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Walkability Towards Transit Station the Case of Al Mansoura Metro Station

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Abstract

There is a growing demand for mass transportation systems to promote sustainable development due to opportunities for Transit-oriented development, where everything for daily life can be reached within walkable distance. The foundation of sustainable mobility is the integration of mass transportation systems and non-motorized transport. Therefore it is necessary to evaluate the whole environment around mass transit stations to attract pedestrians and cyclists, including the elements such as the street network, sidewalks, cycle lanes, crossings, lighting, signage, etc. Therefore, the need for a more integrated urban environment is necessary. The objective of this study is to investigate the walkability design towards the transit station by taking the case of Al-Mansoura metro station, which serves three most dense neighborhoods in Qatar; Najma, Mansoura and Fareej Bin Durham. The study also includes outdoor thermal comfort of the metro station premises concerning Qatar's hot and arid climate. After conducting a literature review on the related field, the proposed indicators by Monteiro & Campos (2012), have been modified according to the context of Qatar and used for evaluating the surrounding walkability of Al-Mansoura metro station. The findings include the need for improvement of the physical conditions of the street network and infrastructure for pedestrians and cyclists, and absence of public space within the study area to promote the social welfare of the surrounding neighborhoods.

Index Terms— *Walkability, Thermal Comfort, Transit-Oriented Development, Street Network.*

Introduction

Background of Qatar

The increasing revenue from the petroleum industry paved the way for rapid immigration and urbanization in the country. This, accompanied by the lack of proper public transportation and the hot, humid climate, caused Qatar to easily become an automobile-dependent city with segregated and poorly connected urban forms. The increasing number of private vehicles in the past years also adds to it. According to the [1] last year alone witnessed a 29.9% increase from the previous year. Studies have shown that, with the rise in vehicles in all cities, the authorities must build more roads to accommodate them. In addition, people must rely entirely on automobile transport due to reduced choice of transport mode and stigmatization of alternative methods. This will influence urban planning policies, and again the cycle continues, leading to higher carbon emissions, thereby decreasing outdoor thermal comfort of the people. The other main drawback of the automobile dependency of the city is the neglect of the pedestrian or cyclist facilities.

The introduction of QMR (Qatar Metro Rail Network) as a part of TOD (Transit Oriented Development) is a critical step in the development of Qatar towards sustainability. The TOD approach

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to urban development includes perimeter transport hubs such as metro stations and mixed land use within safe and well-connected areas. The study aims to investigate the walkability design towards transit stations, by taking the case of Al-Mansoura metro station, which is dense and connect to major neighborhoods. The study focuses on density diversity, accessibility, safety, security, infrastructure, mobility, thermal comfort.

TOD As a Response to the Growth of Qatar.

Winning the bid for FIFA World Cup (2022) was one of the key reasons for the development of Qatar's metro rail network, connecting all the major locations in the state (**Fig.** 1). However, many of the metro stations in Qatar happened to have a perceived lack of connectivity with their surrounding neighborhoods [2], which is essential for promoting walkability. Citizens, residents, and visitors have fewer transport options as they cannot walk or cycle to several Doha metro stations.

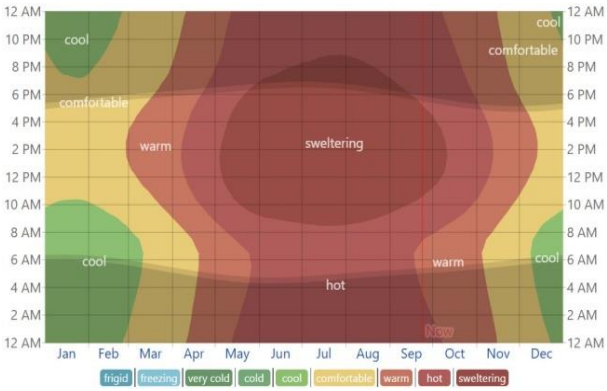
Fig. 1:Qatar Metro Rail Network. Source: Authors/ Google Map.

As all public transport journeys begin and end on foot, walkability is a foundation for the establishment of TOD. It is also necessary to integrate the transit stations with its surrounding urban environment as well as with other modes of public transportation facilities [3]**.** Walking adds life to the street and contributes to a safe urban environment. It is also linked to the quality of the urban environment, affecting people's attitudes towards it.

Walkability and Outdoor Thermal Comfort

Lively and healthy urban spaces can be seen in many large cities like New York and San Francisco, where the climate is

Fig. 2: *Temperature in Qatar throughout a year. Source: Weather and climate, 2022.[4].*



*also, a favoring factor in promoting outdoor life. However, urban outdoor life is challenging for cities in hot arid zones. As Qatar has a hot and dry climate that lasts for half a year with a maximum temperature of 45 degrees centigrade and relative humidity of 20 per cent during the summer (**Fig. 2**), attention is to be paid to outdoor life and walkability in urban planning. The only consideration provided in most of the places in Qatar is the human comfort inside a building utilizing air conditioning. Such carbon emissions alone cause a notable change in the urban microclimate. Concurring to Zeke Hausfather, climate information researcher at Berkley Soil, Qatar is one of the quickest warming regions of the world.*

In the best interests for the transit-oriented development, the climatic and current conditions around some metro stations in Qatar do not encourage walkability. Thereby, this paper aims to investigate the walkability design towards transit stations, by taking the case of Al-Mansoura metro station, which serves the three most dense neighbourhoods in Qatar; Najma, Mansoura and Fareej Bin Durham.

Literature Review

Method For Analyzing Walkability Towards Transit Station.

There are existing studies on pedestrian and cyclist accessibility towards mass transit stations, among which the one by [5] was adopted for this study. In that study, the researchers conducted an analysis of the entire environment surrounding mass transit stations including bus rapid transits, tramways, subways and commuter train stations in Rio de Janeiro, Brazil. After a detailed literature review and a survey of users in selected subways, a set of indicators were proposed (Table 1) to evaluate walkability to the mass transit stations, which investigates the accessibility infrastructure and effectiveness of the urban environment near the transit facilities. Through these indicators, strategies can be developed and implemented to attract and encourage non-automobile- oriented transport around transit stations.

Table 1: Proposed Indicators for The Evaluation of Walkability Towards Mass Transit Station By [5}.

URBAN USE	
Indicators	**Criteria**
Density	Population density
Diversity	How many stores in the immediate surrounding
	Type of stores
URBAN DESIGN	
Indicators	**Criteria**
Infrastructure for pedestrians and cyclists	Provision of sidewalk
	Provision of cycle lane
	Width of the sidewalk
	Quality of pavement of sidewalk
	Vegetation around
	Street lighting
Accessibility and Mobility	Access ramp on the curb at pedestrian crossings

	Sidewalk in tactile surface
	Visual and audible signaling at pedestrian crossings
	Gradient of the sidewalk
Safety	Safe road crossings
Security	Police on street

Methods for Improving Walkability Towards Transit Station.

Safety and comfort are the main factors that are to be maximized while planning for pedestrians and cyclists, whose quality depends on continuity of paths, distance to be travelled, conditions of the sidewalks, convenience and attractiveness [5]. Therefore, researchers advise treating the surrounding mass transit facilities cautiously. According to recent studies [6] 0, ensuring pedestrian safety, supporting mixed land uses with commercial interfaces at the ground-floor level, designating space for active transport modes, and reducing on-street parking can all improve walkability to the transit station. Therefore, researchers advise treating the surrounding mass transit facilities cautiously. Considering harsh and arid climate conditions, thermal comfort is required for social outdoor life and walkability. However, according to [8], the microenvironment and outdoor thermal comfort are rarely considered in urban planning and design procedures, a significant factor in why urban areas frequently being excessively uncomfortable. Also, from recent research [7], it has been noticed that distributing just a good land use and zoning layout, such as parks, plazas, open spaces and all critical areas will not help the neighborhood, if an adequate circulation, pedestrian pathways and connectivity are not. [9] reviewed blighted neighbourhood in Qatar that could be improved through urban regeneration with urban design input. Furthermore, [10] indicated that smart features in the street can improve pedestrian experience towards better public health. [11] described shading strategies that can be adopted to improve pedestrians on transit areas through temporary and permanent shading.

Strategies for Improving Outdoor Thermal Comfort.

Outdoor thermal comfort depends on many factors, such as solar radiation, air temperature, air movement, urban heat island, humidity, and sometimes air quality. Increased air temperature and severe solar radiation can cause thermal discomfort, heat stress and other health issues, escalated by the climatic changes. Therefore, resilience strategies must be developed for the city and building-level planning to cope with climatic problems. Among these, this study will concentrate more on shading strategies that can be easily applied to an existing urban space.

Shading strategies

Shading of outdoor spaces can be done in many ways. Among the different shading strategies, the building shade is the most efficient when assessing the thermal comfort index 0. A compact urban form is the most suitable for shading by buildings, which has been practiced since ancient times in many hot-arid countries. Traditionally, it is a characteristic of Qatari cities to have narrow road networks, called 'sikkas,' as well as narrow gaps separated by buildings [13] [14] [15]. Here, massing is used as a design tool for minimizing sun exposure by arranging buildings in such a way that they shade each other[11]. Thus, the walkways become a shaded network of streets. The additional use of arcades, colonnades, cantilevered buildings or other building components etc., provided with proper ventilation and airflow, promotes thermal comfort.

Studies have shown that roads with a high H/L (building height/roadway width) ratio are beneficial in summer as buildings provide shade. [16] Claims that the north-south road is easy to form a large shade by using the aspect ratio height. A ratio of 0.95 to 1.13 will result in less than 4 hours of sunshine on the road, providing a more comfortable thermal environment.

Another strategy is to use trees to provide shade. Suitable tree species can be selected based on comfortable climate requirements; for example, deciduous trees such as mulberry are ideal for hot, dry climates. Deciduous trees provide shade in the summer while losing their leaves in the winter, allowing the sun's rays to warm the building. According to research conducted by [17], while assessing the temperature variations in three (3) different scenarios; developing, urban, and coastal areas, the addition of mature trees (with approximately 10m height, at 10m intervals on both sides of the road) is the most effective remedy in reaching thermal comfort, compared with changing roads and pavements to lighter colors. According [18], vegetation can produce significant changes in thermal comfort with only a small effect on temperature. Vegetation not only blocks direct sunlight and provides comfort but also reduce long-wave radiation from the courtyard area and limit the amount of sunlight reflected from it. Therefore, walled garden or green walls could be more efficient in public spaces.

Shading by built structures can also be seen in many open areas, for example, the automatic giant umbrellas in the courtyard of Medina Mosque in Saudi Arabia, which work according to the solar radiation, open during the sunshine hours and folded backrest of the time. Using suitable land cover could help reduce air temperatures during the transitional period of the day when outdoor activities are most beneficial. For example, a standard light red paver for the ground could lower the surface temperature up to 12 degrees when compared to that of asphalt surfaces and 3 to 4 degrees when compared to areas with bare soil. Cool pavement, or the application of increased albedo materials for the ground surface, is a customary practice nowadays.

Research Design and Method of Study

Indicators for Walkability Evaluation

In the context of assessing walkability and thermal comfort around Al Mansoura Metro Station, the study employs a set of modified indicators tailored to the specific needs and challenges presented by the Qatari urban environment. These indicators are designed to comprehensively evaluate the pedestrian experience, safety, and thermal conditions, considering the unique climatic conditions of the region.

Pedestrian Infrastructure:

Sidewalk Quality: Assessing the condition and quality of sidewalks, including surface evenness, accessibility, and overall maintenance.Crosswalks and Pedestrian Signals: Evaluating the presence and effectiveness of crosswalks and pedestrian signals to ensure safe and regulated pedestrian crossings.

Cyclist-Friendly Infrastructure:

Cycle Lanes: Examining the availability and quality of designated lanes for cyclists, promoting a safer and more inclusive urban environment.

Bike Parking Facilities: Assessing the accessibility and quantity of bike parking spaces to encourage cycling as a viable mode of transportation.

Mixed Land Uses:

Diversity of Land Uses: Gauging the mix of residential, commercial, and recreational spaces around the metro station to enhance the vibrancy and functionality of the area.

Proximity to Amenities: Evaluating the accessibility of essential amenities such as shops, healthcare facilities, and recreational spaces to reduce the need for motorized transportation.

Safety and Security:

Crime Rate: Considering the safety aspect by analyzing the crime rate in the vicinity, promoting a secure environment for pedestrians and cyclists.

Lighting and Surveillance: Assessing the adequacy of street lighting and surveillance systems to enhance visibility and discourage illicit activities.

Public Spaces and Comfort:

Shade Availability: Investigating the presence and effectiveness of shading elements, such as trees, canopies, or built structures, to mitigate the impact of high temperatures.

Seating and Rest Areas: Evaluating the provision of seating and rest areas to enhance the comfort and overall experience of pedestrians and cyclists.

Thermal Comfort:

Microclimate Analysis: Utilizing microclimate analysis to understand the local thermal conditions, considering factors like wind patterns, humidity, and solar exposure.

Greenery and Urban Heat Island Effect: Assessing the role of green spaces in reducing the urban heat island effect and enhancing overall thermal comfort.

The study employs a multi-faceted approach, integrating Geographic Information System (GIS), Google Earth, and field observation methodologies to comprehensively assess and analyze the urban environment around Al Mansoura Metro Station. Each of these tools plays a distinct role in gathering spatial data, conducting analyses, and providing valuable insights for the study.

Geographic Information System (GIS)

Data Integration and Analysis: GIS is utilized to integrate and analyze diverse spatial datasets, such as land use patterns, transportation networks, and environmental factors. This helps in understanding the complex interplay of various elements within the study area.

Spatial Mapping: GIS enables the creation of detailed spatial maps that visually represent the distribution of different features relevant to the study, including land uses, infrastructure, and environmental conditions.

Overlay Analysis: GIS facilitates overlay analyses, allowing researchers to identify areas with specific characteristics, such as high pedestrian traffic, lack of green spaces, or suboptimal walkability.

Google Earth:

High-Resolution Imagery: Google Earth provides access to high-resolution satellite imagery, offering a detailed and up-to-date view of the study area. This imagery aids in identifying existing infrastructure, land uses, and potential areas for improvement.

3D Visualization: Google Earth's 3D visualization capabilities enhance the understanding of the urban landscape, allowing researchers to assess the vertical dimension of the built environment. This is particularly valuable for analyzing the presence of tall buildings, shading, and the overall visual aesthetic.

Field Observation:

Ground Truthing: Field observations involve physically visiting the study area to validate and supplement data obtained through GIS and Google Earth. Researchers can confirm the accuracy of mapped features, assess real-time conditions, and identify nuances that may not be evident in remote sensing data.

Microclimate Assessment: Field observations are crucial for evaluating the microclimate and thermal comfort on-site. Researchers can collect data on factors such as temperature variations, wind patterns, and the availability of shade, contributing to a more accurate assessment of thermal conditions.

The research design for the study is shown in Fig. 3. From the literature review, to analyze pedestrian comfort, which affects the walkability, shading, vegetation, and ground cover material, also should be added to the indicators proposed by [5], (2012). (Table 2). A 400-meter radius surrounding the Al-Mansoura Metro station was examined. Based on indicators and criteria related to urban use and design. The tools used for the study are GIS, Google Earth, and field observation of transit station premises. For shading analysis, field observation was done during the peak sunshine hours to understand the effect of street canyon and urban forms on shading. During thestudy (October), the peak sunshine hour was from 12 pm to 1 pm. Thereby, the site visit times were 1:30 pm and 3:30 pm.

Fig. 3: Method of Study.

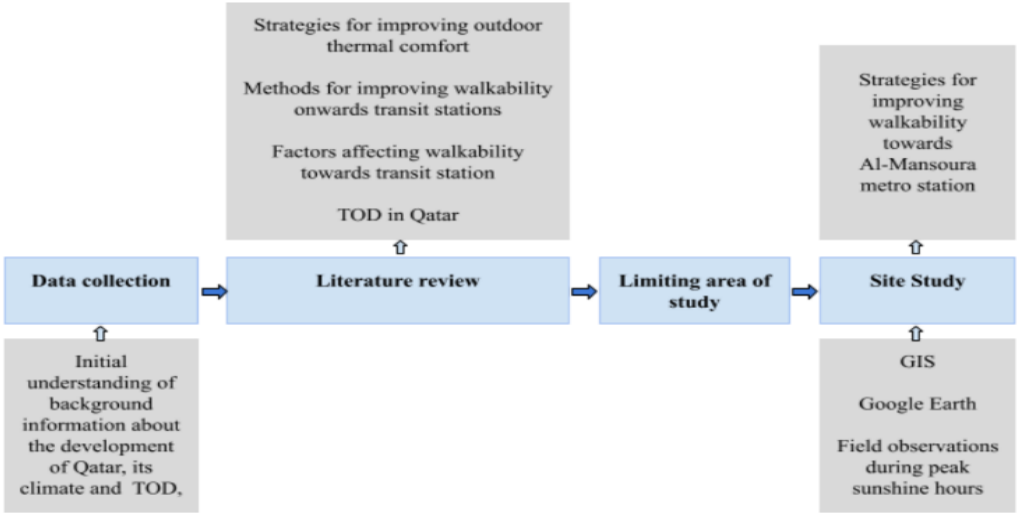


Table 2: Updated Set of Indicators for The Evaluation of Walkability Towards the Mass Transit Station. Source: Adapted from [5].

URBAN USE	
Indicators	**Criteria**
Density	Population density
Diversity	How many stores in the immediate surrounding
	Type of stores or diversity
URBAN DESIGN	
Indicators	**Criteria**
Infrastructure -Pedestrians/ Cyclists	Presence of sidewalk on both sides of the street
	Presence of cycle lane on both sides of the street
	Width of the sidewalk
	Quality of sidewalk pavement
	Vegetation around
Accessibility and Mobility	Access ramp on the curb at pedestrian crossings
	Sidewalk in tactile floor
	Visual and audible signaling at pedestrian crossings
	Gradient of the sidewalk
Safety	Safe road crossings
Security	Police on street

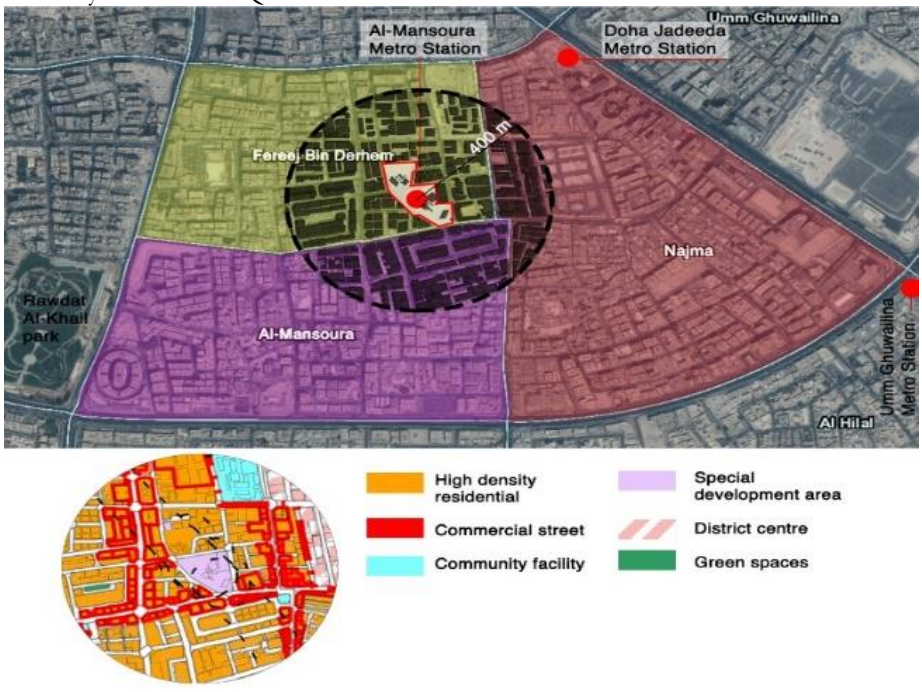
Thermal Comfort	Presence of trees
	Shading by street canyon and urban form
	Ground cover material

Case Study Findings: Al-Mansoura Metro Station

Morphological, Land Use, and Spatial Analysis

Al- Mansoura Metro Station serves Qatar's three most dense neighborhoods; Najma, Mansoura and Fareej Bin Durham (**Fig. 4a**). It lies between the B and C ring roads, the major arterial roads in the country, and consists of mixed-use land uses, including high-density residential and commercial activities (**Fig. 4b**). This compactness and mix of land uses could encourage the idea of 15-minute cities, where everything for our day-to-day needs is available within 15 minutes of travel. However, the neighborhoods were

Fig. 4: (a) Area of study within 400m radius around Al- Mansoura metro station. Source: Authors. (b) Land use of the study area. Source: Qatar National Master Plan.



developed over time due to rapid urbanization, population, growth especially expatriates, improper planning, and resulted in an automobile-oriented region with poor pedestrian and cyclist networks. According to [15], the surrounding area of Al-Mansoura metro station is dense, consisting of varying building typologies, including traditional courtyard houses from the 1960s. There is no open area, gathering space, or public park other than the open area around the Metro station within a 5-minute walk. The nearest park is at an 11-minute walking distance from the metro station, which is small and could not serve the entire neighborhood. The nearest neighborhood park, Rawdat Al Khail Park, is a 20-minute walking distance.

The main street provides access towards the metro station; Al- Mansoura Street and the local streets; Al-Khubaib Street, Al-Barab Bin Malik Street, and Aasim Bin Ali Street.Traffic congestion is high on the street network in the study area, which consists primarily of 4-line and 2-line roads. Streets in the study

area are mainly three-way and four-way intersections, creating smaller blocks, which make the area more walkable. Even though cycling activity was observed in the surrounding neighborhoods at a reasonable level, no designated cycling lanes or bicycle depots were seen.

Urban Use

Al-Mansoura Metro Station is located at the intersection of the three most dense neighborhoods in Qatar; Najma, Mansoura and Fareej Bin Durham (**Table 3**), which enriches the value of the transit station. The local area of the Al-Mansoura metro station is primarily made up of residential uses on the upper levels and commercial uses on the ground level. There are more than 35 shops which include several types, such as eateries, saloons, typing center, supermarkets, butcheries, grocery shops etc., among which eateries are in ample quantity, which is one of the factors that make the area more active, especially in the evenings. Many people can be seen around the station premises sitting on the safety barriers over the rooftop HVAC units of the underground metro station (**Fig. 5**).

Table 3: Density of The Surrounding Neighborhoods. Source: Adapted from [1].

Zone no	Neighborhood	Area in square kilometers	Population density per kilometer square
23	Fareej Bin Mahmoud	0.6347	29,701
24	Rawdat Al-Khail	1.7	16,561
25	Al-Mansoura	1.5	43,975
26	Najma	1.1	38,474
35	Fareej Kulaib	1.1	10,548

Fig. 5: People from Nearby Areas Using The Open Area Around Metro Station. Source: Authors.

Kids and family from nearby residential units use the accessible open area around the metro station for playing and friendly conversations, as it is the only accessible public space for social interaction.

Urban Design

Facilities for Pedestrians and Cyclists

The low availability of land in that area could be why there is no park and ride facility in Al- Mansoura metro station. The traffic congestion, which may have been caused by the drop-off or pickup vehicles, including metro link buses and taxis, has been avoided by providing multiple access points around the station. People also depend on bicycles to reach the station; however, no space is allocated for bicycle parking, and they are parked around the station entrances. Furthermore, no cycling track is provided along the streets within the 400m radius around the metro station. Most metro users are pedestrians whose pattern of movements was observed during the field study to understand which area is mainly used. Moreover, no designated pathways for pedestrians or cyclists along the metro station premises.

The **Fig. 6**, shows that most of the surrounding roads are provided with sidewalks on both sides with

street lighting, except for some residential areas where no sidewalks are provided and some with sidewalks on only one side. However, the quality of sidewalks is not good in many areas. It could be cracked, undulated or full of obstacles like bollards in the middle of the sidewalk. The sidewalks' width is also inconsistent in all areas, which is reduced along main streets to provide on-street parking for commercial activities. In some areas the continuity of sidewalk facility is broken. All these factors are causing difficulty for pedestrians to use the space effectively and sometimes lead to choosing to avoid walking. Smart building s can provide shade and information that make pedestrian experience more liveable and sustainable through adopting smart strategies [19]. Furthermore, inclusive design is vital for pedestrian safety [20]

Accessibility and Mobility

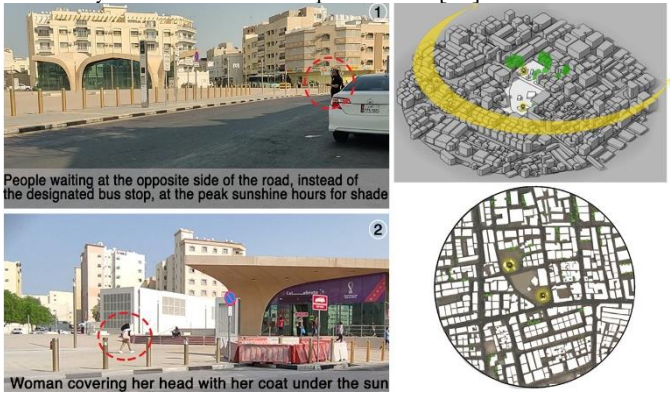
The immediate surroundings of the metro station are provided with access ramps on the curbs at pedestrian crossings. The situation is the same for the major junctions in the main streets like Najma and Mansoura. However, it is not valid for all areas; towards interior parts of the neighbourhood, the accessibility for pedestrians is reducing. All the signalized junctions are visualized but not provided with audible facilities. The street with more traffic is provided with sidewalk gradient in driveways connecting to the sidewalks, at the bus stops along the sidewalks etc. (**Fig. 6**).

Safety and Security

Qatar being one of the safest countries in the world; the streets are safe to walk at any time. The additional policing by the shop owners in front of their shops makes it safer. But when it comes to the overlap of traffic and uncontrolled pedestrian movements, people must be more cautious. Even though the roads connecting to the metro station have crossings from all sides, only major junctions are provided with crossings or signalized in the 400m radius around it (**Fig. 6**). At the street intersections along Najma Street and Al-Mansoura Street, informal crossings have been avoided using handrails along the sidewalk, ensuring pedestrians' safety. These informal crossings are seen more around the metro station (**Fig. 6).**

Thermal Comfort

Fig. 6: (a), (b), Need for shading in the metro station premises. Source: Authors. (c)Urban fabric of the study area showing vegetation around the metro station along with sun path. (d) Vegetation present in the study area. Source: Adopted from [15].



Most of the areas in the neighborhood, except for the Metro station area, have a compact settlement which causes shaded urban canyons. The effect of vegetation is underutilized in most of the areas. No consideration was given to the harsh climatic conditions either, as demonstrated in the **Fig.6,** how people are finding available shaded spaces to cover themselves from the direct sunlight, clearly showing

the need for shaded areas. Since the metro stations in Qatar are constructed to be stand-alone structures and no other buildings could come around them in future, the street typology remains the same, with one side of buildings and the other side void. The surrounding streets, such as Al-Khubaib Street, Al-Mansoura Street, Al-Barab Bin Malik Street, and

Aasim Bin Ali Street, were subjected to field study to understand the effect of the urban canyon in the peak sunshine hours, which is from 12PM to 4PM during the time of the study, October (**Fig. 7**). The areas covered by the shade from the urban canyon were marked at 1:30 and 3:30 pm at selected spots in each street, as shown in **Fig. 7.**

The orientation of streets also affects the level of shading for pedestrians. If both sides of the street have buildings, streets-oriented East-West direction are most comfortable. Still, here the case is different, as there are buildings only on one side of the street and the effect of shade changes according to which side of the streets the buildings are occupied. Here, Al-Mansoura Street provides the most shade, as the southern side has buildings which block most of the sun. However, except for some areas in Al-Khubaib Street without sidewalks, all the other streets surrounding the metro station do not provide shade along the sidewalk for pedestrians during peak sun hours.

Fig. 7: Site Observation for Street Shading by The Urban form During the Peak Sunshine Hours. Source: Author.

Discussion and Recommendation

Urban Design and Use.

Ensuring well-established mixed land uses near Al-Mansoura metro station could enrich the social life around it. Considering the abundance of eateries, outdoor seating could create opportunities for developing social activities and improve the quality of the physical environment, as Gehl (1961) suggests. Furthermore, as the site study shows, the open area around the metro station has the potential for developing a center for the surrounding residential neighborhoods. It could be designed as a public plaza, including seating spaces and a play area, which could eliminate the absence of public spaces within the study area. Introducing a plaza will also enhance the social welfare of society and public safety, by increasing street surveillance by the people everywhere or by the eyes on the street, as [21] Jacobs (1961)

recommends.

The street network should be upgraded to accommodate the pedestrian and cyclist infrastructure by improving sidewalks, ensuring its continuity, and adding sidewalks where they are missing. The proposal of a cycle lane towards the transit station and green spine along Al-Mansoura Street from Al Maha et al. (2022) study, is appropriate for improving walkability (**Fig. 8b**).

Outdoor Thermal Comfort Around the Metro Station.

The essence of a city depends on how it serves the people who are contained in it, which relies on the comfort it gives to the people to use the urban space. The use of urban space is more when it provides a better, thermally comfortable outdoor environment. As the proposed social space for people is an open area under continuous solar exposure observed during the site study, proper shading is required in the areas where the people's movement is most (**Fig. 8a**) in the form of shaded walkways, shaded informal seating spaces, etc. Minimum vegetation inside the site area could be improved to reduce the surface air temperature. Some of the ground cover could be changed to grass. The service structures within site could give a green wall along the side where people walk the most, thereby making it aesthetically improved as well.

Figure 8: (A) Observed Pedestrian Movement Pattern Around the Metro Station (B) Al Mansoura Street's Proposed Green Spine (C) Proposed Cycling Lane. (D) Proposed Improvements to The Sidewalk Network. Source: [15] Al Maha Al-Malki, Reem Awwad, Raffaello Furlan, Michael Grosvald and Rashid Al-Matwi, 2022.

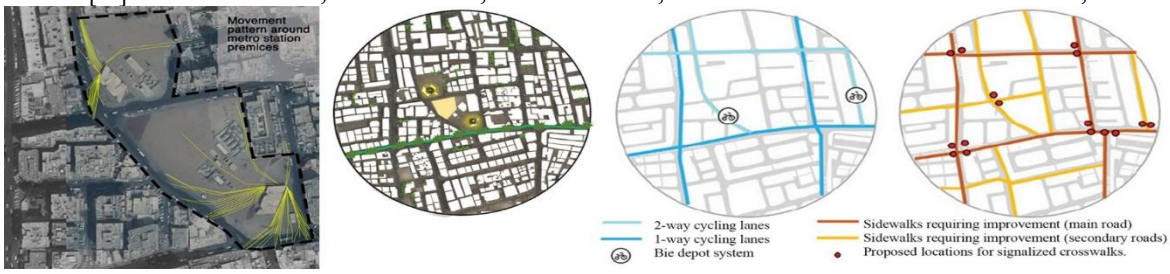


Figure 9: Proposed Design of Plaza. Source: Authors.

The TOD approach to urban development includes perimeter transport hubs such as metro stations and mixed land use within defined walkable areas. Several of the metro stations in Qatar have perceived a lack of connectivity with their surrounding neighborhoods; walkability is facilitated by connectivity. Citizens, residents, and visitors are hindered from utilising public transportation due to various challenges that include lack of proper shading and connectivity, cycling lanes with adequate parking systems within several Doha metro stations. The study aims to investigate the walkability design towards transit stations, by taking the case of Al-Mansoura metro station. The study focuses on density diversity, accessibility, safety, security, infrastructure, mobility, thermal comfort. The field study conducted at the

station indicates that there is lack of shading around the metro station. There is a need for street shade. [21] proposed strategies for shading spaces within the GCC. These include temporary and permanent shading such as shade from buildings and trees, and temporary shade from street shading devices. The methodology for the study focuses on site observations during peak periods of daylight. Furthermore GIS and Google Earth was employed review maps. Findings show metro station can be improved in both short-term and long-term. The integration of cycling racks at the station is vital for cyclist. The shading of bus stops and walking pathway towards station is vital.

Conclusion

The exhaustive study centered on Al Mansoura Metro Station has delivered profound insights into the factors that shape walkability and thermal comfort within the urban landscape. The evaluation of walkability revealed deficiencies in pedestrian infrastructure, with inadequacies in sidewalks, crosswalks, and amenities, compounded by high vehicular traffic and a dearth of green spaces, collectively undermining the overall pedestrian experience. The thermal comfort analysis unearthed localized thermal variations, attributing heightened temperatures in specific zones to impervious surfaces, insufficient greenery, and limited shade. Utilizing GIS and Google Earth facilitated the identification of suboptimal walkability areas, aiding targeted interventions. High-resolution imagery added depth to the understanding of three-dimensional aspects influencing thermal comfort. Field observations corroborated challenges identified remotely and identified areas where shade, green infrastructure, or other interventions could enhance thermal comfort. The subsequent recommendations encompass upgrading pedestrian infrastructure, implementing traffic calming measures, integrating green spaces strategically, considering urban design interventions, fostering community engagement, and incorporating microclimate-aware planning. This holistic approach forms the basis for interventions aimed at augmenting walkability and thermal comfort around Al Mansoura Metro Station, providing a roadmap for local authorities and urban planners to cultivate a sustainable, vibrant, and pedestrian-friendly urban environment..

Acknowledgment

The authors declare and acknowledge no conflict of interest.

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