Research Paper

Accessibility of Public Urban Green Spaces within the Spatial Metropolitan Network of Doha, State of Qatar

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Abstract

Most people regard green spaces as a necessity to enhance the physical health and psychological well-being of residents in promoting the general health and welfare of citizens and the environment (Röbbel, 2016). In the Modern Era, the availability of green spaces has become an integral component of urban planning for sustaining the quality of life in city environments, especially since the dawn of the 20th century. Due to globalization in rapidly-developing cities around the world, studies about green spaces are becoming an increasingly important part of the urban planning process (Mitchell and Popham, 2007). Accessibility can play an essential role in determining the location of green public facilities to maximize their usability for large populations, or otherwise limit use to a smaller community (Ottensmann and Greg, 2008). However, some public green spaces are inefficiently located or distributed in urban environments (Beatley, 2000, Gehl, 2010, Gehl and Svarre, 2013). In this paper, the accessibility of urban green spaces means the ease of reaching such locations from many origins within the urban spatial network from the macro- to the micro-scale. The inaccessibility or absence of green spaces in some urban areas is a notable consequence of rapid urbanization in many cities around the world. It is especially noticeable in the capital city of Doha in the State of Qatar, where rapid urban expansion and globalization has had a significant impact on the quality and quantity of green spaces available (Salama and Wiedmann, 2013a). The paper utilizes the network analysis techniques of space syntax to objectively investigate the accessibility of urban green parks and promenades in the metropolitan region of Doha (Penn et al., 1998, Hillier et al., 1993, Hillier and Hanson, 1984). At the heart of the paper is the question, does the size and location of urban green spaces follow a discernible spatial logic in terms of accessibility, linked to the design intent of public planning policies? Some findings in the paper indicate there is distinctive spatial and social logic to the physical and spatial characteristics of urban green spaces above a certain size in terms of metric area. In contrast, these characteristics in smaller urban green spaces tend to be more random, primarily due to issues of land availability and amenity provision in private developments. We conclude by discussing the potential implications of the study for public planning policy about green urbanism in the State of Qatar and other rapidly urbanizing cities around the world.

Keywords

Accessibility, Green Spaces, Network Science, Planning Policy, Urban

1. Introduction

Many of the major cities in the developing world share common problems arising from rapid development and population growth. It is a result of changes in land use to cater to the growing need for industrial, commercial, and residential development. Such growth is further intensified in the case of the capital city of Doha in the State of Qatar, driven by rapid economic development during the last two decades. There are significant government efforts to transform Doha physically and economically from its fishing and pearling village origins of the early 20th century into a modern diversified economy with global aspirations in the 21st century. The population of Qatar is over 2.8 million inhabitants in 2020 with a projected increase of 1 million within the next 20 years based on the most recent United Nations data. Over half of the population is concentrated in Metropolitan Doha (Ministry of Development Planning and Statistics, 2020).

Although the natural gas and petroleum resources are immense, the government is aiming economic diversification plans at the tourism, education, sports, and other service-related industries (Dumper and Stanley, 2007). Doha is currently constructing several mega-projects, stadiums, and the associated facilities necessary for hosting the FIFA World Cup in 2022. Other projects include the Qatar Rail metropolitan public rail transit system, Lusail City masterplan, Hamad Port, Green Parks, and expanded road infrastructure network (**Figure 1**). With many of these projects along the coastline, large sections have been artificially modified involving reclaimed land as the original shoreline was located further inland (**Figure 2a**).

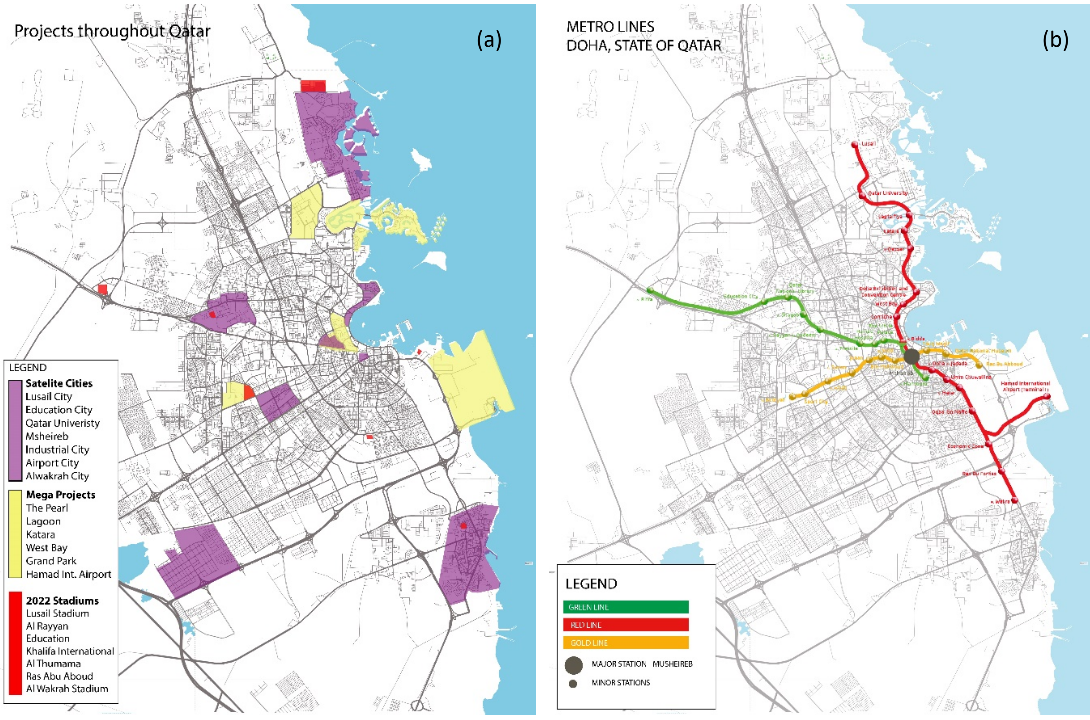


Figure 1. Maps of Doha highlighting (a) satellite cities, mega-projects, and FIFA 2022 Stadium, and (b) Qatar Rail main metro lines and stations. (Source: Authors/Qatar Rail).

Driven by this rapid growth, Qatar has one of the fastest-growing populations in the Arab world with the population increasing by approximately 30% between 2003 and 2012 (Tannous, 2020) (**Figure 2b**). The majority of this population (~90%) live in the capital city of Doha. Under these circumstances, the provision of green spaces does not become a high priority compared to other necessities such as housing, industrial, and infrastructure (Hashem, 2015, Tan et al., 2013). The overall urban planning strategy of simultaneous densification and land consumption is a major contributory factor for environmental deterioration in the country (Salama and Wiedmann, 2013a).

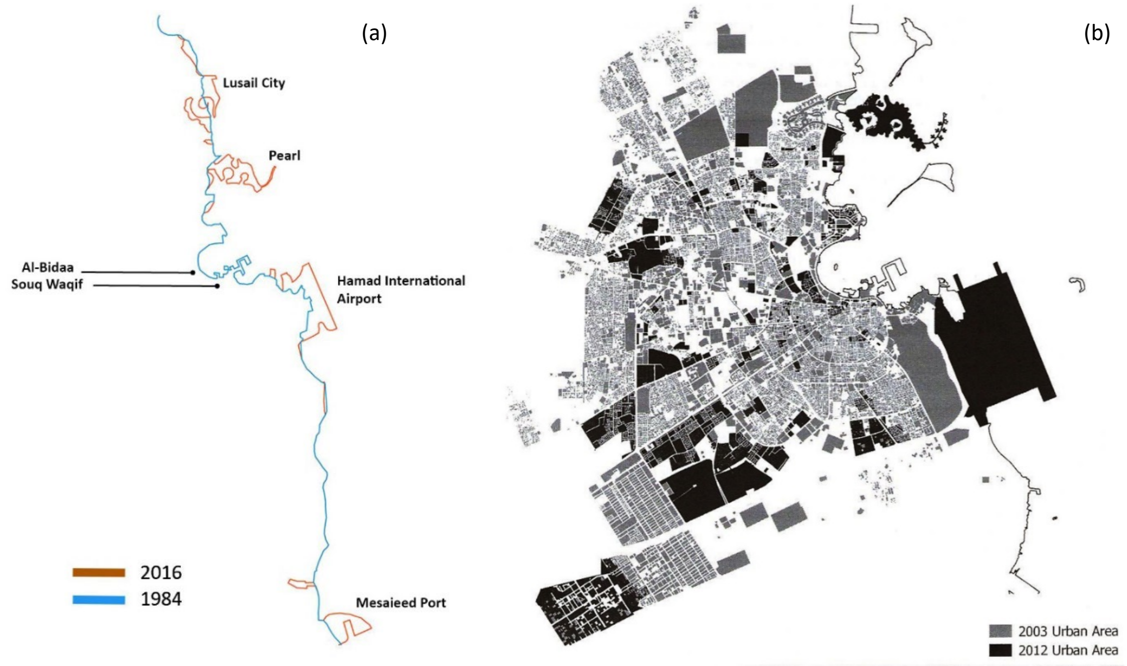


Figure 2. (a) Changes in Doha's shoreline through 1984-2016; (b) Urban Land in Doha between 2003 through 2012 (Source: Authors/(Salama and Wiedmann, 2013b).

The State of Qatar government developed the Qatar National Vision 2030 (QNV) to address the lack of a national planning framework. It aims to guide the development strategies across all sectors of the country. In the light of the QNV, the Ministry of Municipality and Urban Planning (MMUP) and Ministry and Municipality of Environment (MME) has adopted a national framework for urban development with a master plan under the Qatar National Development Framework (QNDF) (Ministry of Municipality & Environment, 2016a). One of the main principles for guiding development is the appropriation of urban design and planning strategies to ensure sustainable growth and preservation of land for public green spaces (**Figure 3**).

In the case of Doha, green spaces are very resource-demanding due to the dry and hot desert climate. Due to the extreme heat and lack of rain, most irrigation water comes from desalination plants that are expensive to run (Hashem, 2015). These public green spaces also require high investment in labor forces for maintenance and sophisticated irrigation systems used in cities within a desert climate. Given these issues, the Public Parks Department of the MME has successfully implemented a field experiment intending to minimize water used in irrigation. This is an initiative to help increase the green areas in different parts of the country (Ministry of Municipality & Environment, 2016b).

Figure 3. Key components of Qatar National Vision 2030 (Source: (General Secretariat for Development Planning, 2008).

Green Urbanism

Green Urbanism is interdisciplinary by definition. It involves collaboration between the fields of landscape, architecture, engineering, urban planning, transport planning, ecology, psychology, sociology, economy, and many other specialists. Green Urbanism is an approach that adopts different disciplinary perspectives in promoting sustainability as its primary objective. It highlights the role of cities in reducing greenhouse gas emissions based on fossil fuels and the preservation of the natural systems of the environment. The principles of Green Urbanism form the basis for a conceptual framework, which allows for the development and transformation of existing neighborhoods and communities in cities. It offers a way to re-think about the way we design and build our future urban settlements. A key goal of Green Urbanism involves retrofitting existing built environments to operate within ecological limits through the promotion of compact development utilizing different modes of transportation (Beatley, 2000). We can summarize the principles of Green Urbanism into four categories: urban planning and transport, energy and materials, socio-cultural features, and water and biodiversity (Lehmann, 2014). Lehman offers perhaps the best outline of these general principles for Green Urbanism and their inter-relationship (**Figure 4**).

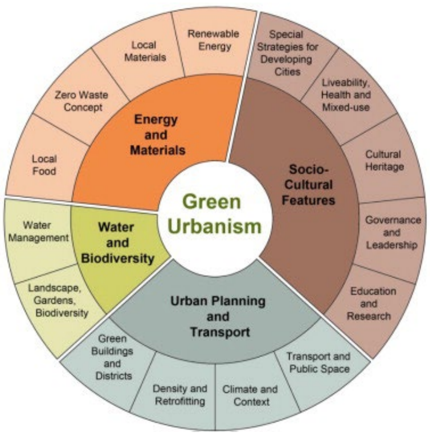


Figure 4. 15 principles and their inter-relationship in Green Urbanism (Lehmann, 2014).

Urban Green Spaces

Public green spaces are a component of 'green infrastructure,' which provides for many social, physical, and environmental benefits including urban heat reduction (Anguluri and Narayanan, 2017). They can serve as recreational areas for residences and enhance the environmental quality of neighborhoods. The availability and accessibility of green spaces are a significant contributor for human well-being in urban cities (Amano and Butt, 2018). With a set of a range of policies on urban green spaces, the European Environment Agency recommends that citizens should have access to green spaces within 15 minutes walking distance, i.e., approximately 2 km (Stanners and Bourdeau, 1995). Other studies in planning and environmental disciplines highlight the social and ecological benefits of urban green space depending on their size and accessibility (Box and Harrison, 1993, Harrison et al., 1995). In addition to user needs and the quality of green spaces, there is a large body of research focusing on the role of the built environment on human behavior in public open spaces over the last half-century (Jacobs, 1961, Whyte, 1980, Hillier, 1996b, Gehl, 2010, Campos, 1999, Gehl, 2011). Many argue additional benefits like improving air quality, general health and well-being of the citizens, and enhancing the urban setting of cities (Lee et al., 2015, Mitchell and Popham, 2007). Therefore, just like any other land use, the way these green spaces are located and distributed is essential. Selecting inappropriate locations for public green spaces can make them less accessible to the public, leading to underutilized or sometimes neglected spaces. At worst, these spaces become abused or exploited for illicit and criminal behaviors (Hillier, 1996a).

The smart allocation of easily accessible and equally-distributed green spaces can serve as a health-promoting setting for all members of the urban community. Sustainable and accessible public green spaces are necessary to provide a higher quality of life in cities. Public green spaces are generally any outdoor space providing green vegetation for active or passive uses accessible to the general public. Such areas include formal parks, community gardens, informal green spaces/landscapes, playgrounds, and plazas but not spaces that can be characterized as exclusively landscape medians for only visual appearance, i.e., curb appeal.

Accessibility of Urban Green Spaces

Most studies about the accessibility of urban green spaces are based on metric distance. However, topological distance in space syntax terms is also a potentially important, often overlooked factor for the location of public green spaces (Koohsari et al., 2014). Instead of mere location based only on metric distance, understanding and quantifying the distribution and accessibility of public green spaces based on the configurational measurements of space syntax using axial analysis might prove fruitful for promoting the physical and social functioning of public green spaces in a city.

This research paper aims to examine the accessibility of public urban green spaces relative to metric size in the area of Metropolitan Doha, Qatar. The research draws on a previous study by the authors examining the accessibility of public green spaces in Doha in the year 2013 (Tannous et al., Forthcoming). Subsequently, this study identifies and incorporates four (4) parks and three (3) promenades that were not previously listed by the MME as public amenities at the time of the previous research study (**Figure 5a**). The classification of these different types of public green spaces in this research study relies on the metric area and service radius. It is divided into seven (7) types: mini-neighborhood, neighborhood, local, community, regional, metropolitan/national, and promenades. Promenades are the only classification not based on metric area but due to their location adjacent to the coastline of the Arabian/Persian Gulf (**Figure 5b**). In addition to these promenades, there are also many parks located in the vicinity of the coast due to the importance of the Arabian/Persian Gulf for the city of Doha. However, the quantity of green space is not necessarily the defining characteristic of promenades as public amenities. Sports fields such as football pitches serving as support facilities for World Cup 2022 are not included in this analysis, especially if the MME does not list them as official parks.

The research reviews the current availability and accessibility of thirty-three (33) public parks and promenades based on high-resolution aerial photos from 2013-2019, supplemented by the use of an

MME index listing official parks in the city of Doha. This study continues and expands on the analysis of these public green spaces in the urban spatial network of Metropolitan Doha used in the earlier study (Tannous et al., Forthcoming). The underlying basis for quantifying the accessibility of public green spaces using space syntax is the *theory of natural movement.* This theory states that movement patterns in cities arise naturally from the way the street network organizes the simplest routes to and from all locations involving the fewest changes of direction in the network *before* accounting for the location of attractors or generators of that movement such as specific land uses (Hillier et al., 1993, Penn et al., 1998). Based on the analysis and findings of this study, the paper argues for the existence of a spatial and social logic to the public green spaces of Metropolitan Doha, especially above a certain size. The paper concludes with some suggestions for the future planning and expansion of some public green spaces in Metropolitan Doha.

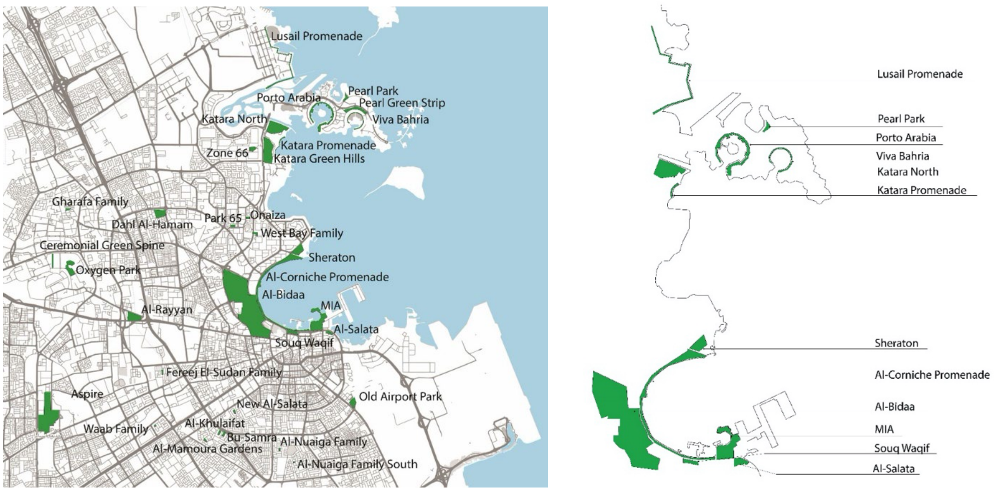


Figure 5. (a) The studied public parks and promenades on the map of Metropolitan Doha; b) promenades and parks running parallel to the coastline of Doha (Source: Authors).

Space syntax

Space syntax has been used in a wide range of research projects to explain human behaviors and predict patterns of movement from the point of view of spatial configuration (Hillier, 1996a). Some of this research examined the morphological structure of buildings (Peponis et al., 1990), sociocultural implications of different plans (Hanson, 1989), urban renewal (Miller, 1989), predictions of spatial patterns of crime in urban areas (Hillier et al., 1989), and, frequently, movement patterns in urban settings (Hillier and Hanson, 1984, Hillier et al., 1983, Hillier et al., 1987, Hillier et al., 1989, Peponis et al., 1989). Space syntax researchers have also found significant correlations between spatial configuration and empirical observations of pedestrian and vehicular movement levels (Hillier, 1996b, Hillier et al., 1993, Penn et al., 1998). Major development projects around the world extensively applied space syntax as a design and planning tool over the last thirty years (Major, 2018). In its simplest formation, space syntax allows us to better identify and understand human behavior in the urban environment in terms of movement, occupation, and use.

There are many previous research-based studies of urban green spaces based on statistical evaluation of demographics and design characteristics, location-based attraction modeling, or user surveys to understand some attributes of accessibility (Ottensmann and Greg, 2008, Strauss and Miranda-Moreno, 2013, Sahebgharani et al., 2019). Other studies focus on localized issues such as human thermal comfort (Indraganti and Boussaa, 2018), quality and status of green parks, or the impact of road network expansion on the urban landscape (Wenbo et al., 2017). However, there is a lack of quantitative research on the subject in the GCC region. The study utilizes space syntax for the quantitative measurements of accessibility within the urban spatial network. It uses a distance concept (relativized mean depth) measured in steps or changes of direction called topological distance (Hillier and Hanson, 1984). Space syntax models the spatial configurations of the urban space by using a connectivity graph representation. It highlights the most accessible (or integrated) spaces which tend to obtain higher levels of movement and activities, and the less accessible (or segregated) spaces tend to experience less use most of the time.

The term accessibility has a broad meaning in both green urbanism and space syntax. In this research study, accessibility refers to different ranges of integration from across the urban spatial network of Metropolitan Doha to the perimeter streets providing access points to the public green spaces selected for the study. In this sense, accessibility is an essential factor for consideration to provide a strategic plan for public green spaces within their broader neighborhood, regional, and metropolitan network. However, in this most recent version of the study, we begin to layer metric distance into the analysis based on the drawing of pedestrian sheds within a radii of 400 m from recently-opened Doha Metro stations in relation to the case study parks, green spaces, and promenades.

Measurements and Techniques

Configurational measures offer a scientific basis to *implicate or dismiss* the designed spatial network as a factor in social, functional, and/or cultural outputs. Space syntax software also incorporates metric parameters such as the length of streets/street segments and the plan area/perimeter surface area of visual fields. Over four decades, researchers have developed a diverse number of configurational and metric measures using space syntax. Some are more useful than others, and sometimes it can take years of testing to confirm or refute their usefulness. It can be overwhelming for those unfamiliar with space syntax. Generally, the most useful are:

Connectivity is a simple measure of how many other spaces does a single space immediately connect to within the network.

Integration is the relativized mean depth of a space in relation to all other spaces in a network based on changes of direction using connectivity (see above). It represents how integrated/shallow or segregated/deep is a space within a spatial network. It demonstrates the pattern of 'to-movement' for those spaces most likely used for journeys from anywhere to everywhere else in the spatial network. Researchers can set the radii of integration measures based on specified parameters such as *global integration* (radius=n) and local integration (radius=3).

Local integration is relativized mean depth of a space in relation to all other spaces in a network based on three changes of direction, which highlights the more immediate catchment area of a single space within the network. In effect, the justified topological graph underlying the measure is 'cut' off for every space more than three changes of anywhere from the origin space. Most usually, local integration is strongly related to connectivity (see above) because they measure the more immediate characteristics of space in the network. In the real world, the simplest way to understand local integration is if a person imagines themselves standing in the middle of an intersection of two or more spaces, looks down both spaces in all directions to see all other spaces immediately connected to those spaces defining the intersection, and then repeated that process for all the other intersections they can see from the first intersection. In larger spatial systems such as cities, it is often useful to limit the radius of integration based on relativized mean depth from the most globally integrated space in the spatial network because it reduces, though not necessarily eliminates completely, 'edge effect,' i.e., spaces at the edges of the spatial network tend towards segregation merely because of their location at the edge.

Finally, researchers can also set the radii of various configurational measurements based on metric parameters using the average distance to the center of each segment as defined by the midpoint between two separate connections such as 500 meters (m), 1000m, or 5000m. Despite incorporating metric measures, researchers consistently find that the correlation with configurational measures tends to be more significant for understanding the 'social logic of space' than metric ones (Hillier and Vaughan, 2007).

Research methodology

The main research study methodology consists of two main phases:

Identifies and locates official public parks and promenades in mapping for the case studies of the research study.

Obtains and analyzes the quantitative measurements of different levels of integration relative to the metric area of all perimeter streets providing points of access to the studied public green spaces to all other axial lines in the urban spatial network of Metropolitan Doha. We utilize three parameters of integration, i.e., global (radius=n), local (radius=3), and mean depth based on the most integrated streets in Doha (radius=8).

Table 1. Classification and categories of the studied parks and promenades according to their metric areas and service radius.

Type	Amount	Area	Service Radius
Mini-neighborhood (MN)	10	<4	1/4 miles radius
Neighborhood (N)	7	4-10	1 mile radius
Local (L)	2	10-20	1-2 miles radius
Community (C)	4	20-50	2-5 miles radius
Regional (R)	3	50-150	5+ miles radius
Metropolitan/national (M)	2	>150	Entire metropolitan region and/or serve as an urban setting on a national basis
Promenade (P)	5		No specified area
TOTAL	**33**		

The research study focuses on the metropolitan region of Doha, Qatar. We classify and organize the case study parks and promenades according to metric area and size parameters into the following categories (**Table 1** and **Figure 6**):

- Mini-neighborhoods (N) below 4 acres in size with a service radius of approximately ¼ miles.
- Neighborhood (N) ranging in size between 4-10 acres with a service radius of 1 mile.
- Local (L) ranging in size between 10-20 acres serving 1-2 miles radius.
- Community (C) ranging in size between 20-50 acres with a service radius of 2-5 miles.
- Regional (R) ranging in size between 50-150 acres with a service radius of over 5 miles.
- Metropolitan/national (M) with the metric area over 150 acres serving the metropolitan region.
- Promenades are identified and located due to their location along the coast of Doha.

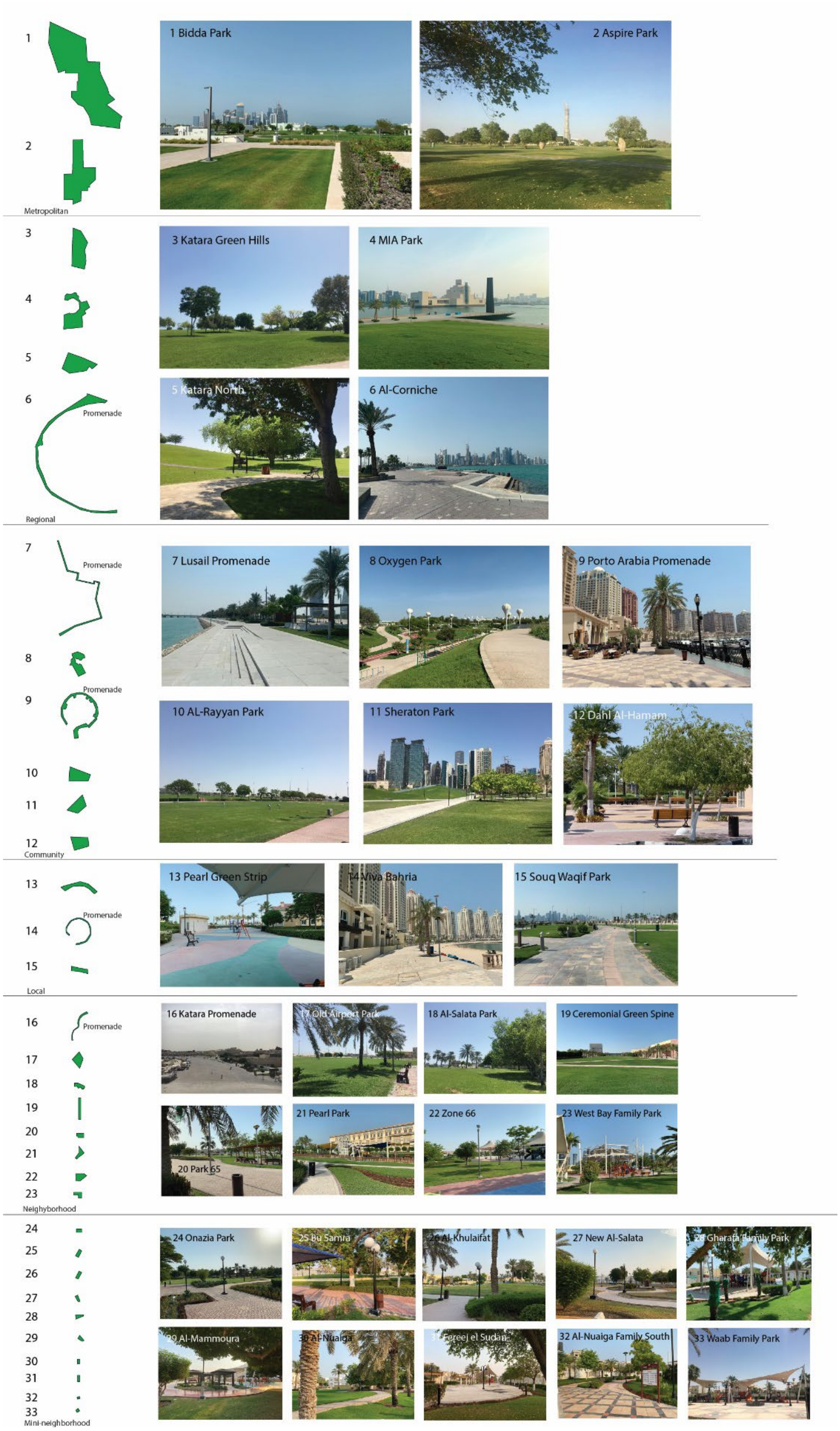


Figure 6. Case study green spaces in descending order (in terms of metric area) within Metropolitan Doha (Source: Authors).

The axial map in this study stretches from Lusail in the north to Al-Wakrah to the south and from the Arabian/Persian Gulf in the east to the Orbital Highway to the west (**Figure 7a**). Researchers constructed the 2019 space syntax model of Metropolitan Doha based on a collection of high-resolution satellite images in 2019, updated against the initial modeling based on a 2013 MME map showing building footprints at a scale of 1:400 and various satellite images from 2013-2018. The axial map consists of over 24,200 streets covering an area of over 1,000 km^2. Researchers located the streets defining the perimeter of the 33 public parks and promenades of the study in the axial map. The analysis of different degrees of accessibility was based on the average value of all perimeter streets, as well as relative to the metric area of the urban green space itself.

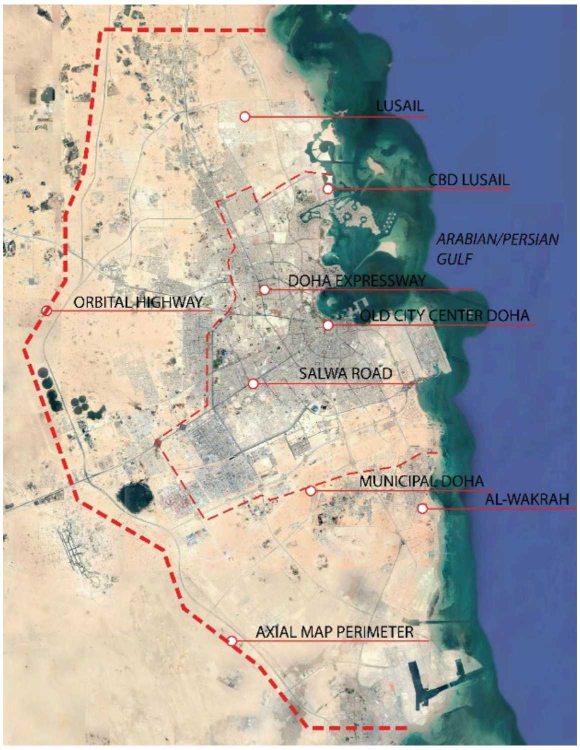


Figure 7. The area of study for the axial map referred to as Metropolitan Doha (Source: Authors).

Findings

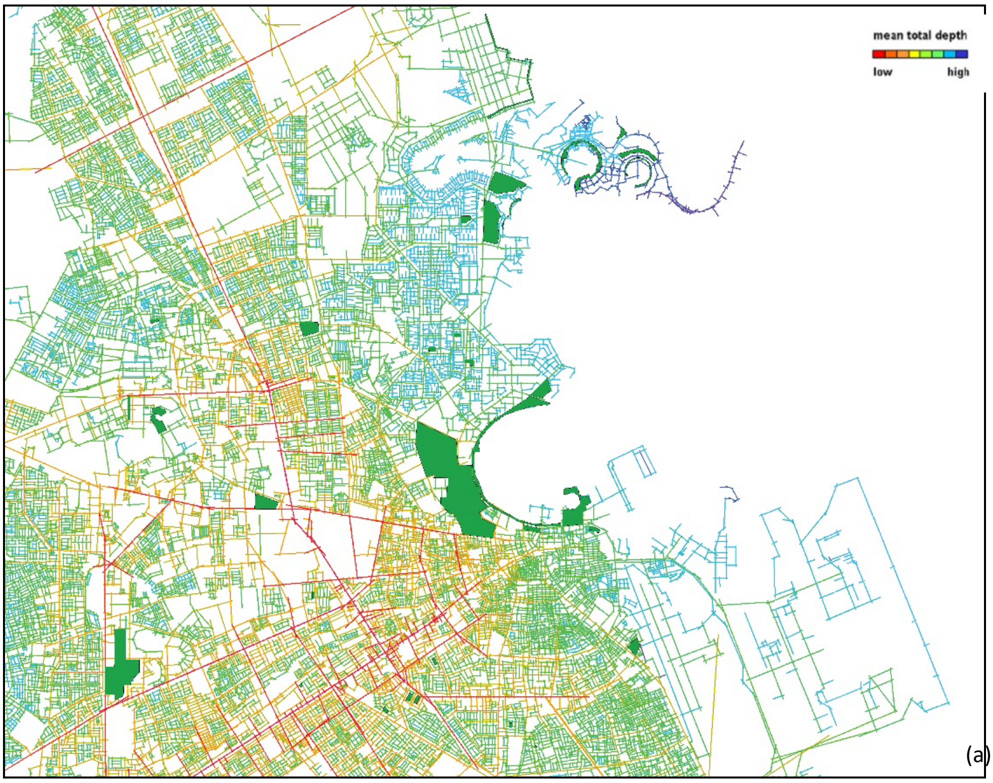
As explained in the previous section, this research study illustrates the levels of accessibility of 33 public parks and promenades. The total area of these green spaces is approximately 1,132 acres or about 1 acre every 1,200 residents in Metropolitan Doha. According to the National Recreation and Parks Association (NRPA), the typical park level of services is 9.9 acres per 1,000 residents across different parks and recreation agencies of the United States. It suggests that the current levels of service for public parks and promenades in Metropolitan Doha are nearly 12 times lower than that found in the USA in general. All the promenades and many of the parks locate immediately adjacent or relatively near to the Persian/Arabian Gulf coastline in the city. These green spaces include all the parks and promenades at The Pearl, Sheraton, Al-Corniche, Al-Bidda, and MIA from north to south of the coastline. Others consist of smaller parks serving their immediate surrounding neighborhoods, such as the Al-Gharafa, Al-Khulaifat, and Al-Nuaiga parks.

The spatial structure of the metropolitan region is characterized by the ortho-radial grid based on long radial routes (e.g., Salwa Road to the southwest, and Al Rayyan Road to the west) from the old city center of Doha near the coastline and a successive series of ring roads (A-G) radiating outward from Doha Bay to the metropolitan edges and the new Orbital Highway (Ring Road G). A few research studies elaborate on the well-defined spatial logic of Doha at the macro- and micro-scale of its metropolitan region using space syntax (Tannous, 2020, Tannous and Major, 2020, Mirincheva, 2015). An aim of this research study is establishing the spatial parameters of the green parks and promenades by locating them in the space syntax model of Metropolitan Doha based on their streets defining their perimeter based on an average of each accessibility measure. It provides a common representative measurement for each park and promenade within its local and larger metropolitan context **(Table 2** and **Figure 7)**.

Table 2. The public parks, promenades, and green spaces from largest to smallest for metric area showing (from left to right): name of the green space, type classification, region within the city, area in acres and m2, and the average global integration (Rn), local integration (R3), and integration based on mean depth from most integrated street (R8).

	Park Name	Type	Region	Area Acre	Area m2	Global rad=n	Local Integration rad=3	Integration rad=8
1	Bidda	M	East	426.0	1,723,962	**1.282**	**2.578**	**1.668**
2	Asipire	M	South West	185.7	751,502	**1.496**	**3.256**	**2.007**
3	Katara Green Hills	R	East	74.3	300,682	**0.972**	**2.199**	**1.433**
4	MIA	R	East	70.5	285,304	**0.939**	**1.973**	**1.223**
5	Katara North	R	North	65.4	264,665	**0.877**	**1.807**	**1.247**
6	Al-Corniche	P	East	57.2	231,480	**1.114**	**2.179**	**1.480**
7	Lusaail	P	North	33.5	135,570	**0.976**	**1.714**	**1.231**
8	Oxygen	C	West	31.3	126,667	**0.989**	**1.500**	**1.115**
9	Porto Arabia	P	North	28.0	113,312	**0.552**	**1.083**	**0.826**
10	Al-Rayyan	C	West	24.2	97,934	**1.488**	**2.941**	**1.877**
11	Sheraton	C	East	22.9	92,673	**0.990**	**2.292**	**1.413**
12	Dahl Al-Hamam	C	North	21.6	87,412	**1.275**	**2.978**	**1.802**
13	Pearl Green Strip	L	North	19.3	78,104	**0.605**	**1.599**	**1.006**
14	Viva Bahria	P	North	10.9	44,111	**0.552**	**1.083**	**0.826**
15	Souq Waqif	L	East	10.1	40,873	**1.259**	**3.087**	**1.704**
16	Katara Promenade	P	East	8.2	33,265	**0.758**	**1.389**	**0.959**
17	Old Airport Park	N	South	6.8	27,519	**1.202**	**3.105**	**1.787**
18	Al-Salata	N	South East	6.2	25,091	**1.106**	**2.895**	**1.577**
19	Ceremonial Green Spine	N	West	5.9	23,876	**1.467**	**2.847**	**1.599**
20	Park 65	N	North	5.5	22,258	**1.019**	**2.238**	**1.487**
21	Pearl Park	N	North	5.1	20,639	**0.647**	**1.776**	**1.090**
22	Zone 66	N	North	4.2	16,997	**0.924**	**2.216**	**1.345**
23	West Bay Family Park	N	North	4.0	16,187	**1.071**	**2.339**	**1.532**
24	Onaiza Park	MN	North	2.4	9,712	**0.846**	**1.200**	**1.175**
25	Bu Samra	MN	South	2.4	9,712	**1.522**	**2.624**	**1.951**
26	Al-Khulaifat	MN	South	2.3	9,308	**1.100**	**0.887**	**1.294**
27	New Al Salata	MN	South	1.8	7,284	**1.115**	**1.295**	**1.409**
28	Gharafa Family	MN	North West	1.7	6,880	**1.032**	**2.491**	**1.389**
29	Al-Mamoura Garden	MN	South	1.7	6,880	**1.272**	**2.100**	**1.685**
30	Al-Nuaiga family	MN	South	1.0	4,047	**1.028**	**1.489**	**1.370**
31	Fereej Al Sudan Family	MN	South	1.0	4,047	**1.389**	**2.603**	**1.845**
32	Al-Nuaiga family (South)	MN	South	0.9	3,642	**1.139**	**2.503**	**1.629**
33	Waab Park	MN	South	0.8	3,076	**1.184**	**1.484**	**1.595**
	TOTAL			**1142.8**	4,621,595			
	AVERAGE			**34.6**	**144,425**	**1.066**	**2.114**	**1.442**

** Because of its size, Katara Promenade falls within the neighborhood range, but there are beach extensions and under-construction continuation of the promenade.*



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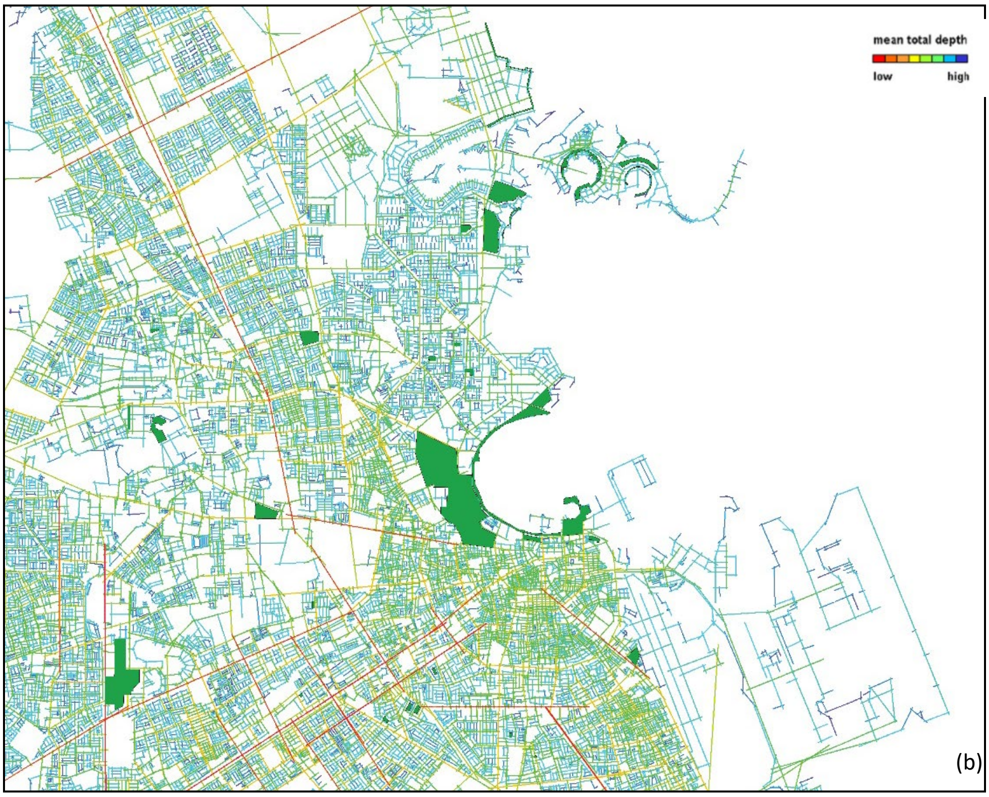

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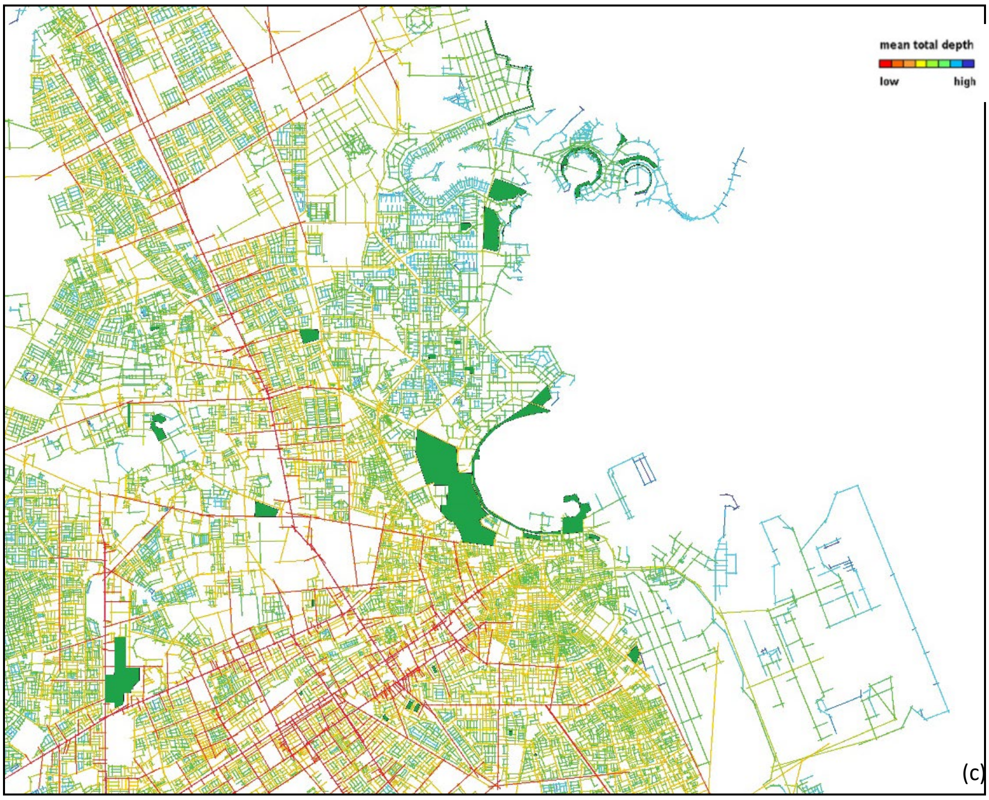

Figure 8. Space syntax model of the urban spatial network Metropolitan Doha showing the pattern of accessibility of the studies green spaces for (a) global integration, (b) local integration, and (c) integration (radius=8).

The global integration core, as previously identified in the earlier research, has shifted southwest to the D-ring Doha Expressway and the intersection between Al-Waab Road and Al-Rayyan Road. With the majority of the regional and metropolitan parks located along the coast, they are relatively locally segregated. Aspire Park is one of the few major parks that have strong local integration along the western edge. When different levels of accessibility measures are relativized for the metric area for these urban green spaces, interesting distinctions start to emerge in the data. Since 2013, there are a few important streets that have opened like the Orbital Highway and Sabah Al-Ahmad Corridor along with the south district in Lusail City. With these new roads and the additional parks and promenades, updating the space syntax model, recalculating the accessibility measures, and the ratio to size, the results appear largely consistent between 2013 and 2019. This is mainly due to two reasons. There is only a 6 year difference the two studies. Although Doha is rapidly developing, this amount of time is not enough to have a considerable difference with regards to the urban spatial network at the metropolitan scale. It also points to the robustness of the space syntax model as an objective tool to better understand the current conditions of the urban spatial network and measure the accessibility of these parks within their urban settings.

We added Al-Waab Park to this study. It is one of the smallest mini-neighborhood parks in the city. However, it is highly integrated due to its contextual relations located between Salwa Road and Al-Waab St. which are two of the most integrated streets in the city. Similar to Al-Rayyan Park, our analysis suggests Al-Waab Parks warrants special due care in its design and planning for any future expansion because of its strategic location at the local and metropolitan scale of the network. There is land available to the north and west of the park. However, it is privately owned and currently set aside for residential land uses.

To determine whether there is an underlying spatial logic to the locating of the parks and promenades regardless of their size, we control for size utilizing a ratio. When accessibility measures are relativized for the metric area, many interesting distinctions emerge in the data **(Table 3)**. However, the metric area remains a strong indicator of the distribution, as some variations might simply attributable to land availability and amenity provisions in private developments.

Some of the previous findings indicate there appears to be a lack of correspondence between accessibility and metric area in some parks like Al-Rayyan Park and Porto Arabia Promenade (Tannous et al., Forthcoming). Al-Rayyan Park seems too small for its strong degree of accessibility in the urban spatial network. On the other hand, Porto Arabia Promenade appears oversized for its degree of accessibility at the macro- and micro-scale of the urban spatial network. Onaiza Park and West Bay Family Park both represent the most typical parks in the city as their values hover nearest to the mean for different measurements of integration. Other parks below 4 acres tend to possess higher values for local integration, which is unsurprising since they serve specific neighborhoods.

Table 3. The rank order of public parks, promenades, and green spaces set to a ratio based on metric area for (left) global integration, (center) local integration, and (right) integration (radius-8) where green indicates the highest (extremely accessible for its size), orange indicates the lowest (very large for its accessibility) and the thick black line indicates the mean for the sample.

Decending order of Global Rn/Area			
Park Name	**Area Acres**	**Global rad=n**	**Global/Area Acres**
Waab Park	0.8	1.184	**1.559**
Fereej Al Sudan Family	1.0	1.389	**1.389**
Al-Nuaiga family (South)	0.9	1.139	**1.266**
Al-Nuaiga family	1.0	1.028	**1.028**
Al-Mamoura Garden	1.7	1.272	**0.748**
Bu Samra	2.4	1.522	**0.634**
New Al Salata	1.8	1.115	**0.620**
Gharafa Family	1.7	1.032	**0.607**
Al-Khulaifat	2.3	1.100	**0.478**
Onaiza Park	2.4	0.846	**0.353**
West Bay Family Park	4.0	1.071	**0.268**
Ceremonial Green Spine	5.9	1.467	**0.249**
Zone 66	4.2	0.924	**0.220**
Park 65	5.5	1.019	**0.185**
Al-Salata	6.2	1.106	**0.178**
Old Airport Park	6.8	1.202	**0.177**
Pearl Park	5.1	0.647	**0.127**
Souq Waqif	10.1	1.259	**0.125**
Katara Promenade	8.2	0.758	**0.092**
Al-Rayyan	24.2	1.488	**0.061**
Dahl Al-Hamam	21.6	1.275	**0.059**
Viva Bahria	10.9	0.552	**0.051**
Sheraton	22.9	0.990	**0.043**
Oxygen	31.3	0.989	**0.032**
Pearl Green Strip	19.3	0.605	**0.031**
Lusaail	33.5	0.976	**0.029**
Porto Arabia	28.0	0.552	**0.020**
Al-Corniche	57.2	1.114	**0.019**
Katara North	65.4	0.877	**0.013**
MIA	70.5	0.939	**0.013**
Katara Green Hills	74.3	0.972	**0.013**
Asipire	185.7	1.496	**0.008**
Bidda	426.0	1.282	**0.003**
AVERAGE	**34.6**	**1.066**	**0.324**

Decending order of Local Intg R3/Area			
Park Name	**Area Acres**	**Local Intg. rad=3**	**Local Intg./Area Acres**
Al-Nuaiga family (South)	0.9	2.503	**2.782**
Fereej Al Sudan Family	1.0	2.603	**2.603**
Waab Park	0.8	1.484	**1.952**
Al-Nuaiga family	1.0	1.489	**1.489**
Gharafa Family	1.7	2.491	**1.465**
Al-Mamoura Garden	1.7	2.100	**1.235**
Bu Samra	2.4	2.624	**1.093**
New Al Salata	1.8	1.295	**0.719**
West Bay Family Park	4.0	2.339	**0.585**
Zone 66	4.2	2.216	**0.528**
Onaiza Park	2.4	1.200	**0.500**
Ceremonial Green Spine	5.9	2.847	**0.483**
Al-Salata	6.2	2.895	**0.467**
Old Airport Park	6.8	3.105	**0.457**
Park 65	5.5	2.238	**0.407**
Al-Khulaifat	2.3	0.887	**0.386**
Pearl Park	5.1	1.776	**0.348**
Souq Waqif	10.1	3.087	**0.306**
Katara Promenade	8.2	1.389	**0.169**
Dahl Al-Hamam	21.6	2.978	**0.138**
Al-Rayyan	24.2	2.941	**0.122**
Sheraton	22.9	2.292	**0.100**
Viva Bahria	10.9	1.083	**0.099**
Pearl Green Strip	19.3	1.599	**0.083**
Lusaail	33.5	1.714	**0.051**
Oxygen	31.3	1.500	**0.048**
Porto Arabia	28.0	1.083	**0.039**
Al-Corniche	57.2	2.179	**0.038**
Katara Green Hills	74.3	2.199	**0.030**
MIA	70.5	1.973	**0.028**
Katara North	65.4	1.807	**0.028**
Asipire	185.7	3.256	**0.018**
Bidda	426.0	2.578	**0.006**
AVERAGE	**34.6**	**2.114**	**0.570**

Decending order of Local Intg R8/Area			
Park Name	**Area Acres**	**Integration rad=8**	**Integration/ Area Acres**
Waab Park	0.8	1.595	**2.099**
Fereej Al Sudan Family	1.0	1.845	**1.845**
Al-Nuaiga family (South)	0.9	1.629	**1.810**
Al-Nuaiga family	1.0	1.370	**1.370**
Al-Mamoura Garden	1.7	1.685	**0.991**
Gharafa Family	1.7	1.389	**0.817**
Bu Samra	2.4	1.951	**0.813**
New Al Salata	1.8	1.409	**0.783**
Al-Khulaifat	2.3	1.294	**0.563**
Onaiza Park	2.4	1.175	**0.489**
West Bay Family Park	4.0	1.532	**0.383**
Zone 66	4.2	1.345	**0.320**
Ceremonial Green Spine	5.9	1.599	**0.271**
Park 65	5.5	1.487	**0.270**
Old Airport Park	6.8	1.787	**0.263**
Al-Salata	6.2	1.577	**0.254**
Pearl Park	5.1	1.090	**0.214**
Souq Waqif	10.1	1.704	**0.169**
Katara Promenade	8.2	0.959	**0.117**
Dahl Al-Hamam	21.6	1.802	**0.083**
Al-Rayyan	24.2	1.877	**0.078**
Viva Bahria	10.9	0.826	**0.076**
Sheraton	22.9	1.413	**0.062**
Pearl Green Strip	19.3	1.006	**0.052**
Lusaail	33.5	1.231	**0.037**
Oxygen	31.3	1.115	**0.036**
Porto Arabia	28.0	0.826	**0.030**
Al-Corniche	57.2	1.480	**0.026**
Katara Green Hills	74.3	1.433	**0.019**
Katara North	65.4	1.247	**0.019**
MIA	70.5	1.223	**0.017**
Asipire	185.7	2.007	**0.011**
Bidda	426.0	1.668	**0.004**
AVERAGE	**34.6**	**1.442**	**0.436**

Discussion and implications

With the recently-opened Qatar Rail Metro System, public entities and researchers can utilize the methodology and findings of this research study to evaluate the viability of locations for different green urban spaces in the city of Doha. A pedestrian shed of a 400 meter radius walking distance from each Doha metro station employs the general assumption that this is a reasonable distance for a typical pedestrian to walk comfortably, given the hard desert climatic conditions in Qatar (Wakenshawy and Bunn, 2015). There are ten parks and promenades accessible within the bounds of pedestrian shed radii from the Doha Metro stations – three only marginally so at their perimeter – out of the total thirty-three parks in this study or only 30% of the sample. These parks mostly include metropolitan and regional parks such as Al Bidda Park from two stations (Al Bidda Station and Al Corniche Station), the north and southern parks in Katara from two stations (Qassar Station and Katara Station) but not the Katara promenade itself. Finally, it also includes Aspire Park via Azizya Station. However, several neighborhoods of Doha lack access to green parks and recreational area entirely. It requires citizens to travel via vehicles or the Doha Metro to access the large regional and national parks such Aspire Park or Al Bidda Park. Further research in this area might consider the effect of the new Doha Metro lines and stations in potentially promoting the access to more park and promenade spaces.

Figure 9. Pedestrian shed of a 5-minute walk (i.e., 400m radius) from the Doha Metro stations.

CONCLUSION

In a hot and dry desert environment like the city of Doha, outdoor public green spaces provide important relief for users. They are also important for enhancing social interaction and the aesthetic values of the society as well as contributing to the general health and welfare of the users and citizens. This paper focused on morphological analysis for the accessibility and size of public parks and promenades in Metropolitan Doha via the application of space syntax modeling. The methodology developed and applied in this study can assist the ministries, municipalities, and other concerned agencies and entities of the State of Qatar to objectively select the most optimal locations and assess the appropriate sizing of public urban green spaces in service to their citizens. When strategically located for their degree of accessibility within the urban spatial network, these public facilities and infrastructure have the potential to bring the greatest benefit to the greatest number of residents and visitors. The paper came to several conclusions based on this analysis. The first concerns a morphological design outcome and the second, about the planning process itself. The findings indicate there is distinctive spatial and social logic to the physical and spatial characteristics of urban green spaces above a certain size (regional and metropolitan) in terms of metric area in Metropolitan Doha. In contrast, these characteristics for smaller urban green spaces (neighborhood and mini-neighborhood) tend to be random. This appears to be primarily due to land availability and the nature of amenity provision (or lack thereof) in private developments. Moreover, some public parks perform better for their size and degree of accessibility than others within their local, regional, and national contexts. The analytical assessment outlined in the research study also demonstrates that land-use efficiency and open space distribution do not have to be mutually exclusive, but tailored to provide more effectively for urban life and vitality based on quality of design instead of mere allocation for the quantity of space.

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