan
Cantonment	DHA Phase I, Cantt, Askari X
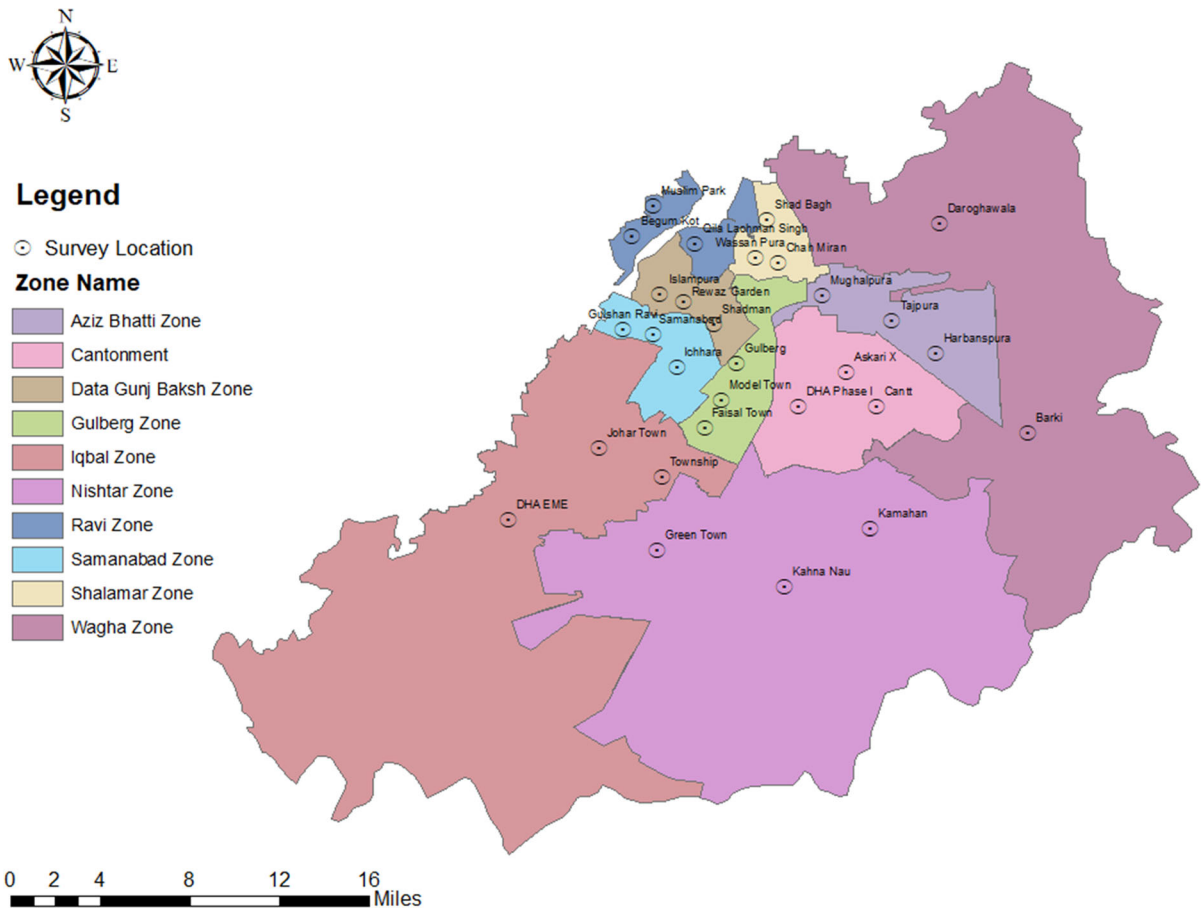
Fig. 2 Geographical location of survey Areas *Source*: (Authors Own Work, 2021)

frequency, purpose, and nearest green space location, etc. It also included questions dealing with respondent satisfaction level for green space facilities related to maintenance, security, cleanliness, plantation, and availability of parks for comparative analysis between zones.

Results and discussions

Distribution of urban green spaces

Parks and open spaces are considered as lungs for cities, as green spaces represent a strong connection to sustainable development. Lahore has 7.3 square meters of green space per inhabitant, on the contrary Delhi has a lesser area but more population than Lahore. There are 21.52 square meters of open space per capita in Delhi whereas, Mumbai has an abysmal

1.24 square meters of accessible open space per person. Other global megacities have much better green spaces distribution like London has 31.68 square meters; New York City has 26.4 square meters and Tokyo has 3.96 square meters of open space per capita (Manikikar, 2020). The United States of America (USA), has on average 12.1% area covered by parks in high-density cities (City Park Facts, 2017).

According to Table 1, Lahore, being a highly dense city of Pakistan has only 5% space covered by green spaces, with most of the green space area (27.22 sq. km) available in the Iqbal zone and least (1.22 sq. km) in the Wagha zone. By keeping into consideration, the percentage and green spaces distribution, it showed that the Gulberg zone had allocated 35% of the total area (15 sq. km out of 43.54) to green space that is the highest. Most of the high-income housing and commercial locations are within the boundaries of Gulberg (including Gulberg, and Model Town). The land area

for green spaces in Wagha and Aziz Bhatti zones which comes under the responsibility of PHA is less than 2% of the total. Whereas Ravi, Shalamar, Samanabad, Data Gunj Baksh, and Cantonment have more than 7% of the total area allocated to green spaces. Figure 3 illustrates the spatial distribution of green spaces in town boundaries, whereas Fig. 4 shows green space presence with population distribution in the respective zones.

Pakistan has no specific rules and regulations that emphasize certain percentages of green development in cities. The National Reference Manual (NRM) devised in 1983 advises having 4.85 to 8.62 square meters of space per capita for multiple parks in a city. The standards are outdated and not enough to cover the green space requirements for present cities with the growing population. Moreover, the NRM suggests having at least 5% to 7.5% open spaces in land use distribution in new development schemes (Government of Pakistan, 1984). Developed countries are more focused on green cities to achieve high quality of life for citizens. Therefore, greenery should be prioritized in policies and plan-making to develop sustainable and livable cities.

Lahore is developed on a typical leapfrog development pattern that has no capability of land-use alterations. The development sector of Lahore is under the control of LDA, LG&CDD, DHA, and Cantonment Board. The authorities mutually decided that new guidelines are required to prepare for future development. It will help achieve a certain land-use percentage, so the minimum standard for open spaces (green spaces) has been set to 7% and above in Punjab Private Housing Schemes & Land-use Sub-Division Rules. (Government of Punjab, 2010). LDA has also proposed similar standards for minimum open spaces that defined a minimum of 7% open spaces for housing schemes of size 500 Kanal and less, and a minimum of 10% for housing schemes with more than 500 Kanal area (LDA, 2014).
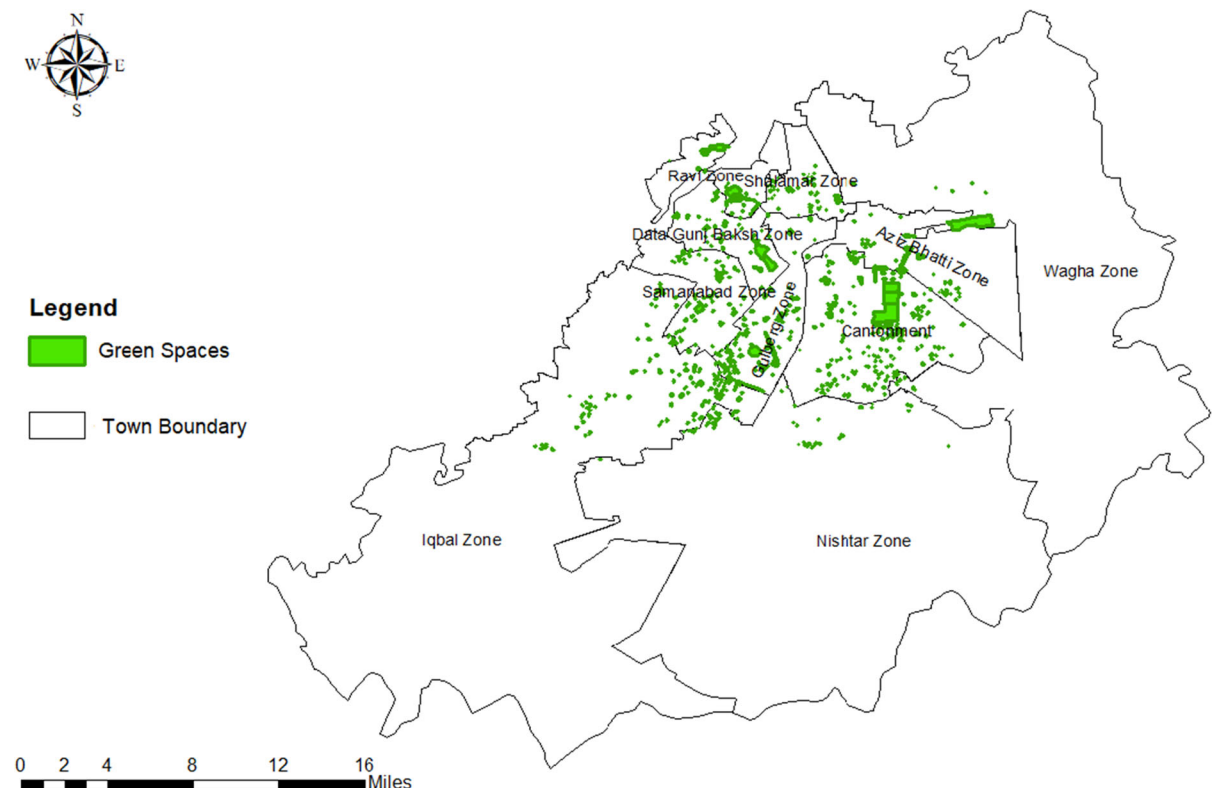
Fig. 3 Spatial distribution of green spaces in Lahore *Source*: (Authors Own Work, 2021)
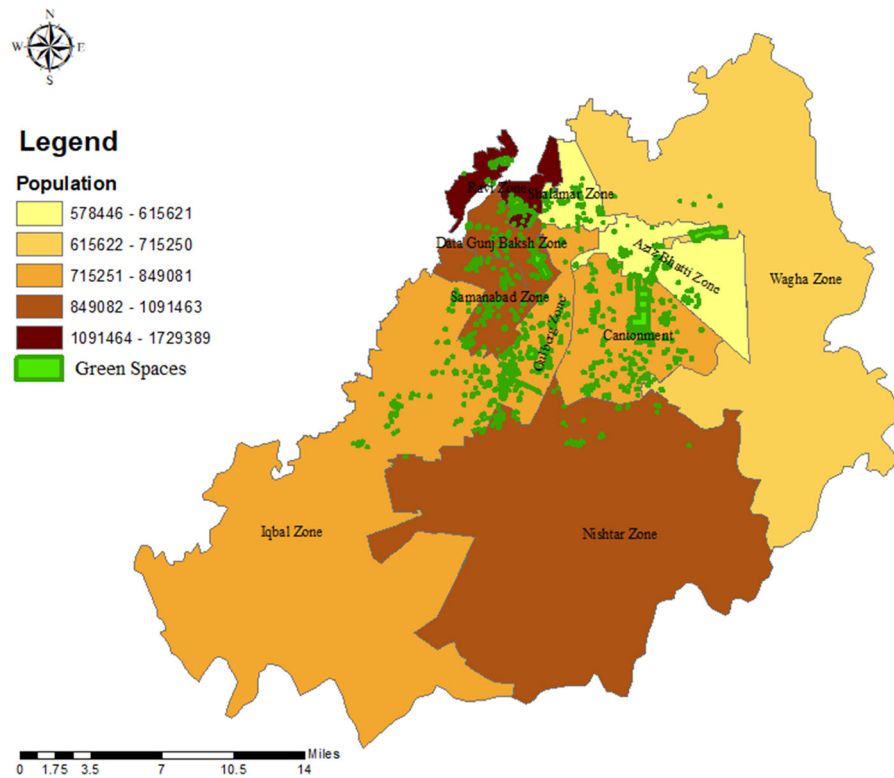
Fig. 4 Population and green spaces distribution in Lahore *Source*: (Authors Own Work, 2021)

Analyzing air quality with urban green spaces

The mean centralized technique was used to formulate an air quality index map with the available data, average values of all the points computed using weighted against latitude and longitude positions with the formula:

$$\overline{x}_{\omega C} = \frac{\sum f_i x_i}{\sum f_i}$$

where ωC = Weighted Center and f_i = Frequency/weighted factor.

The resultant points were then added to ArcGIS and the inverse distance weighting (IDW) technique was applied to generate Air Quality Index Map for Lahore as shown in Fig. 5. The map uses eight categories of air quality assessment ranging from very good, good, good-moderate, moderate, moderate-unhealthy for sensitive people, unhealthy for sensitive people, unhealthy, and very unhealthy in different locations. The result showed that most areas of Cantonment and Gulberg zones have overall very good to good air quality as compared to other areas of Lahore. These

zones have 34% and 8% green spaces respectively which can be a leading factor towards good air quality as it depicts a positive correlation between green spaces and air quality. Whereas Samanabad, Ravi, and Shalamar zones have unhealthy and very unhealthy air quality index with some areas in Bandh Road, Daroghwala, and Misri Shah with stressed emphasis on very unhealthy environment. Data Gunj Baksh and Nishtar zone had good-moderate to moderate air quality and Iqbal zone, Wagha zone had categorized as unhealthy for sensitive people. Overall, the map illustrates that air quality level in majority areas of Lahore falls in the category of moderate and unhealthy for sensitive groups.

Residents satisfaction

The questionnaire survey was conducted in selected ten zones to analyze resident satisfaction for the available facilities in green spaces. Total 1110 questionnaires, 111 in each zone were randomly filled from people living in the specific area for at least 5 years.
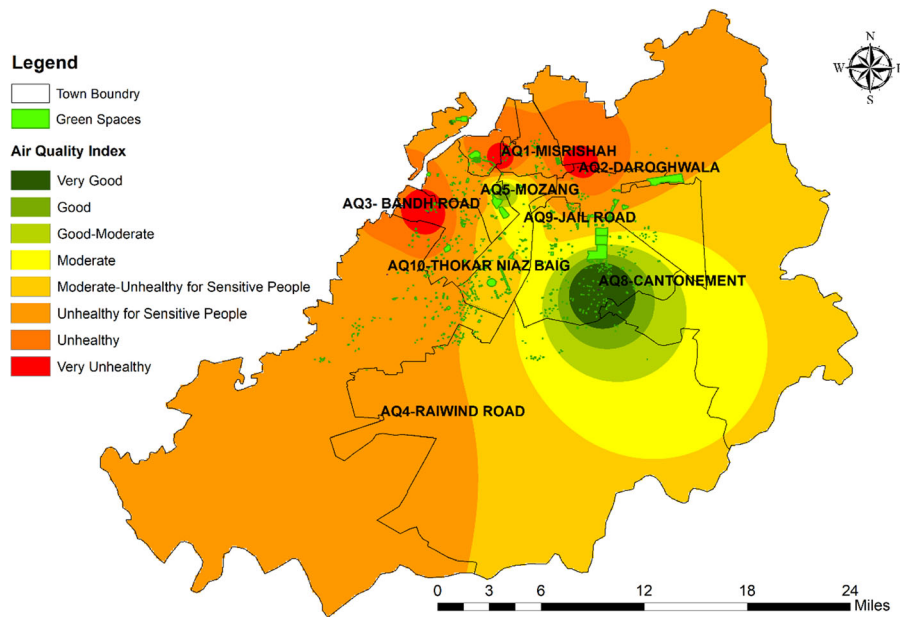
Fig. 5 Air quality index and green Spaces in Lahore *Source*: (Authors Own Work, 2021)

Data were analyzed on an individual as well as collective town basis to generate comparative results.

General characteristics of respondents

Table 3 shows complete detail of the personal characteristics of respondents. The results revealed that 47.5% of respondents included males and 52.6%

females of which 51.3% respondents were unmarried and 48.7% were married. Most people belonged to the young age group, 37% people were between 18 and 24 bracket and 28% in 25–30 years. 11% of the respondents had an age between 30 and 40 years, 13% in 40–50, and 11% were above 50 years.

The majority of the people (91.3%) responded that they prefer to visit green spaces. 48% of people visit

Table 3 General characteristics of respondents *Source*: (Authors Own Work, 2021)

| Personal characteristics of respondents	Categories	Percentage (%)
Gender	Male	47.40
	Female	52.60
Marital status	Married	48.7
	Unmarried	51.3
Age group	18–24 years	37
	25–30 years	28
	30–40 years	11
	40–50 years	13
	Above 50 years	11
Education	High	33
	Medium	41
	Low	17
	Illiterate	9
Visit green spaces	Yes	91.3
	No	8.7

parks and open spaces in the evening and 27% in the morning, 16% at night time and only 9% visit green areas in the afternoon. Due to extreme sunlight and warm weather most of the year people avoid visiting parks in the afternoon time (Fig. 6).

When asked about the distance to the nearest park, most of the respondents (57.3%) were of the view that parks are available within 10 min of walking distance, 21% had within a 15-min walk, 14% had green spaces in 20 min, and 8% with more than 20 min from home. Inquiring about the mode of travel for visiting green spaces, 53% people walk, 28% go by bike and 19% by car.

The purpose of visiting green spaces for the majority of the respondents (41%) was jogging/walking, 26% for outdoor activity, 15% visit with children and 7% as an escape from home, and 11% use for peace of mind and mental relaxation. The frequency of park visits also plays a vital role in satisfaction level 29% of respondents visit parks twice or more in a week, 28% daily, 14% once a week, and 3% never visit green spaces within 6 months (Fig. 7). 41% of respondents were of the view that vegetation and green spaces have reduced in the city due to infrastructural projects, 14% blamed lack of governmental interest, 21% believe it is due to the development of private housing schemes on agricultural areas and 24% thought because of road widening projects.

Satisfaction level for urban green spaces

The planning of cities matters when it comes to the provision of services and facilities. Copenhagen is known as the greenest city in the world. The idea
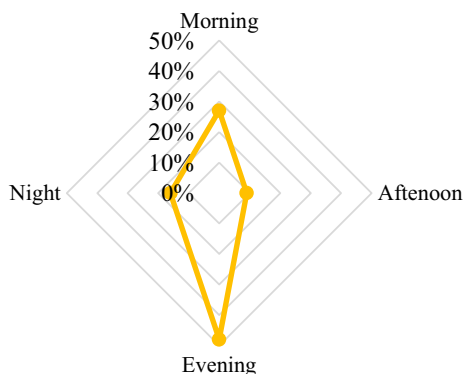
Fig. 6 Preferred time to visit green spaces *Source*: (Authors Own Work, 2021)

behind its sustainable greenery lies in the "Green Wedge Principle" to preserve green spaces between the settlements (Wilmott, 2020). The concept has made Copenhagen greener to the extent that 96% of the population can visit parks (or beaches) in less than 15 min (Ćirković, 2019). In Lahore, almost 75% population have this privilege although, service delivery in planning is not given much focus in Pakistan.

Park size and distance have a high impact on the frequency of visits (Tu et al., 2020), other characteristics of parks include security, cleanliness, plantation, and maintenance. It has been observed that plantation feature is achieved in green spaces but, when it comes to cleanliness and maintenance are deserted. People do not prefer to visit ill-managed parks as green spaces should focus on physical and mental health. The physical features, ease in the provision, and social interactions contribute towards peace of mind (Lee & Maheswaran, 2011).

Different indicators were selected to examine resident satisfaction for available green spaces in their neighborhoods. The indicators included maintenance, security, cleanliness, plantation, and availability of parks for comparative analysis between different zones (Fig. 8). The majority of the people living in Gulberg and Cantonment had high satisfaction with all the facilities, whereas, those living in Ravi, and Shalamar zones were least satisfied. Table 4 shows the values of coefficient of variance for all indicators which are highest (0.88) in Gulberg and least (0.42) in residents of the Ravi zone for green space facilities.

Overall, respondents had great satisfaction (80% and above) about the plantation, but people in all zones were not satisfied with security. Residents of Ravi, Shalamar, and Nishtar zones were 55%, 58%, and 67% unhappy about overall parks availability, whereas 90% and 91% residents of Gulberg and Cantonment contended with the current parks. Respondents living in Aziz Bhatti and Iqbal zones had 81% and 76% satisfaction, whereas those in Data Gunj Baksh and Samanabad zones were neutral about the availability of green spaces.

Conclusions

Urban green spaces are vital to enhance local resilience and promote sustainable living by

Fig. 7 Frequency of visits to green spaces *Source*: (Authors Own Work, 2021)
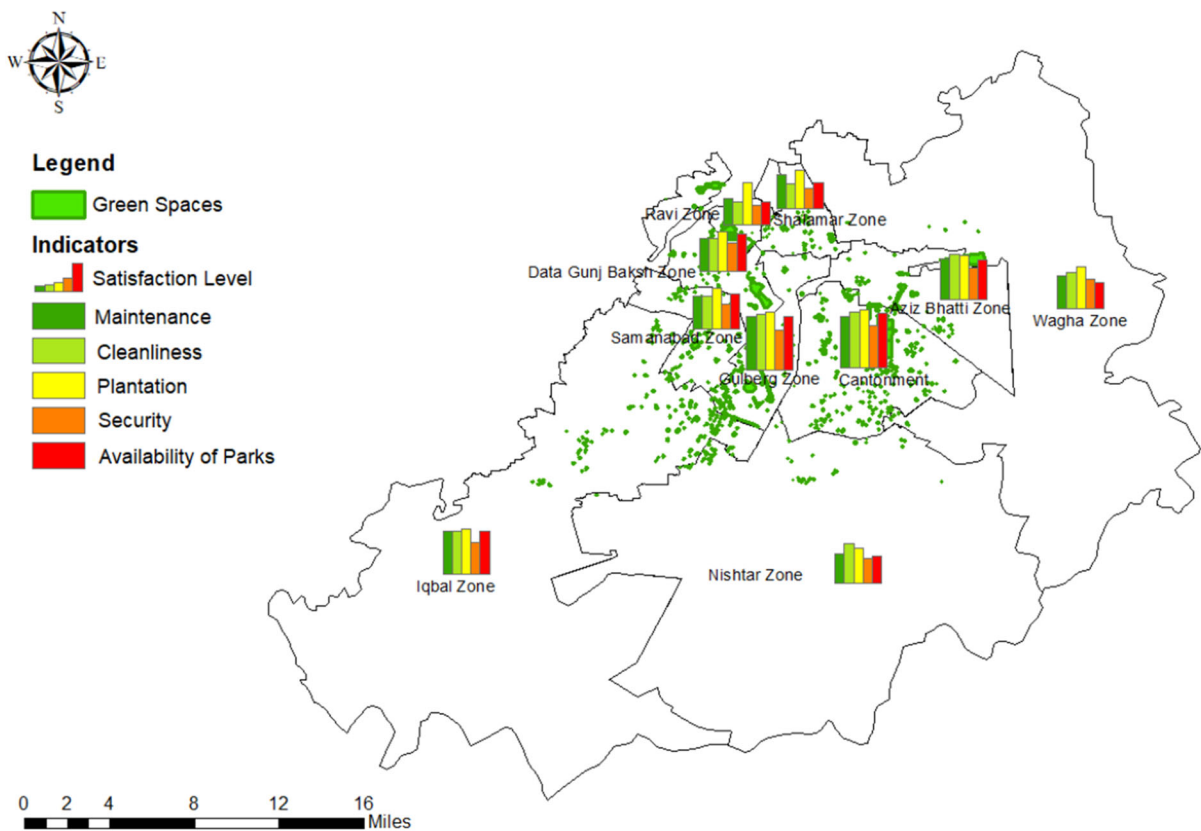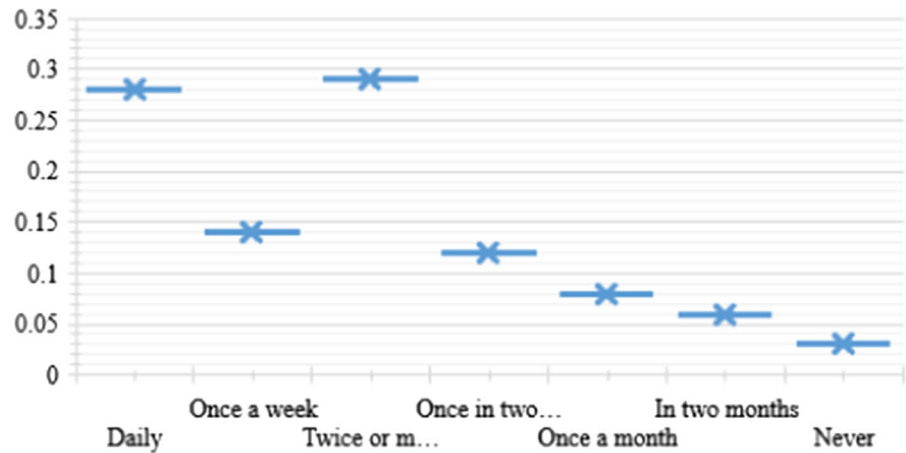
Fig. 8 Residents satisfaction level for green space facilities in Lahore *Source*: (Authors Own Work, 2021)

improving the health and well-being of residents. The quality and quantity of green spaces should be adequate with easy access for all population groups in the city. This research explored the distribution of urban green spaces and resident satisfaction with the green space facilities in administrative zones of Lahore. PHA is the controlling authority for the maintenance and management of urban green space in most of Lahore. The jurisdiction of PHA includes a total of 828 parks and almost all green belts for public roads.

Table 4 Values of coefficient of variance for resident satisfaction *Source*: (Authors Own Work, 2021)

Zones	Ravi	Shalamar	Aziz Bhatti	Data Gunj Baksh	Samanabad	Gulberg	Wagha	Iqbal	Nishtar	Cantonment
Coefficient of variance	0.42	0.47	0.67	0.58	0.55	0.88	0.55	0.70	0.53	0.87

Green spaces have acquired 5% of the total area of Lahore, with 27.22 sq. km in the Iqbal zone and the least land area of 1.22 sq. km in the Wagha zone. Gulberg zone has allocated 35% of the total area for green space. Overall, Lahore has 7.3 square meters of green space per inhabitant. The air quality index map-projected positive correlation between green spaces and air quality in different zones of Lahore. Cantonment and Gulberg zones had very good air quality whereas, Samanabad, Ravi, and Shalamar zones had unhealthy to very unhealthy air quality. There are no specific rules and regulations that emphasize the certain percentages of green development in Pakistani cities. No laws exist for the established built-up areas but for redevelopment purposes, it is mandatory to have 7% or above green space area. The questionnaire survey revealed that (48%) people prefer to visit green spaces in the evening and 29% of respondents prefer to go to parks twice or more a week. 53% of people use walking as a primary mode as (57.3%) residents had parks within 10 min of walking distance from their home. The reason for visiting parks for (41%) population is for jogging or walk and only 11% use green spaces for mental peace. 41% of respondents believed infrastructural development in the city has reduced vegetation and green spaces.

The people living in Gulberg and Cantonment had high satisfaction (0.87 mean value) for all the facilities. The green space distribution and air quality levels were also best in these two zones. Those living in Ravi, and Shalamar zones were least satisfied with the services. Overall, respondents had great satisfaction with the plantation, but people in all zones were least satisfied with security. Hence, emphasis should be on the rehabilitation and construction of secure and lush green spaces for a healthy community.

The research implies that the following radical steps should be taken on priority to improve green space management in Lahore.

1. PHA should have a proper management system for responsible garden managers for urban spaces. This will improve cleanliness and neat plantation with regular maintenance.
2. There is a dire need for proper planning standards for developing quality f It is suggested to devise three types of park standards:
   Design standards: Different infrastructure elements are required in various types of green spaces. These should be based on the size and location of green spaces
   Density-wise requirement standards: As per population density, the requirement of different parks should be devised. Catchment areas should be defined for developing these standards.
   Distance standards: The frequency of visiting green spaces majorly depends upon travel distance, so there should be defined guidelines for distance as well.
3. To improve the comfort level, there must be exclusive ramps for wheelchairs of the elderly/disabled and baby strollers to increase accessibility.
4. Proper hand wash facilities, washrooms, and drinking water facilities should also be available.
5. To gain monetary benefits, trusted vendors with clean food must also be given a small place as in a mini food court. This would help to bear the expenses of rehabilitation and maintenance of parks.

Declarations

Conflict of interest The authors have no conflict of interest to declare that are relevant to the content of this article.

Consent to participate All authors have given their consent to participate in a publication.

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References

Adinolfi, C., Suárez-Cáceres, G. P., & Cariñanos, P. (2014). Relation between visitors' behavior and characteristics of green spaces in the city of Granada, South-Eastern Spain. *Urban Forestry and Urban Greening, 13*(3), 534–542.

Akpinar, A. (2016). How is quality of urban green spaces associated with physical activity and health? *Urban Forestry and Urban Greening, 16*, 76–83.

Braubach, M., Egorov, A., Mudu, P., Wolf, T., Thompson, W. C., & Martuzzi, M. (2017). Effects of urban green space on environmental health, equity, and resilience. In N. Kabisch, H. Korn, J. Stadler, & A. Bonn (Eds.), *Nature-based solutions to climate change adaptation in urban areas.* Cham: Springer.

Burley, B. A. (2018). Green infrastructure and violence: Do new street trees mitigate violent crime? *Health & Place, 54*, 43–49.

Cartier, K. M. S. (2021). Growing equity in city green space, - *Eos, 102*, https://doi.org/10.1029/2021EO158443. [Online] Available from 21th October 2021: https://eos.org/features/growing-equity-in-city-green-space

Chawla, L. (2015). Benefits for nature contact for children. *Journal of Planning Literature, 30*(4), 433–452.

Cilliers, J. E. (2015). The importance of planning for green spaces. *Agriculture Forestry and Fisheries, 4*(4), 1–5.

Ćirković, S. (2019). Land use and transport in Denmark. *Centre for Public Impact* (*CPI*). [Online] Available from 14th July 2021: https://www.centreforpublicimpact.org/case-study/land-use-and-transport-denmark/

City Park Facts. (2017). City parks facts report. *The Trust for Public Land*. [Online] Available from 4th August 2021: https://www.tpl.org/2017-city-park-facts

Constable, P. (2018). In Pakistan, an ambitious effort to plant 10 billion trees takes root. *The Washington Post.* [Online] Available from 5th June 2021: https://www.washingtonpost.com/world/asia_pacific/in-pakistan-an-ambitious-effort-to-plant-10-billion-trees-takes-root/2018/10/12/18f14474-c015-11e8-9f4f-a1b7af255aa5_story.html?noredirect=on&utm_term=.ef008770bc2b

Demographia. (2021). Demographia world urban areas. 17th Edition 202106. [Online] Available from 9th October 2021: http://www.demographia.com/db-worldua.pdf

Evenson, K. R., Jones, S. A., Holliday, K. M., Cohen, D. A., & Mckenzie, T. L. (2016). Park characteristics, use, and physical activity: A review of studies using SOPARC (system for observing play and recreation in communities). *Preventive Medicine, 86*, 153–166.

Fruth, E., Kvistad, M., Marshall, J., Pfeifer, L., Rau, L., Sagebiel, J., Soto, D., Tarpey, J., Weir, J., & Winiarski, B. J. L. U. P. (2019). Economic valuation of street-level urban greening: A case study from an evolving mixed-use area in berlin. *Land Use Policy, 89*, 104237. https://doi.org/10.1016/j.landusepol.2019.104237

Garau, C., & Pavan, M. V. (2018). Evaluating urban quality: Indicators and assessment tools for smart sustainable cities. *Sustainability, 10*(3), 575.

Ghani, A. (2018). Lahore is losing its green cover – fast. *MIT Technology Review, Pakistan*. [Online] Available from 15th June 2021: http://www.technologyreview.pk/lahore-is-losing-its-green-cover-fast/

Government of Pakistan. (1984). National reference manual on planning & infrastructure standards (NRM). *Environment & Urban Affairs Division, Ministry of Housing & Works*, Pakistan.

Government of Pakistan, District Census Report (2000a) Lahore population census organization. *Statistics Division, Islamabad*.

Government of Punjab. (2010). Punjab private housing schemes and land sub-division rules. *Local Government & Community Development Department, Punjab*.

Government of Pakistan. (2010). Task force on climate change final report. *Planning Commission, Government of Pakistan, Islamabad*.

Haaland, C., & Van Den Bosch, C. K. (2015). Challenges and strategies for urban green-space planning in cities undergoing densification: A review. *Urban Forestry & Urban Greening, 14*(4), 760–771.

Harris, L. (2021). 8 cities rewilding their urban spaces. World Economic Forum. [Online] Available from 8th October, 2021: https://www.weforum.org/agenda/2021/06/8-cities-rewilding-their-urban-spaces/

Hassan, A. (2017). A major reason behind lahore smog revealed by Belgian Researchers. *Pro Pakistani.* [Online] Available from 16th July 2021: https://propakistani.pk/2017/11/14/major-reason-behind-lahore-smog-revealed-belgian-researchers/

Ives, C., Oke, C., Hehir, A., & Gordon, A. (2017). Capturing residents' values for urban green space: Mapping, analysis and guidance for practice. *Landscape and Urban Planning, 161*, 32–43.

Jahan, Z., Shirazi, S. A., & Sharkullah, K. (2019). Evaluation of residents perception about socioeconomic and environmental impacts of urban green spaces of Lahore, Pakistan. *International Journal of Economic and Environmental Geology, 10*(2), 87–96.

Jim, C. Y., Konijnendijk van den Bosch, C., & Chen, W. Y. (2018). Acute challenges and solutions for urban forestry in compact and densifying cities. *Journal of Urban Planning and Development, 144*(3), 1–12. https://doi.org/10.1061/(ASCE)UP.1943-5444.0000466

Jim, C. Y., & Shan, X. (2013). Socioeconomic effect on perception of urban green spaces in Guangzhou, China. *Cities, 31*, 123–131.

Khawar, H. (2017) Lahore World's largest city in 2050. *The Express Tribune*. [Online] Available from 30th June 2021: https://tribune.com.pk/story/1498663/lahore-worlds-largest-city-2050/

Kim, D., & Song, K. S. (2019). The multifunctional benefits of green infrastructure in community development: An analytical review based on 447 cases. *Sustainability, MDPI, 11*(14), 3917.

Kolavalli, C. (2018). Strategies for creating equitable urban greenspace in global cities [Book review]. *Journal of Agriculture, Food Systems, and Community Development, 8*(1), 193–195. https://doi.org/10.5304/jafscd.2018.081.014

Krefis, A. C., Augustin, M., Schluzen, K. H., Obenbrugge, J., & Augustin, J. (2018). How does the urban environment affect health and well-being? A systematic review. *Urban Science, 2*, 21.

Law, E. P., Diemont, S., & Toland, T. R. (2017). A sustainability comparison of green infrastructure interventions using energy evaluation. *Journal of Cleaner Production, 145*, 374–385.

Lawler, D. (2018). The global cities with the most and least green space. *Axios.* [Online] Available from 3rd October, 2021: https://www.axios.com/the-cities-with-the-most-green-space-around-the-world-f92a437f-1de8-41e8-b534-6a9a00aa09d5.html

LDA (Lahore Development Authority). (2014). Punjab housing scheme rules. *Housing, Urban Development & Public Health Engineering Department, Government of Punjab.*

Lee, A. C. K., & Maheswaran, R. (2011). The health benefits of urban green spaces: A review of the evidence. *Journal of Public Health, 33*(2), 212–222. https://doi.org/10.1093/pubmed/fdq068

Maas, J., Verheij, R. A., Groenewegen, P. P., De Vries, S., & Spreeuwenberg, P. (2006). Green space, urbanity, and health: How strong is the relation? *Journal of Epidemiology and Community Health, 60*(7), 587–592. https://doi.org/10.1136/jech.2005.043125

Mankikar, U. S. (2020). Formulating open-space policies for India's cities: The case of Mumbai. *ORF.* [Online] Available from 8th July 2021: https://www.orfonline.org/research/formulating-open-space-policies-for-indias-cities-the-case-of-mumbai-65007/

Morar, T., Radoslav, R., Spiridon, L. C., & Păcurar, L. (2014). Assessing pedestrian accessibility to green space using GIS. *Transylvanian Review of Administrative Sciences, 10*(42), 116–139.

Nigam, J. Robertson, D., & Sinogba, J. E. (2020). For healthier cities, it's time we give them some (green) space. *Asian Development Blog.* [Online] Available from 21st October 2021: https://blogs.adb.org/blog/for-healthier-cities-it-s-time-we-gave-them-some-green-space

Orr, S., Paskins, J., & Chaytor, S. (2014). *Valuing urban green space: Challenges and opportunities [Policy Briefing].* UCL Public Policy.

Ostoić, S. K., Cecil, C., van den Bosch, K., Vuletić, D., Stevanov, M., Živojinović, I., Mutabdžija-Bećirović, S., Lazarević, J., Stojanova, B., Blagojević, D., Stojanovska, M., Nevenić, R., & Malovrh, ŠP. (2017). Citizens' perception of and satisfaction with urban forests and green space: Results from selected Southeast European cities. *Urban Forestry and Urban Greening, 23*, 93–103.

Parker, J. A. (2017). Survey of park user perception in the context of green space and city liveability: Lake.

Claremont, Western Australia. Master's Thesis. *Murdoch University,* Perth, Australia.

Peterson, A. L. (2017). Exporting strategies for urban livability: Examining copenhagen, Denmark as a model city for quality of life generated through urban design. Senior Theses, Trinity College, Hartford. *Trinity College Digital Repository.* [Online] Available from 1st July 2021: http://digitalrepository.trincoll.edu/theses/668

Ray Gozalo, G., Barrigon Morillas, J. M., Montes Gonzalez, D., & Atanasio Moraga, P. (2018). Relationships among satisfaction, noise perception, and use of urban green spaces. *Science of Total Environment, 624*, 438–450.

Rayan, M., Gruehn, D., & Khayyam, U. (2021). Green infrastructure indicators to plan resilient urban settlements in Pakistan: Local stakeholder's perspective. *Urban Climate, 38*, 100899.

Riaz, R., & Hamid, K. (2018). Existing smog in Lahore, Pakistan: An alarming public health concern. *Cureus, 10*(1), e2111. https://doi.org/10.7759/cureus.e2111

Rigolon, A., Browning, M. E. H. M., Lee, K., & Shin, S. (2018). Access to urban green space in cities of the global South: A systematic literature review. *Urban Science, 2*(3), 67. https://doi.org/10.3390/urbansci2030067

Sang, Å. O., Knez, I., Gunnarsson, B., & Hedblom, M. (2016). The effects of naturalness, gender, and age on how urban green space is perceived and used. *Urban Forestry and Urban Greening, 18*, 268–276.

Scruggs, G. (2015). How much public space does a city needs? *Next City.* [Online] Available from 2nd October, 2021: https://nextcity.org/urbanist-news/entry/how-much-public-space-does-a-city-need-UN-Habitat-joan-clos-50-percent

Shabbir, A. (2018). Smog season starts in Pakistan for the fifth consecutive year. *Pro Pakistani.* [Online] Available from 16th July 2021: https://propakistani.pk/2018/10/22/smog-season-starts-in-pakistan-for-the-5th-consecutive-year/

Shirazi, S. A., & Kazmi, J. H. (2016). Analysis of socio-environmental impacts of the loss of urban trees and vegetation in Lahore, Pakistan: A review of public perception. *Ecological Processes, 5*(5), 1–12.

Shoaib, A. (2021). Multiple benefits of green infrastructure. In R. Brears (Ed.), *The palgrave encyclopedia of urban and regional futures.* Cham: Springer.

Sturm, R., & Cohen, D. (2014). Proximity to urban parks and mental health. *The Journal of Mental Health Policy and Economics, 17*(1), 19–24.

Suppakittpaisarn, P., Jiang, X., & Sullivan, W. C. (2017). Green infrastructure, green stormwater infrastructure, and human health: A review. *Current Landscape Ecology Reports, 2*(4), 96–110.

Tsurumi, T., & Managi, S. (2015). Environmental value of green spaces in Japan: An application of the life satisfaction approach. *Ecological Economics, 120*, 1–12.

Tu, X., Huang, G., Wu, J., & Guo, X. (2020). How do travel distance and park size influence urban park visits? *Urban Forestry & Urban Greening, 52*, 126689. https://doi.org/10.1016/j.ufug.2020.126689

UNDP Pakistan. (2017). Climate public expenditure and institutional review (CPEIR) at a glance and next steps [Policy Brief]. *United Nations Development Programme, Pakistan.*

United Nations. (2018). World urbanization prospects: The 2018 revision, highlights. United Nations, Department of Economic and Social Affairs, Population Division, New York.

Veal, A. J. (2013). Open space planning standards in Australia: In search of origins. *Australian Planner, 50*(3), 224–232.

Wan, C., & Shen, G. Q. (2015). Salient attributes of urban green space in high density cities: The case of Hong Kong. *Habitat International, 49*, 92–99.

Wang, D., Brown, G., & Liu, Y. (2015). The physical and non-physical factors that influence perceived access to urban parks. *Landscape and Urban Planning, 133*, 53–66.

WHO (World Health Organization). (2010). Urban planning, environment and health: From evidence to policy action. [Online] Available from 3rd October, 2021: http://www. euro.who.int/__data/assets/pdf_file/0004/114448/E93987. pdf?ua=1

WHO (World Health Organization). (2016). Urban green spaces and health-A review of evidence. *World Health Organization Regional Office for Europe; Copenhagen, Denmark.*

WHO (World Health Organization). (2017). Urban green spaces: A brief for action. *World Health Organization Regional Office for Europe; Copenhagen, Denmark.*

Wilmott, J. (2020). Have you been to the world's greenest city? *The Telegraph.* [Online] Available from 20th June 2021: https://www.telegraph.co.uk/travel/discovering-hygge-in-copenhagen/worlds-greenest-city/

World Cities Culture Forum. (2021). Percentage of public green spaces (parks and gardens). World Cities Culture Forum. [Online] Available from 7th October, 2021: http://www. worldcitiescultureforum.com/data/of-public-green-space-parks-and-gardens

Worldometer. (2021). Pakistan population live. *Worldometer.* [Online] Available from 27th July 2021: https://www. worldometers.info/world-population/pakistan-population/

WWF (World Wide Fund). (2018). Living planet report-2018: Aiming Higher. Grooten, M. and Almond, R. E. A. (eds), *WWF, Gland, Switzerland.*

Xiao, X. D. (2018). The influence of the spatial characteristics of urban green space on the urban heat island effect in Suzhou Industrial Park. *Sustainable Cities and Society, 40*, 428–439.

Zhang, Y., Van den Berg, A., Van Dijk, T., & Weitkamp, G. (2017). Quality over quantity: Contribution of urban green space to neighborhood satisfaction. *International Journal of Environment Research and Public Health, 14*(5), 535.

Zuniga-Teran, A. A., Staddon, C., de Vito, Laura, Gerlak, A. K., Ward, S., Schoeman, Y., Hart, A., & Booth, G. (2020). Challenges of mainstreaming green infrastructure in built environment professions. *Journal of Environmental Planning and Management, 63*(4), 710–732.