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Blue City Framework for Evaluating Equitable Accessibility to Natural Blue Spaces in Coastal Urban Areas

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Abstract

Blue spaces have various spatial structures, natural or artificial, that positively contribute to urban livability and enhance the quality of life for humans and urban areas across all aspects- social, health, etc. Consequently, blue spaces should be considered in discussions of environmental justice and equity. Previous studies of blue spaces are limited and remain underexplored concerning equitable distribution and accessibility from all income levels in residential urban areas compared to urban green spaces. This research aims to design an initial evaluation and guiding framework, "Blue City Framework BCF, " to assess the accessibility and coverage service area of natural public blue spaces, as an indicator of quality of life for coastal residential areas. The BCF is designed and created based on qualitative and quantitative approaches: identifying definitions, benefits, distribution of blue spaces, and their relation to the 15-minute city concept, as well as definitions and measuring methods of accessibility. In addition, a comparative study between international and local case studies is conducted to identify the accessibility variable of blue spaces. Then, to prove the efficiency of BCF, an applied study is conducted on Alamein City, using the network origin-destination (OD) distance method. The research results classified the quality of life of Alamein residential urban areas based on the coverage service area of natural blue spaces. The findings are that public transportation affects urban connectivity of blue spaces, furthermore, BCF should be integrated with urban design policies, as the blue city is considered the future of improving human quality of life.

Keywords: Blue Spaces, Blue City, Accessibility, Alamein City, Coastal Residential Urban Areas.

1 Introduction

Water is the most significant natural element, and is considered the life source, as 71% of the Earth's planet is water. In the previous centuries, humans located and lived near water elements; rivers, and seas, to drink, cultivate food, and transport from one place to another, etc., so the urban settlements connect and integrate with nature, especially water elements. Consequently, water elements have become a vital natural element in urban environments on a macro or micro scale, which affects the urban form of cities, neighborhoods, and urban spaces. Due to the increase in built density, the connection and integration between urban settlements and nature, water elements, have gradually faded and separated. In addition, new urban settlements are built on land without any proximity or connection to the water [1,2].

Water in the urbanism field means the various blue spatial structures of water, natural or artificial; for instance, seas, rivers, oceans, canals, ponds, fountains, pools, lagoons, waterfalls, etc., that are connected and integrated with urbanism, built environment [3-6]. Consequently, blue urbanism / blue city / urban blue spaces / blue spaces / blue-ways /waterfront city are terminologies that appear in the urbanism field, which refers to the outdoor environment, either natural or artificial, that includes water features and easily accessible to individuals; whether proximally (being in or on or near water), or virtually; the ability to hear, see, etc. [3, 6-11].

Based on the literature reviews, studies of blue spaces in urban environments focused on two aspects. The first aspect is integrated urban blue spaces with mental well-being. Studies are concerned with the effect of availability, exposure, and access to blue urban spaces on improving human mental well-being or providing restoration experience for all humans in general, as well as for specific categories; such as older people or children [3, 6, 9, 10, 12-14], besides considered blue urban spaces as a wellness tourism space [15]. Moreover, studies compared the exposure effect of green urban spaces and urban blue spaces on mental health benefits [16], on the other hand, studies are focused on identifying which type of urban blue spaces is most attractive and visited; either the urban spaces along seasides, riversides, and beaches or the blue urban spaces within the city, for improving mental health [17]. The second aspect is focused on livability, accessibility, and the development of urban blue spaces. Studies are concerned with measuring and examining the difference in the accessibility of various types of urban blue spaces from an individual's house to the nearest water site based on socio-economic characteristics [11,18,19]. In addition, A study assesses the vitality of waterfront urban spaces and the factors that affect the vitality of blue spaces [20]. Moreover, studies are focused on determining the intensity of facilities, development principles, and aspects of public waterfront spaces to improve human quality of life [21,22].

Although Previous studies of water urbanism remain limited compared to urban green spaces, recently, few studies have started to shed light on the effect of water urbanism, blue urban spaces, on quality of life. In addition, Studies have identified that urban environments with water elements are rated higher than other natural elements in improving the quality of life, behavior, health, aesthetics, etc., of urban environments and humans [3,7,9,12,16,17,23]. Consequently, the connection and integration of urbanism with blue spaces is significant, as blue spaces is a vital element and component of urban environments that positively affects the quality of life of humans and urban areas in all aspects; social, economic, health, etc., [23,24], in addition, should be considered in environmental justice and equity in their distribution and accessibility [6,11,12,18]. Hence, future cities cannot be healthy without blue framework implementation [6,24].

The research aims to design a "Blue City Framework BCF" that evaluates the equity distribution and physical accessibility to natural blue spaces, as an indicator of the quality of life for all income levels of coastal residential urban areas. BCF, as shown in Fig.1, is created and designed based on a theoretical study of identifying definitions, benefits, and distribution of blue spaces and their relation to the 15-minute city concept, also, clarifying the definitions, factors, and measuring methods of accessibility. Furthermore, a comparative study was conducted between international and local case studies focusing on blue spaces accessibility variables: place and person-based accessibility. Hence, the "Blue City Framework BCF" is concluded, which is considered an initial guide to evaluating the coverage service areas, proximity, and accessibility of blue urban spaces from Egyptian coastal residential urban areas, by using the network origin-destination OD distance method. Then, prove the validation and efficiency of BCF by an applied study on Alamein City.

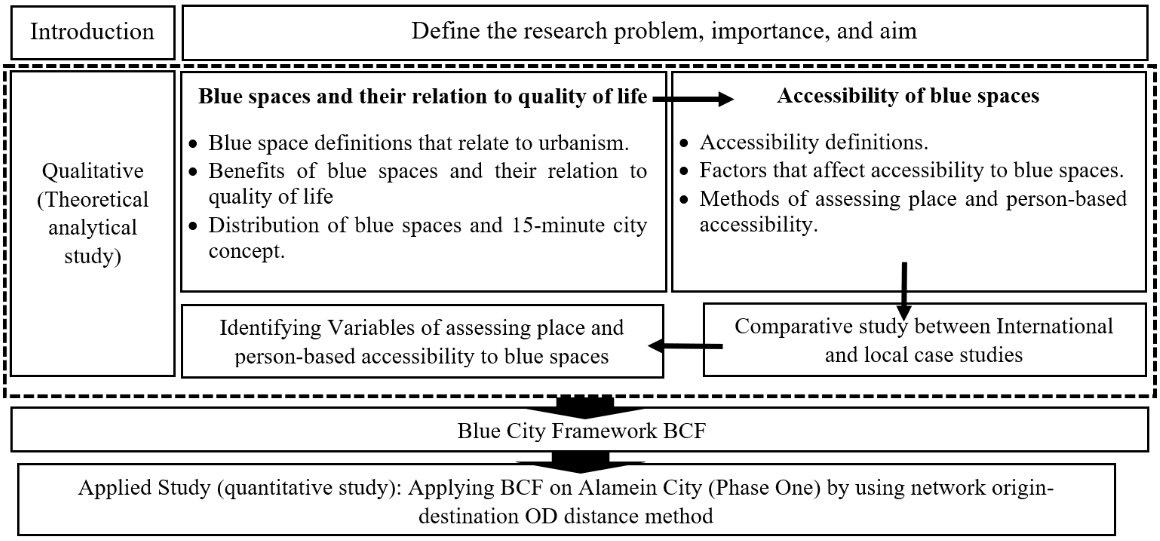


Fig. 1: Research Structure

2 Blue spaces and urbanism

This section is divided into two parts. The first part is concerned with identifying the relationship between blue spaces and quality of life, through identifying blue spaces' definitions, benefits for individuals, and urbanism, as well as their distribution. The second part is focused on the accessibility definitions, factors affecting the accessibility of blue spaces, methods of assessing accessibility, besides conducting a comparative study of international and local case studies to identify the place and person-based accessibility variables of blue spaces.

2. 1 Blue spaces and their relation to quality of life

Blue spaces are surfaces covered by water, varying in their types and scale [11]. Blue spaces are natural and artificial. Natural blue spaces include seas, rivers, oceans, canals, wetlands, waterfalls, lakes, etc., while artificial blue spaces are, for example, ponds, fountains, pools, artificial lakes, water walls, water playgrounds, etc. [3,11,15,17,25].

Various terms refer to the integration of water with the built environment or land, such as urban blue spaces, urban blue ways, waterfront urban areas, blue urbanism, and blue cities. Previous studies agree that urban blue spaces are defined as outdoor environments- either natural or artificial- that include land and water features, with at least one land-water edge [3,6,8,9,11,15,23,26]. Blue spaces are considered significant components of the urban fabric [5]. Consequently, blue urbanism, blue cities, or blue neighborhoods defines as urban areas that are connected to, integrated with, or include water features, whether natural or artificial, additionally, easily accessible for humans either visually, audibly from their homes, workplaces, etc., or physically through street networks, outdoor environments, water activities, or virtually [6]. This research focuses on urban blue spaces and the networks linking coastal residential areas, forming a blue city or neighborhood.

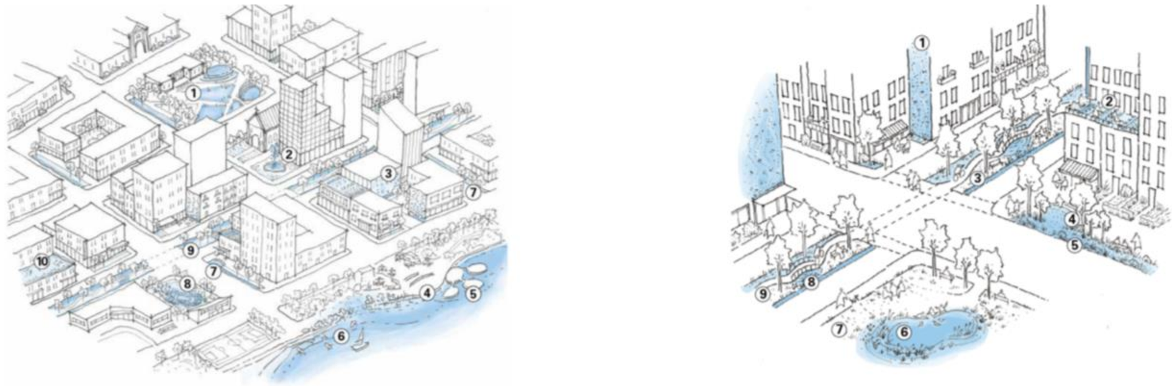
Blue spaces, with their various types, are significant in urbanism for their functions, aesthetics, and health benefits, which affect the individual's productivity: personally, professionally, socially, and quality of life. These effects or benefits of blue spaces differ based on socio-economic characteristics [25], such as the accessibility to blue spaces depending on income level and vehicle ownership [18]. Moreover, water contact types, water quality, amount of water, and types of water elements affect the degree of benefits [6].

The function benefits are thermoregulatory role, noise reduction, circulation, recreational activities, economic, and focal point [3-5,18,23,25,27]. For example, water surfaces are considered an age-old tool that has a significant role in improving the air quality of urban areas through their thermoregulatory role, as during the day when air temperature exceeds water temperature, absorbing heat, and releasing it during the night when water temperature exceeds air temperature [6,11,27]. Furthermore, although water increases the level of environmental sounds, opposite to the role of the green areas that absorb and reduce sounds, but contributes positively to the disturbance of unpleasant city noises by the combination of pleasant aquatic sounds; for instance, waterfalls, fountains, and waves of the sea with unpleasant sounds [11].

while aesthetic benefits are related to water elements' appearance, color, sound, etc., which affect human health, real-estate prices that are in proximity to it, building orientation, and city urban form. Health benefits, from engagement activities by, in, and on water, visual exposure, and hearing the sound of water, are divided into three parts. Part one is related to physical health, for instance, reducing blood pressure, and maintaining a healthy weight. Part two is mental well-being, such as reducing stress, anxiety, and mental fatigue, while part three is regarding social health, which includes increasing social interaction and belonging [3-5,7,11-13,18,23,25-27].

Based on the above, blue spaces should be distributed in urban environments, especially residential urban areas, to provide equitable benefits and accessibility for all individuals and improve quality of life, as shown in Fig. 2, which clarifies the distribution of various blue spaces in urban areas at different scales; city, and neighborhood [3,6,11]. So, the accessibility to blue spaces could be considered an indicator that reflects the quality of life in coastal residential urban areas.

The distribution of blue spaces appears in the form of a blue network, which forms either in points: fountains, pools, etc., or lines: rivers, canals, etc., or areas: ponds, lakes, lagoons, etc. [3]. Most studies identified the convenient coverage service of blue spaces with a radius ranging from 500m to 1 km, with a maximum of 5 km [6,11,18,21,26]. Based on the 15-minute city concept, as shown in Fig.3; the convenient distance for different modes to reach a destination by; walking is 400m (5 mins) to 1 Km (15 mins), cycling is 1.5 Km (5 mins) to 5 Km (15 mins), and car is 4 Km (5 mins) to 16 Km (15 mins) [28]. Hence, the research paper will depend on the distribution and coverage service of natural blue spaces in coastal residential urban areas based on the convenient walking distance of a 15-minute city concept in the assessment of the efficiency of the blue spaces network in urban environments.



1	Hybrid water square	6	Access to water activities	1	Water wall	6	Stormwater retention pond
2	Water surface	7	Blue edges	2	Rooftop rain garden	7	Rainwater swale
3	Water wall	8	Retention pond	3	Sustainable street drainage system	8	Natural water features
4	Urban waterfront edge	9	Linear park	4	Hybrid water feature	9	Linear Park
5	Waterfront park engagement	10	Rain garden	5	Blue edges		

Blue city scale **Blue neighborhood scale**

Fig. 2: Blue city and neighborhood scales [6]

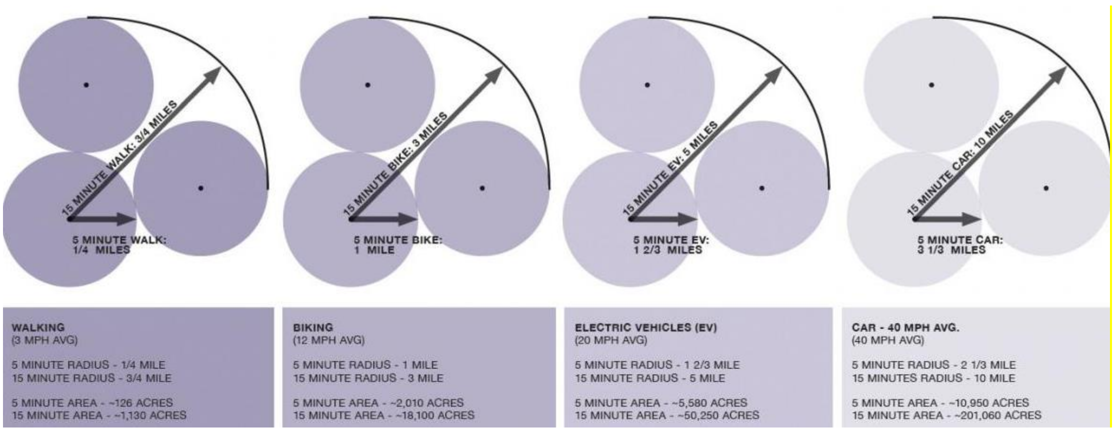


Fig. 3: 15 minutes concept [28]

2. 2 Accessibility of blue spaces

Accessibility has changed over time. It is first defined as the possibility of interaction opportunities, then as the easy way to reach a specific destination by a particular transport mode [11]. Lastly, it is defined as the potential to reach spatially distributed destinations by one or a combination of transportation modes [11,19].

The Accessibility of blue spaces is affected by economic, social, geographical, urban planning, and health factors, which are considered barriers to equity accessibility [5,6,18]. Income level and car ownership are two main economic factors that affect people's choices of mode and travel time. In addition, land value affects the type of land uses, which could be private spaces that detach individuals from water environments, and also affect the heights of buildings that could close visual exposure to blue spaces. Urban patterns, street networks, especially horizontal streets parallel to blue spaces, and private-public spaces along blue spaces, such as clubs and private beaches, are urban planning and urban design factors that affect accessibility and could be considered barriers. Furthermore, human physical health is a medical factor that affects the choice of mode, either walking or public transportation [5,11,13,18].

The variables of measuring accessibility are divided into two types: person-based accessibility and place-based accessibility. Person-based accessibility is the easy access a person has to a specific place. It is hard to investigate because of the requirement for detailed user activity travel information, which is usually collected based on a questionnaire with users. It varies based on the socio-economic characteristics of individuals, for instance, income level and car ownership. Place-based accessibility is the easy way a place can be accessed. It is based on the hypothesis that individuals living in the same urban area have equal access to the same destinations, based on the urban planning and urban design of an urban area. It is measured using spatial maps to identify the level of accessibility [11,13,21,27]. According to previous studies, place-based accessibility is measured by three methods: euclidean distance, network origin-destination OD distance, and gravity mode [5,11,18,29]. Euclidean distance, the simplest geographical method, measures the shortest straight linear distance between a residence (specific location) and the blue space without considering travel barriers, for example, road networks, and land uses [11,18,29]. The network OD distance method (OD cost matrix analysis method) measures the distance from a specific location to blue spaces along the street network pattern [11,29]. The Network OD distance method is more accurate than the euclidean distance method in measuring the effect of a blue space on human health regarding physical activities, identifying accessibility to the blue space in urban areas with complex street networks, or blue spaces with inaccessible parts. While euclidean distance, the linear distance method, is appropriate for measuring visual access/exposure to blue spaces, besides investigate environment improvement for noise reduction or temperature mitigation [5,11]. The gravity mode method measures accessibility by identifying the attractiveness weight of the destination to the travel demand of origin, which is considered a realistic method, as determining the attractiveness of a location decreases with distance [11,29].

According to the literature reviews of accessibility to blue spaces, a comparative analysis was conducted between six international and local case studies to determine the accessibility variables of person and place-based accessibility, as shown in Table (1). The first case study, Wuhan City, China, is concerned with investigating the accessibility to different types of blue spaces: lakes, rivers, ponds, fountains, and reservoirs, in dense cities, by using a questionnaire with visitors and residents, combined with GIS accessibility analysis by OD cost matrix measurement. This study is focused on walking, public transportation, and private car distances within 10 km, besides dividing the distances into 5 categories: easy-to-get distances (≤1 km), hard walking distances (2.5 km), traffic-reachable distances (5 km), and hard-to-reach distances (10 Km) [11]. The second case study, Kyrenia City, Cyprus, deals with assessing Kyrenia’s waterfront from various urban aspects, which include accessibility to the waterfront, by using a questionnaire [27].

The third case study, Changning Section in Shanghai Suzhou Creek, depends on combining GIS spatial analysis (point of interest POI data) with users’ questionnaires to determine the intensity of facilities in public spaces along the waterfront within a radius of 1 Km (15 minutes walking) from each facility, to evaluate the satisfaction level of accessibility of each facility along the waterfront [21]. The fourth case study, Ancient City of Suzhou, China, is focused on identifying the spatial vitality model of the waterfront spaces, which includes and considers evaluating accessibility analysis of the waterfront as one of the vitality variables. This study evaluated vitality variables, especially accessibility, by a questionnaire with experts to weigh the variables, then used GIS spatial analysis to translate the variables on maps [20].

The fifth and sixth are local case studies, one in Mamsha Ahl Masr, Cairo City, Egypt, and the other in Alexandria City, Egypt. Mamsha Ahl Masr's case study relies on identifying the design principles and aspects of river waterfront development that improve human quality of life, which including some principles regarding accessibility to the waterfront. The study measured accessibility principles using a field survey combined with theoretical previous studies [22]. Alexandria City’s case study aims to determine the effect of accessibility level of walking, private cars, and public transportation PT, to reach the sea waterfront on human mental well-being by comparing two zones, one is proximity and integrated with the sea waterfront (The northern zone along waterfront which include Stanley, Saba Basha, Gleem, San Stefano, and Lauran), and the other is detached from the sea (Smouha zone). The comparison analysis between the two zones is conducted and implemented by a questionnaire and spatial analysis on maps [13].

Most previous studies that measured accessibility to the blue spaces have used place-based accessibility [13], while other studies depended on place-based accessibility integrated with person-based accessibility [5,11,13,21], or depended on person-based accessibility only [27]. Thus, accessibility can be measured by one or two types of accessibility variables. The research focuses on the physical accessibility variable as highlighted in Table 1, which could be measured by quantitative methods (OD cost matrix analysis method), as well as excludes the other variables regarding visual accessibility and quality of water for their difficulty in assessing.

Table 1: Accessibility variables based on case studies

Accessibility Variables			Case studies					
			Wuhan City, China	Kyrenia Waterfront, Cyprus	Changning Section in Shanghai Suzhou Creek	City of ancient Suzhou city, China	Mamsha Ahl Masr, Egypt	Alexandria waterfront, Egypt
Person-based accessibility	Socio-economic characteristics of individuals (visitors or residents), such as age, gender, income, region, etc.		+	+	+			
	Type of blue spaces frequently visited: lake, river, sea, pond, fountain, etc.		+					+
	Visits duration (minutes).		+	+				
	Traffic accessibility/ Travel modes to blue spaces: walking, cycling, public transportation, private car.		+	+	+	+	+	+
	Route frequency (The street that is taken to access the blue spaces).						+	+
	Travel time (minutes) to the blue spaces by	Walking	+		+	+		+
		Private car			+	+		+
		Public transportation			+	+		+
		Cycling				+		
	Visits frequency: per week, month, year, every day		+	+	+			+
	Visit time at holiday, weekend, weekday		+		+			+
	Purpose of visit (Activities in blue environments): boating, fishing, swimming, Physical exercise (yoga – walking), social activities, etc		+	+	+		+	
	Quality of the blue spaces		+	+			+	
	Parking conditions, and design for urban needs and aesthetics			+			+	
	Satisfaction level for the blue environment and its services.				+			
	Travel cost= duration + effort							+
	Travel safety and security							+
	Non-physical accessibility barriers						+	+

Place-based accessibility	Spatial location of different types of blue spaces.			+					
	Land-uses		Diversity of land-uses/activities of urban blue spaces destination.					+	+
			Continuity distribution of Land-uses (Movement through land-uses); especially regarding walking travel mode for attractiveness and safety (Vital streets).			+		+	+
			Functional types of urban blue spaces (Land-use types): educational, housing, shopping, daily life services, etc.			+	+		
	Street networks		Spatial street types: pedestrian, vehicle, inclusive.				+		
			Hierarchy of street network.	+					+
		Street continuity	Physical continuity					+	+
			Visual continuity: visual access that enhances visual continuity to generate a good experience.				+	+	+
			Connectivity: diversity and directness of roads to reach from A to B through the network.						+
			Depth: The blue spaces connect easily with the district.					+	+
			Pedestrian crossing (perpendicular to street).					+	
			Entrances of urban blue spaces on main roads (access points).					+	
	Physical accessibility barriers (major-minor).							+	+
	Blue spaces attributes: water depth – water width – water quality.						+		

Physical accessibility variables (Research Focus)

Source: Author based on [11,13,20-22,27]

3 Blue City Framework BCF

Blue City Framework BCF is designed based on Table 1, as the research relies on the physical accessibility variables. BCF evaluates the equitable distribution of blue spaces for different income levels of coastal residential urban areas to identify equitable accessibility to public natural blue spaces, which is considered an indicator of quality of life for coastal residential urban areas. BCF excludes assessing access to private blue spaces as it reflects the quality of life for specific people, which is affordable for them. BCF consists of three phases, as shown in Fig.4, blue accessibility variables, analysis, and results.

- Phase one is concerned with identifying the existence status of blue accessibility variables, which are divided into three aspects: variables of land uses, street networks, and physical barriers. The land use variables are concerned with determining the location of the public blue spaces, whether their function is recreation, commercial, tourism, etc., and whether they are public or private. In addition, regarding the variables of diversity of land uses, to clarify the categories of coastal residential urban areas based on income level. Regarding the variables of street networks, they are significant in determining the pedestrian, vehicle, etc., paths, their directions, and integration with each other, as well as identifying the hierarchy of streets, besides the access point of public urban blue spaces on the street networks. Lastly, identifying physical barriers that prevent access to public urban blue spaces has an impact on assessing accessibility.
- Phase two relies on analyzing the integration between blue accessibility variables to identify the coverage services area of different types of public blue spaces within 400m and 1 km by walking from coastal residential urban areas to public blue spaces, by using the network origin-destination OD distance method, and the connectivity degree. Figure 4 shows the variables that are integrated to determine the coverage services area and connectivity.
- Phase three is concerned with classifying the coastal residential urban areas into three categories of quality of life: high, medium, and low, based on the layering of coverage service area of each type of urban blue spaces with connectivity degree.

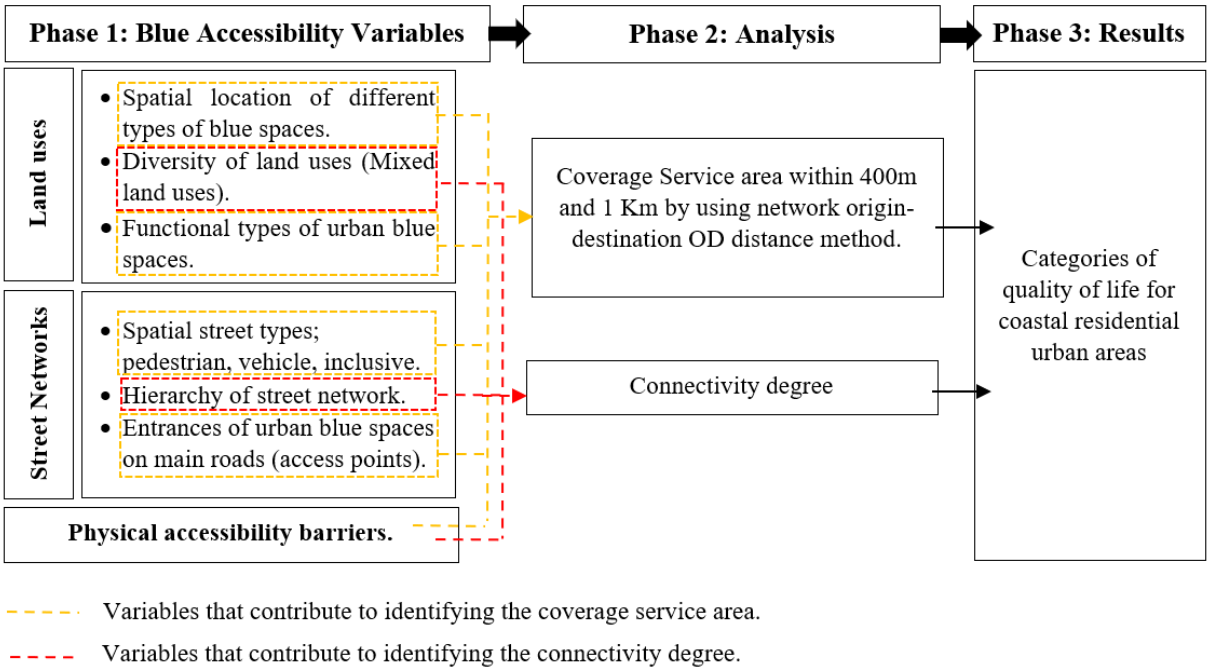
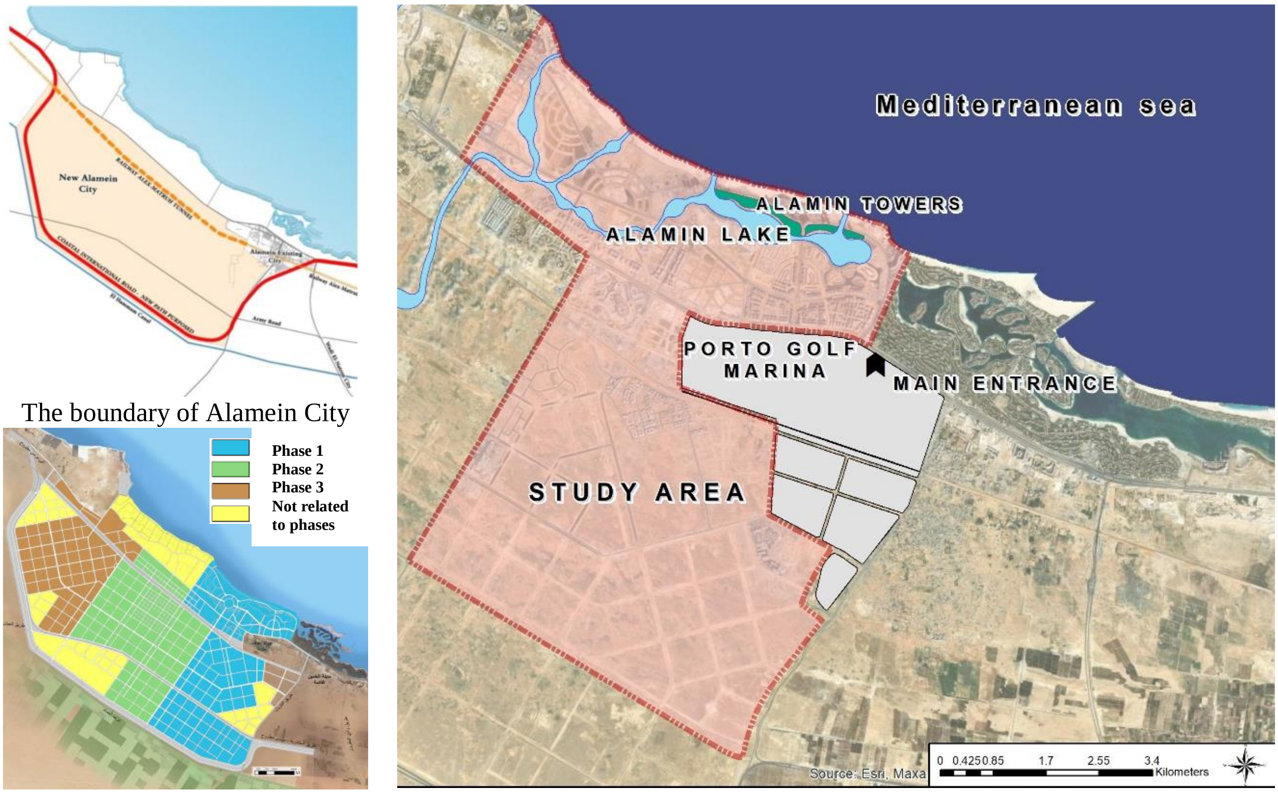


Fig.4: Blue City Framework BCF
Source: Author based on Table (1)

4 Methods

This section is concerned with proving the BCF's applicability and efficiency as an initial guiding framework for assessing the accessibility of blue spaces to identify the quality of life for Egyptian coastal residential urban areas. Proving the applicability and efficiency of the BCF by using the network OD distance to identify the coverage service area and accessibility of blue spaces by walking within 400m and 1 km.

The research focuses on new coastal residential urban areas that are connected to and integrated with natural blue spaces. The research selected the study area “Alamein City” because it is one of the fourth-generation new cities in Egypt, a tourism and residential city, that enhances sustainable development to afford a good living urban environment for its residents, besides it will be an independent city like the existing Egyptian coastal cities, Alexandria and Marsa Matrouh, that will have permanent residential urban areas. In addition, it is located on the North Coast along the Mediterranean Sea, which is considered a central point between Alexandria, to the east, about 120 kilometers away, Marsa Matrouh to the north, and Siwa to the south. So, it can be reached easily from the surroundings. Furthermore, Alamein City has Alamein Lake, and availability of public transportation networks; buses, monorails, and trams, that ease accessibility and movement of individuals either to public blue spaces, or any other destination in the city. Alamein City is divided into four construction phases, as shown in Fig.5. The research will focus on the first phase, excluding the industry area, as the city is still an under-construction city [30].



The boundary of Alamein City

Phases of Alamein City

Boundary of the study area at Alamein City

Fig. 5: Study area at Alamein City (phase one)
Source: Author based on [30,31]

4.1 Landuses

Figure 6 shows the land uses, spatial location of blue spaces, and categories of residential urban areas based on income level. The spatial location of the blue spaces indicates that the city is directly connected and integrated with natural blue spaces, stretching over 14 kilometers along the Mediterranean Sea (approximately 8 kilometers in phase one), and includes Alamein Lake, which is situated within the city.

Regarding the residential urban areas, there are four categories based on income level: high, upper-middle, middle, and low [31]. Most high and upper-middle income residential areas are gated communities, which have a direct private connection with Alamein Lake. while middle and low-income residential areas are situated away from the sea and Alamein Lake, separated by the Alex-Marsa Matrouh railway line and the Alex-Marsa Matrouh coastal road. Consequently, most of the seafront and lakefront is for recreational activities besides high and upper-middle income residential areas, as illustrated in Fig.6. About 2 kilometers of the seafront, 4 kilometers of lakefront, and all intersection points of the roads with the lake (lake bridges) have public accessible to all residents and tourists during phase one.

4.2 Streets Networks

As shown in Figure 6, there is a strong hierarchy in the street networks that connect all the land uses. All the arterial streets are considered complete streets, which include pedestrian, public transportation, and car lanes, while the collector streets feature all the lanes of the arterial plus cycle lanes [31]. Hence, Alamein streets are healthy complete streets that enhance the physical health of their residents by promoting walking and cycling. Additionally, various types of public transportation- bus, monorail, LRT, tram, and railway- connect and facilitate accessibility within the city, and to the surrounding urban context via railway lines, as illustrated in Fig.7.

4.3 Physical accessibility barriers

As shown in Figure 7, two physical barriers could affect the accessibility of middle, low, and part of upper-middle income residential urban areas to the Mediterranean Sea and Alamein Lake. These barriers are the existing coastal road and railway of Alex-Marsa Matrouh, as the proposed alternatives have not yet been constructed.

4.4 Coverage services area of blue spaces

This study is concerned with analyzing the coverage service area of Alamein Lake and the Mediterranean Sea within 400m and 1 km by walking, to identify the accessibility of various types of residential urban areas to public access points of blue spaces. This study relies on the accessibility method of network origin-destination OD distance.

Regarding the coverage service area of public access points for Alamein Lake within 400m and 1 km by walk, as shown in Fig.8, Alamein towers, and the majority of high and upper-middle income residential urban areas have full access to the Alamein Lake public access points. While some areas of high and upper-middle income residential urban areas have full private access to Alamein Lake. The accessibility of middle and low-income residential urban areas to public access points of Alamein Lake is only by using public transportation, especially bus lines, as there are only two bus stations within the coverage service area, which can be reached from them by walking to Alamein Lake. Regarding the coverage service area of the Mediterranean Sea and its public access points within 400m and 1 km by walk, as shown in Fig.9, there are only 8 kilometers along the Mediterranean seafront have public access in phase one of Alamein City, while all the other length of the seafront are private for recreational and tourism activities. In addition, Alamein towers, and part of high-income residential urban areas, have full access, while low, middle, and upper-middle income residential urban areas have no access to public access points of the Mediterranean Sea within the coverage service.

4.5 Connectivity

Based on Figures 6 and 7, the connectivity degree of high and upper-middle income residential urban areas is medium, as they are gated communities and have specific entrance gates, so they should take specific routes either to reach them or the public access points of blue spaces. while the connectivity degree of low and middle-income residential urban areas is high, as the good hierarchy of streets, besides the availability of bus lanes and cycle lanes.

4.6 Quality of life

Based on the analysis of the coverage service area that identifies the accessibility of Alamein Lake and the Mediterranean Sea, residential urban areas are classified into three quality of life levels, as shown in Fig.10. Almost all Alamein towers have a high quality of life, while high and upper-middle income residential urban areas have medium levels of quality of life. Furthermore, some parts of high and upper-middle income residential urban areas have private access to Alamein Lake within their gated communities, but they are not within the coverage service area of the public access points for Alamein Lake. Hence, they are highlighted by a yellow color different from the colors of quality of life levels, as they have private access only with a high quality of life. Low and middle-income residential urban areas have low levels of quality of life, due to their physical accessibility to blue spaces is not within the coverage service area.

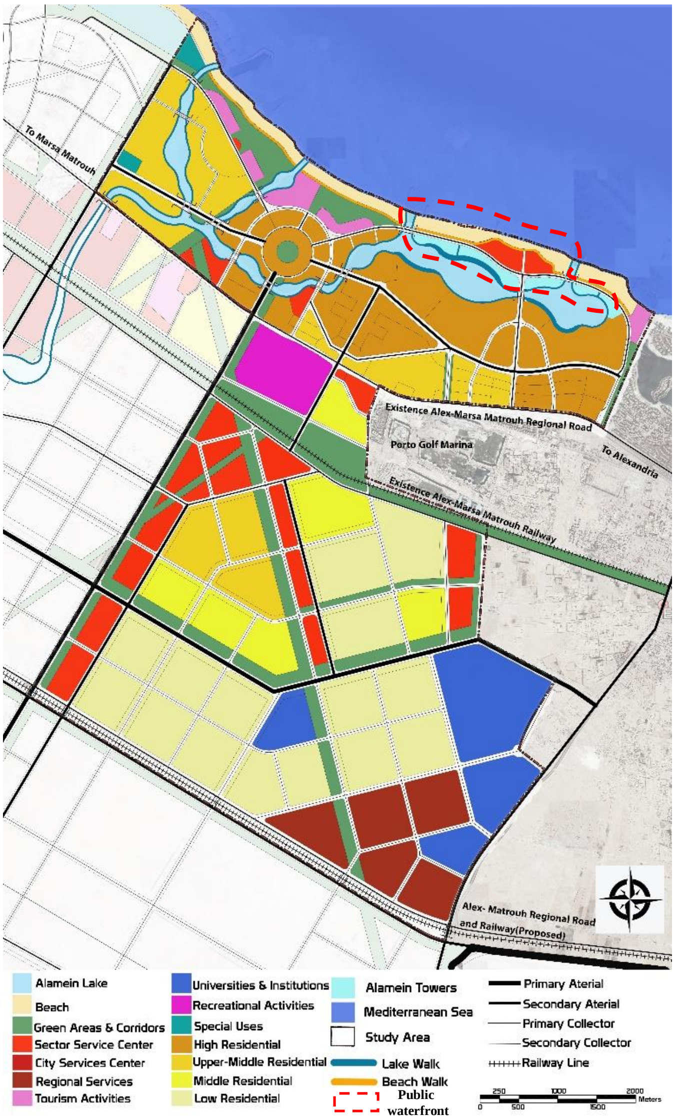


Fig. 6: blue spaces and residential urban areas
Source: Author based on [30,31]

Fig. 7: Public transportation
Source: Author based on [31]

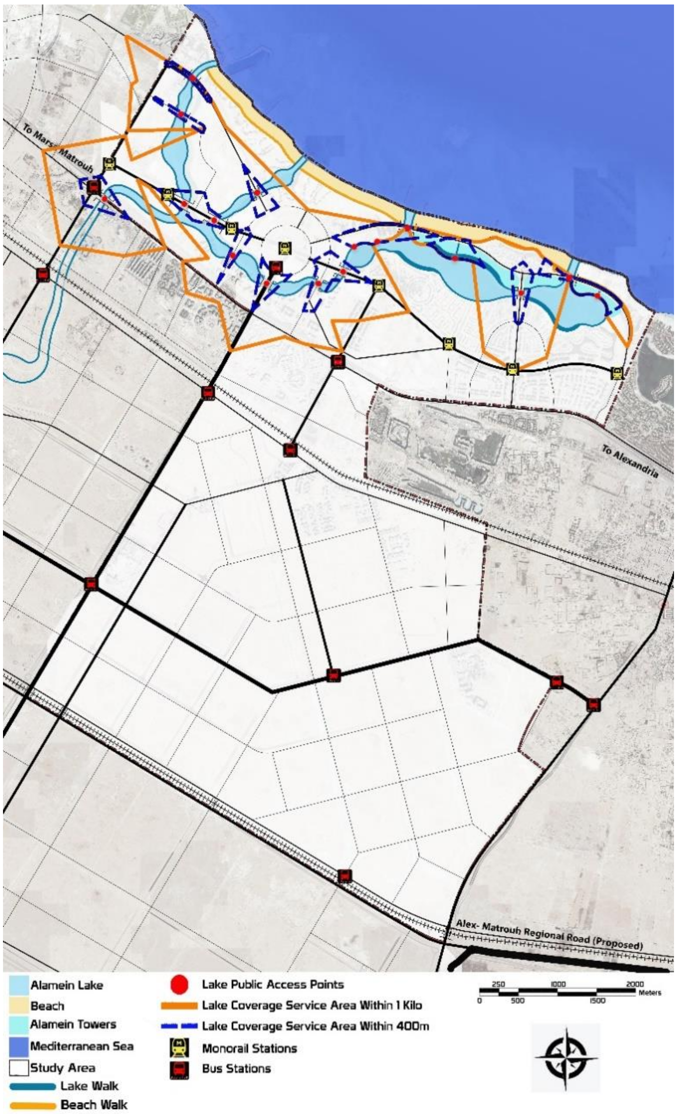


Fig. 8: Coverage service area of Alamein Lake
Source: Author

Fig. 9: Coverage service area of the Mediterranean Sea
Source: Author

5 Results and Discussion

The research concludes the “Blue City Framework BCF”, as shown in Fig.4, as a guiding and evaluating framework, that can help architects, urban designers, and decision-makers in identifying the accessibility of Egyptian coastal residential urban areas to natural urban blue spaces, to improve the quality of life for Egyptian coastal residential urban areas. The BCF could be applied to evaluate the accessibility of new urban designs and existing Egyptian coastal residential urban areas to Egyptian natural blue spaces. BCF relies on the accessibility method of network origin-destination OD distance. The research focused only on the physical accessibility to the public access points of natural blue spaces, excluding the artificial blue spaces, and visual accessibility, which were research limitations.

Based on the analysis of the applied study, the high and upper-middle income residential urban areas are more accessible to the Alamein Lake and the Mediterranean Sea than the low and middle-income residential urban areas. Moreover, most public transportation stations are not within the blue spaces coverage service of 400m or 1 km by walk, except two bus stations that are within the coverage service of Alamein Lake. Hence, the quality of life for residential urban areas is categorized, as shown in Fig.10, based on the coverage services area, which reflects proximity and accessibility to Alamein Lake and the Mediterranean Sea.

High and upper-middle income urban residential areas are always considered a priority to be connected and located directly to the natural urban blue spaces, because architects, urban designers, and decision-makers always depend on the economic factor of high land value more than the needs and equity of every individual to have access to blue spaces. The 11th sustainable development goal, sustainable cities and communities, states the inclusive accessibility of all individuals to public spaces. So, blue spaces are one of the public spaces, which should have equitable access and distribution from all residential urban areas' income levels, due to their positive effect on humans by influencing their productivity and improving their quality of life. Hence, BCF is a significant evaluation and guiding framework that should be integrated within urban development policies for existing and new coastal residential urban areas to improve urban quality of life. Furthermore, public transportation stations should be considered to be located within the coverage service area of urban blue spaces to ease accessibility for the residential urban areas that are either far or not in proximity. consequently, the absence of public transportation within blue space coverage service areas is a critical finding that affects urban connectivity, besides being a significant key to urban quality of life.

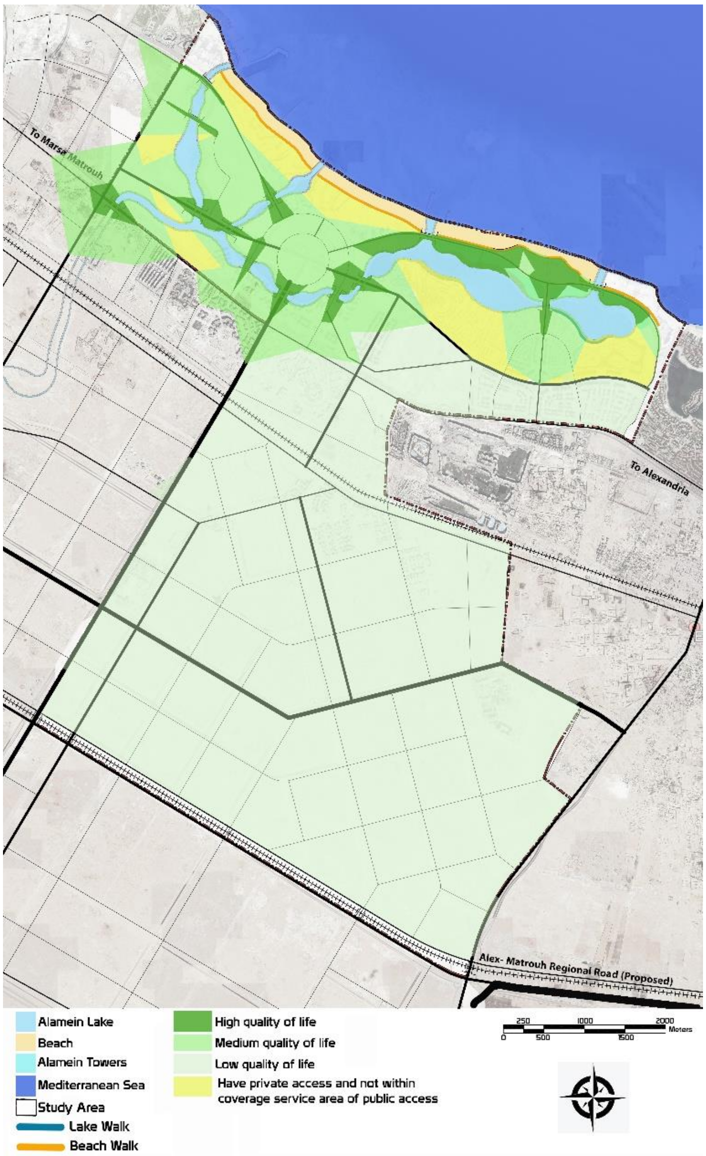


Fig. 10: Quality of life levels
Source: Author

6 Conclusion

Based on qualitative and quantitative approaches, the research identified definitions, benefits, and distribution of blue space, integrated with the 15-minute city concept, as well, the definitions and measuring method of accessibility. A comparative analysis between international and local case studies focused on the accessibility to blue spaces, as shown in Table 1, has been conducted to determine the accessibility variables of measuring person and place-based accessibility for blue spaces. Consequently, the research concluded the “Blue City Framework BCF”, as shown in Fig.4, which is considered an initial guide to evaluating the physical accessibility and proximity of existing and proposed coastal residential urban areas to natural blue spaces, as an indicator for levels of quality of life for coastal residential urban areas. Following that, the research investigates the validation and efficiency of the BCF by an applied study on phase one of Alamein City by relying on network origin-destination OD distance to assess coverage service areas of Alamein Lake and the Mediterranean Sea, combined with their proximity from residential urban areas within 400m and 1 km by walk, as shown in Figs.8 and 9. The applied study concludes the efficiency of BCF, and the high and upper-middle income residential urban areas are more accessible to the Alamein Lake and the Mediterranean Sea than the low and middle-income residential urban areas, due to the dominance of land value factor on the distribution of coastal residential urban areas more than considering needs of equity accessibility and rights of all individual for natural blue spaces. In addition, public transportation within blue space coverage service areas affects urban connectivity and is considered a significant key to urban quality of life. Then, the quality of life for Alamein residential urban areas is classified into three levels, as shown in Fig.10.

Consequently, the research is an initial step to shed light on the importance of urban blue spaces and their relation to the quality of life for Egyptian coastal residential urban areas. Furthermore, the significance of integrating BCF in the urban development policies for existing coastal residential urban areas, and within the urban design process of the proposed coastal cities. Further research is required regarding the assessment of visual access, besides the quality of blue spaces, to identify their effect on the quality of life for coastal residential urban areas. In addition, future research on how to consider the individual's need for equity access to blue spaces, integrating with the other factors, for example, economic, social, etc. Moreover, the need for future studies regarding artificial blue spaces as a critical significant to afford equal distribution for the urban areas that have physical or visual barriers to accessing the natural blue spaces with considering water scarcity.

7 Disclosure statement

No potential conflict of interest was reported by the author(s).

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