Walkability Assessment of a Secondary Commercial Street in Jeddah, Saudi Arabia

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***Abstract*—This walkability has been one of the most prevalent modes of transportation throughout human history. In Saudi Arabia, the primary goal of Vision 2030 is to improve the quality of life by improving the community's socio-economic aspects. Enhancing walkability is one of the ways to strengthen socio-economic aspects regarding achieving Saudi Vision 2030. In this regard, this research investigates walkability in one of Jeddah's prime commercial streets. The study utilizes eleven measures and their sub-measures to set criteria for assessing the walkability on sub-commercial streets, notably Abdul Maqsud Khojah sub-commercial street in Ar Rawdah district in the Midwest of Jeddah city.**

In the east side interface of the street, only five of the walkability measures and (or) sub-measures met the success criteria. Similarly, on the west side of the street, six of the assessment measures and (or) sub-measures met the success target only. From the results and findings of the field survey, we found that the walkability of the street understudy was suboptimal. However, optimization of the walkability measures could improve walkability, which in turn may invite visitors and residents of the street to assume walking as a method of transportation. (*Abstract*)

Keywords*— Walkability; Walk Score; Walking Accessibility; Measurement; Daily Needs.

I. INTRODUCTION

Saudi Arabian cities have and still struggling to confront motorization challenges. These cities often cannot implement policies targeting street enhancements to facilitate walking. The gravity of this challenge escalates as Saudi cities expand geographically and demographically. However, the attention around the issue of walkability grew considerably in 2016 with the introduction of the Saudi Vision 2030" and its associated programs (e.g., the Housing Program and the Quality-of-Life program). The Quality-of-Life program QoL incorporates the need to improve the lifestyle and 'livability' of individuals, families, and communities. Such a need includes safeguarding the comfort and safety of neighborhoods and pedestrians in urban areas.

Ever since, academicians, urban practitioners, and policymakers have started addressing these issues through many guidelines, initiatives, thesis, and projects. However, the shift from car-oriented to people-oriented spatial development requires a profound policy turn. To sustain a long-term transformation toward walkability, urban practitioners should fundamentally restructure the walkability assessment tools.

Assessing urban walkability- the amount of neighborhood is friendliness to walking- has been a focal point of the quality of life and public health research and practice. Recent studies have showcased how walkability assessments provide benefits for the physical environment (Maleki & Zain, 2011; Pinho & Oliveira, 2009), urban health (A EL HELOU, 2019; Ahmed et al., 2016; Baobeid et al., 2021; James et al., 2017), city economy (Gorrini & Bertini, 2018; Kanellopoulou, 2018; Vural Arslan et al., 2018), and social life (Cowen et al., 2018; Zhu & Lee, 2008). The importance of walkability assessment suggests that it conventionally incorporates various knowledge domains, including but not limited to urban studies, architecture, urban sociology, environmental psychology, and computer science (Bandini et al., 2016).

Hence, walkability assessment is becoming one of the significant components of assessing the urban environment and the physical space. However, one of the main challenges of determining walkability relates to which assessment tools are deemed appropriate in a particular context (Gorrini & Bertini, 2018; Vural Arslan et al., 2018). Today, there are many walkability assessment tools. The most usable one among them is the walk scores method. Nonetheless, Walk Score's method has some restrictions. While the walk scores algorithm is centered on modern research around walkability, it does not report other factors affecting the tendency to walk. For example, walk score generally does not include street design, sidewalk presence or width, speed limits and actual automobile speeds, tree cover, and street furniture (Ameneh & POOYAN, 2018).

Delivering a realistic "context-sensitive" walkability assessment tool is crucial to city development. Yet, in the lack of clear guidance to assess walkability, it is challenging to identify the best approach to improve and determine the questions associated with walkability in our cities. The latter challenges range from recognizing the zones for enhancement to discovering the appropriate ways to generate change in the context of our cities. Hence, the Walkability Assessment delivers urban practitioners and academicians step-by-step assistance and guidance on the path to finding walkability solutions that are best fitting the urban context.

II. RESEARCH OBJECTIVES

A. The first is to generate a context-sensitive walkability assessment framework. (Heading 2)

Our aim here is to look at the different variations of walkability assessment tools considering both the social and environmental considerations of Jeddah city. We generally focus on identifying factors that encourage safe walks to daily residential shopping needs-to uncostly, healthy, and environmentally friendly recreational activities for the various resident's group ages groups.

B. Secondly, we aim to utilize this framework to assess the walkability in one of Jeddah's main sub-commercial.

Such assessment is crucial as it provides the essential step to turn our street into a pedestrian-friendly commercial corridor and address and improve access to daily needs and services of residential areas in Jeddah city. Generally, this will help improve the resident's quality of life and directly or indirectly improve the entire community's socio-economic, which are the main goals of vision 2030 of the Kingdom of Saudi Arabia.

III. METHODOLOGY

In response to the primary goals of this study, the authors employed a two-fold methodological strategy established on a qualitative approach to fieldwork data collection and synthesis. These two approaches focus on two parts.

A. Creating a context-sensitive walkability assessment framework

The authors conducted a thorough literature review for the first section to define the most suitable walkability assessment methods that fit the regional context and our case study. For this purpose, a literature review was conducted based on selecting keywords for searching in the Web of Science platform.

In the Web of Science search engine, Walkability Score has used as the first keyword in the search, which selected 363 articles, then filtered down to 37 papers after including > “Measurement” as the second keyword. The latter was narrowed down to 34 articles when the time frame of (2010 to 2021), was included. Moreover, irrelated categories from the search engine, including Nutrition Dietetics, Physiology, Medicine General International, Psychology Multidisciplinary, Biophysics, Computer Science Information System, Geriatrics Gerontology, and Meteorology Atmospheric Sciences, were excluded, which resulted in a reduction of the number of papers to 22. Then, papers were reviewed, and only 12 of them proved to be of relevance to walkability assessment.

The summarized walkability assessment measures obtained from the literature review were then validated through interviews. Four interviews were conducted targeting experts in the field of walkability. The experts were requested to modify our findings in the previous stage and decide whether the assessment criteria fit the required purpose based on the local experience. The result of these interviews is an 11-elements walkability assessment framework- including its sub-measures. In the last step, we set the success criteria for each assessment.

B. Applying the walkability assessment framework to our selected case study

The author selected “ Abdul Maqsood Khojah" secondary commercial street in Jeddah Saudi Arabia as a case study through a specific criterion (a high users density commercial street with multiple land use, serving high-income inhabitants located in the middle of the neighborhood) in the midwest city side (on summer season for one hour during the weekdays and weekend in the morning, afternoon and night) to evaluate the current spatial walking constraints. Our eleven walkability assessment measures were employed and deployed on-site in this part. Fieldwork was conducted for nine successive days in which the researcher collected both the street's physical characteristics and applied our walkability assessment measures on-site.

Currently, the scientific influences in the literature regarding walkability present a strong theoretical and methodological structure to construct a context-sensitive strategy for enhancing the pedestrian friendliness of Saudi urban areas.

IV. LITERATURE REVIEW

The term "walkability" may imply three main phenomena, depending on the scope and scale of use [1]. All use cases of this term relate to the factors that influence a person's decision to either walk in a given environment or opt for motorized transport means [2]. When focusing on environmental features, safety, the ability to transverse, compactness, and physical enticement are the main factors affecting walkability in a given area [2]. Furthermore, an outcome-focused perspective considers liveliness, sustainability of transportation systems, and inducing physical exercise [2]. From an urban design perspective, "walkability" refers to the multiple, measurable dimensions that provide a holistic solution to urban challenges caused by other means of transport [2]. Hence, walkability may describe different scenarios depending on the use case. Still, in all cases, the implication gravitates towards the factors that affect a person's decision to walk from one point to another instead of using other transport systems such as motor vehicles [2].

Recently, the Kingdom of Saudi Arabia (KSA) has experienced fast urbanization, whereby the population in cities has increased, attributed to the economic growth and prosperity witnessed since the 1980s [5]. The rapid population growth led to social and economic consequences, including air and water pollution, lack of affordable housing, traffic congestion, and frequent accidents [6]. Moreover, the high population increased trip time and pressure on the roads due to reliance on motor vehicles [6]. Moreover, there is a lack of sufficient parking spaces because families have more than one vehicle [5]. Consequently, the fast rate of urbanization created undesired social, economic, and environmental conditions, which ought to be addressed [6].

Literature on walkability states that walking in Saudi Arabia cities is affected by three main factors: distribution patterns of community services, travel behavior, perceptions, and people's willingness [5]. Rahman, Tauhidur, and Nahiduzzaman explored the effect of the distribution of community services in the Doha and Dana neighborhoods in Dhahran city [7]. The outcomes indicate that people in the town prefer to walk to service centers, worship areas, and shopping centers close to their homes [7]. However, people opt to use vehicles if the destination is over a kilometer [7]. Thus, the distribution of services, an inherent aspect of accessibility, directly effect walkability in Saudi cities [7].

At the urban design level, the design of sidewalks and roads affects walkability in Saudi cities as people prefer to walk when the sidewalks are comfortable, safe, and accessible [8]. In areas that have well-maintained sidewalks, people moving for short distances may opt to walk [8]. However, streets with poorly maintained sidewalks in terms of cleanliness, space, and

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pavement maintenance had few people preferring walking and instead opted for vehicles [6]. Moreover, unsafe streets have few people, especially at night, which concurs with American pedestrian behavior [6]. Hence, sidewalk and road conditions affect walkability, implying the need to have well-maintained, clean, spacious, and safe sidewalks in Saudi cities [6].

A different perspective of walkability was delivered based on how people perceive it. People's perception affects their walking choices, whereby individuals' willingness to walk in a given city varies significantly [8]. People's choice to walk starts by assessing the distance to their destination. Secondly, people consider the time to travel followed by their journey's perceived conditions, including weather, congestion, pollution, and safety, among others [8]. The hot weather conditions in Saudi Arabia. Based on the previous literature, it is established that four main pillars determine the challenges associated with studying and assessing walkability in Saudi cities, as the following;

- Physical (Structural) indicators that are related to the site settings, including topographical, infrastructural, and urban elements of the space (e.g., presence of public services, quality of road infrastructures).
- Socio-economic indicators related to how social, economic, and demographic characteristics of the urban area (including income level, age groups, sex, groups, and cultural background) influence walkability.
- Behavioral indicators are associated with how the spatial elements impact the actual walking behavior. This includes perceptual issues related to space safety, legibility, and mental maps.
- Environmental indicators focus on the effect the environment places on walkability activities regarding safety, security, and personal comfort. This might include weather and climate conditions, social values, and associated culture.

V. THE IMPORTANCE OF EVALUATING THE WALKABILITY

The accessibility of service centers affects walkability in Saudi cities. Rahman, Tauhidur, and Nahiduzzaman investigated the patterns and distribution of community services to assess the impact of accessibility on walkability [7]. The needs of residents were categorized according to their density and necessity. In this case, schools, banks and ATMs, supermarkets and grocery stores, Health facilities, and mosques were assessed [7]. The distribution of the facilities in a neighborhood compared to the number of people walking per square mile, and the study's outcome indicates that in areas where these needs were dense, a higher number of people preferred to walk [7]. Conversely, places with sparsely distributed facilities depicted a low number of people who chose walking [8]. Hence, the distribution of community services (needs) and walkability are directly correlated [7].

Accessibility is determined by the nature of paths from a centroid to a service center, whereby well-planned and maintained paths encourage people to walk [5]. Rahman, Tauhidur, and Nahiduzzaman assessed the road and sidewalk distribution in Saudi Arabia and correlated it with people's preference for walking [7]. The parameters considered include sidewalk maintenance, demarcation from motorized roads, exposure to weather conditions, and congestion [7]. These factors were summed up and quantified as accessible or inaccessible paths for pedestrians. After that, the accessibility was correlated with walkability patterns [5]. The outcome indicates that people prefer to walk if paths are accessible and opt for motor vehicles in the less accessible paths. Thus, increasing accessibility will raise walkability in Saudi cities [7].

VI. HOW TO EVALUATE WALKABILITY

A. A model of Walkability Assessment in Jeddah City

In this part, we will show the model of walkability assessment we reached out using the methodological approach previously explained.

For testing the walkability assessment of Abdul Maqsud Khojah Secondary commercial street in AR RAWDAH District in the city of Jeddah as a case study, we have used eleven walkability assessment measures "as shown in Table 1". We have generated walkability measuring criteria for the eleven main assessment measures with their sub-measures and generated the measure of their success after we collected the data from the field survey, "as shown in Table 2".

TABLE I. THE WALKABILITY ASSESSMENT MEASURES OF COMMERCIAL STREETS IN JEDDAH

The Walkability Assessment Measures Of Commercial Streets in Jeddah			
Index	Criteria of measurement	Methods	Measures of success (%) out of (100)
1	SIDEWALK SURFACE	Observation	Slipperiness
			Maintenance
			Discontinuity of surface level
2	OBSTACLES	Observation	(Tree or planter, signage or light columns, waste bins, urban furniture, electrical/water pump cabinets or tank cover, building wall)
3	SIDEWALK WIDTH	Observation Using Abu Dhabi urban street and utility design tool	----------
4	GROUND FLOOR USES (per km)	Observation	Active / Inactive
			Varity
			Attractive / Unattractive uses.
5	STREET CONNECTIVITY (Number of intersections to connect the Neighbourhood to the walkway per km)	Spatial analysis (maps)	----------
6	WALKING FACILITIES	Observation and/or Mapping	Planting
			Waste bins
			Urban furniture
			Drinking Fountains
			Temporary prayer Spaces
			Sidewalk
7	ACCESSIBLITY (Ease of access of all segments of society to and walk along a particular walking corridor)	Observation	Curb height
			Blinded pathway
			Disabled people ramp
8	PEDESTRIAN TRAFFIC SAFETY (Protection from Vehicles Buffer safety zones)	Observation	Car parking buffer
			Planting buffer
			Pedestrian protection barrier
			Street lighting
			Ambient Sidewalk lights
			Crossing Protection (Signage & Traffic Lights)
9	CONTINUITY OF THE WALKWAY	Observation	Pedestrian crossing lines
			Full discontinuity (By buildings or car parking)
10	SHADOWS (Building or Tree shadows)	Observation	----------
11	AESTHETICS (The visual scene of shops boards)	Observation	----------

As shown in Table 2, the walkability assessment of both the east and the west interface of the street has been separately evaluated in percentage, as shown in the walkability results column. Moreover, we have proposed the evaluation score per one kilometer out of 100 for all the measures. In addition, the only assumption that we assumed is that the street blocks in both the east and the west interface have the same length. Observation is the method used for all eleven walkability measures and their sub-measures except measure five (STREET CONNECTIVITY) and measure number ten (SHADOWS). Measure five has been analyzed by Space Syntax through the (Jeddah, Unplanned Settlements) project, as revealed in map number five (Jeddah's local spatial accessibility analysis). In measure ten (SHADOWS), the used method is (Google SketchUp analysis) as clarified in map number ten. Furthermore, the rest of the main eleven measures or sub-measures have their measuring criteria and the measure of success for each, as illustrated in the next paragraph. Regarding measure of success, to state the measure evaluation for the street is successful, the evaluation result for any of all main eleven walkability measures or the sub-measures must be equal to or exceed 66 %.

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TABLE II. THE WALKABILITY ASSESSMENT OF ABDUL MAQSUD KHOJAH SECONDARY COMMERCIAL STREET AR RAWDAH DISTRICT IN JEDDAH

The Walkability Assessment of Abdul Maqsud Khojah Sub-Commercial Street AR RAWDAH District in Jeddah.							
Measure	Method	The Evaluation Score out of 100 per kilometer					
		Measuring Criteria			Measure of Success	Walkability Results (%)	
		High above 66 %	Moderate between 33 & 66 %	Low 33 % & below	Coverage Above 66 %	East Interface	West Interface
1 SIDEWALK SURFACE							
Slipperiness	Observation	Non-slippery (concrete or similar) = High Semi-slippery = Moderate Slippery (ceramic tiles or shiny paint) = Low			Percentage of blocks with non-slippery sidewalk surfaces from the total street blocks having a sidewalk / km.	100	91.51
Maintenance	Observation	Blocks with no damages or 1 m length damage = 100 % Blocks with 2 spots of maximum 1 m length damage = 60 % Blocks with more than 2 spots or continues damage exceeding 1 m length = 30 %			The average percentage of blocks that exceed 66 % of the measuring criterion from the total street blocks having a sidewalk/km.	80	60
Continuity of surface level	Observation	Any block with changes in its sidewalk surface level is failed			Percentage of blocks with no changes in its sidewalk surface level from the total street blocks having a sidewalk/km.	25	85.71
2 SIDEWLK OBSTACLES							
Tree or planter Signage or light columns Waste bins Urban furniture Electrical or water pump cabinet or raised tank cover Building wall	Observation	Any block with sidewalk with more than one Obstacle is failed			Percentage of blocks with no or only one Obstacle from the total street blocks having a sidewalk/km.	Zero	50
3 SIDEWALK WIDTH	Observation	Using Abu Dhabi urban street and utility design tool for streets with 40 m width [9]. Sidewalk width = 2.7 m or above is success			Percentage of blocks having a sidewalk with width = 2.7 m or above from the total street blocks having a sidewalk/km.	50	50
4 GROUND FLOOR USES							
Active / Inactive	Observation	Interface width of Active uses			Percentage of interface width of the active uses from street interface width/km.	51.3	27.88
Varity	Observation	Interface width of Varity uses			Percentage of interface width of the variety-uses from interface width of all active uses/km.	10.92	34.23
Attractiveness	Observation	Interface width of Attractive uses			Percentage of interface width of the attractive uses from interface width of all active uses/km.	89.07	33.85
5 STREET CONNECTIVITY	X	Street intersections by Space Syntax [10].			Space Syntax result of Jeddah's local spatial accessibility analysis map [18].	33	33
6 WALKING FACILITIES	Observation						
Planting		The length of continuous planting equal to 10 m more.			Percentage of continuous planting (10 meters or more) from the lengths of the street's blocks/km.	25.86	46.8
Waste Bins		Waste bins availability in a systematic distribution every 200 feet (60 m) [11].			Percentage of waste bins availability in a systematic distribution every 200 feet (60 m) along the street interface/km.	Zero	Zero
Urban Furniture		X			X	Zero	Zero
Drinking Fountains		X			X	Zero	Zero
Temporary Prayer Spaces		X			X	Zero	Zero
Sidewalk		Any sidewalk with a length below half of a street block length will not be considered from the available sidewalk.			Percentage of available sidewalk length from the lengths of the street's blocks/km.	44.79	48.75
7 WALKWAY ACCESSIBLITY							
Curb Height	Observation	Using Chicago Department of Transportation STREET AND SITE PLAN DESIGN STANDARDS [12]. Curb Height of 7.6 to 22.9 cm			The percentage of sidewalks with a curb height of 7.6 to 22.9 cm from the total blocks having a sidewalk/km.	50	66.66
Blind Pathway	Observation	X			X	Zero	Zero
Disabled People Ramps (Crossing street intersections)	Observation	X			X	Zero	Zero
8 PEDESTRIAN TRAFFIC SAFETY							
Car Parking Buffer Zone	Observation	Car Parking Buffer Zone length			Percentage of Car Parking Buffer Zone length from the total length of street blocks/km.	40.68	26.73
Planting Buffer Zones	Observation	X			X	Zero	Zero
Protection Barrier	Observation	X			X	Zero	Zero
Street Lighting	Observation	X			X	Zero	Zero
Ambient Sidewalk Lights	Observation	X			X	Zero	Zero
Crossing Protection (Signage or traffic lights)	Observation	X			X	Zero	Zero
9 CONTINUITY OF WALKWAY							
Pedestrian crossing lines	Observation	X			X	Zero	Zero
Crossing Between Both Street Sides	Observation	X			X	Zero	Zero
Discontinuity of the Walkway (By buildings or car parking)	Observation	Discontinued sidewalks per block is failed			Percentage of continued Sidewalk per block from the total street blocks having a sidewalk/km.	75	100
10 SHADOWS							
Summer Shadows	SketchUp Pro 16 & AUTODESK REVIT 2020 analysis	Shaded sidewalk by building or tree (in summer at 10 am _ in winter at 4:30 pm)			The percentage of shadows coverage by meter on the length of the available sidewalk/km along the street.	64.95	Zero
Winter Shadows						Zero	100
11 AESTHETICS (Visual scene of shops boards)	Observation	Percentage of Active ground floor Uses following the municipal standard			Percentage of Active ground floor Uses following the municipal standard of shops boards/km.	100	100
The Sum		The sum of each interface of the street walkability score				28.01	31.83
		Total sum of the street walkability score				29.92	

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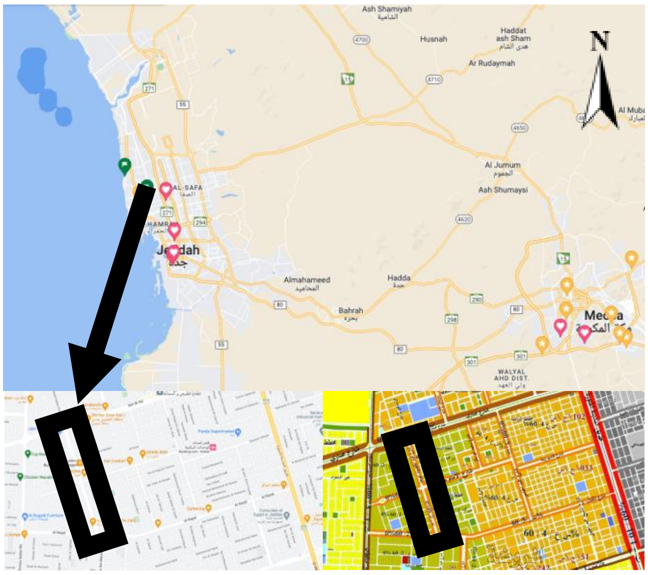
B. Walkability Assessment In Sub-Commercial Street – Background Information

Abdul Maqsud Khojah street is in the Ar Rawdah district on the Midwest side of Jeddah city's urban fabric, as shown doown in "Map. 1".

MAP 1: ABDUL MAQSUD KHOJAH SECONDARY COMMERCIAL STREET AR RAWDAH DISTRICT, JEDDAH



The street locates between Sari Street and Al-Kayyal street, parallel to Prince Sultan Road from the east side. The street length is approximately 1.07 km, and its width is 0.04 km (includes four driving lanes in each direction separated by a traffic island of 5 meters in width).

In terms of social life, it can be said that the social linkages between Abdul Maqsud Khojahstreet street users are relatively low based on the physical and environmental characteristics of the street inferred from the field survey.

As a commercial street (Secondary commercial street), we have classified the economic movement of Abdul Maqsud Khojah street into three categories: night, morning, and afternoon, based on the street user volume. We have conducted random on-street face-to-face interviews with the street's users and shop holders to determine the economic movement density in the street during 24 hours. The result of interviews shows that the highest volume of the street's users is in the night period, then the morning period comes after that. At the same time, the afternoon period has the lowest user volume within 24 hours. In other words, this means that the economic movement of Abdul Maqsud Khojah street is high at night, less than in the morning, and very low in the afternoon compared with the night and morning times.

Abdul Maqsud Khojah sub-commercial street buildings are under the commercial and residential use category as per Jeddah municipality's Atlas (in the middle of a residential villa area). The street's buildings height and the neighborhood behind both of the street sides consist of two stories with an annex. Regarding the ground floor uses. From the field survey, as per the evaluation criteria in Table 2, most of Abdul Maqsud Khojah's street interface is moderately active on one side of the street and low on the opposite side. In addition, the variety of ground floor uses of both of the street's interfaces is almost low. The attractiveness of the ground floor uses is high on one of the street sides and low on the opposite side. Moreover, most of the physical characteristics of the street's surveys that reflect the street environment (such as pedestrian traffic safety, walkway availability, and continuity) have scored very weakly in the walkability assessment, as clarified in Table 2.

VII. RESEARCH FINDINGS

In this part, the outcome of all generated maps of the eleven measures used for the walkability assessment of Abdul Maqsud Khojah Sub-commercial street will separately be explained as shown below.

A. Sidewalk Surface

This measure includes three sub-measures listed in the following order, Slipperiness, Maintenance, and Continuity of surface level. Slipperiness measuring criteria divide into three categories (non-Slippery=high walkability, Semi-Slippery=moderate, Slippery=low walkability). The measure of success of slipperiness is the non-slippery coverage of the sidewalk surface from the length of the total available sidewalk/km. The Slipperiness result of the east interface of the street is 100%, and the west interface is 91.51%. However, this means that the slipperiness results of both east and west interface sides of the street have matched the measure of success target.

Similarly, Maintenance measuring criteria divide into three categories. The first category, street blocks with no damage or 1m length damage=100%, the second category, street blocks with two spots of maximum 1m length damage=60%, the third category, street blocks with more than two spots or continues damage exceeding 1m length=30 %. The measure of success of the maintenance is the coverage of the average percentage of blocks exceeding 66% from the measuring criteria/km. The Maintenance result of the east interface of the street is 80%, but the west interface is 60%. However, this means that the maintenance result of the east interface side of the street matched the measure of success target, but the west side did not. Sidewalk Surface field survey is shown in "Fig. 1".

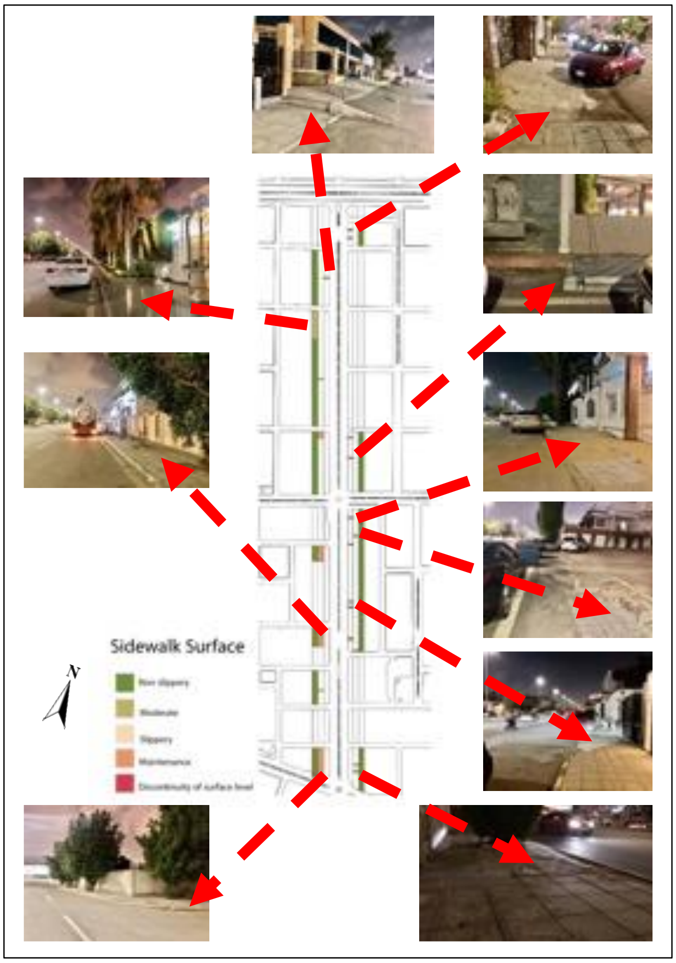


Fig. 1. Sidewalk surface field survey.

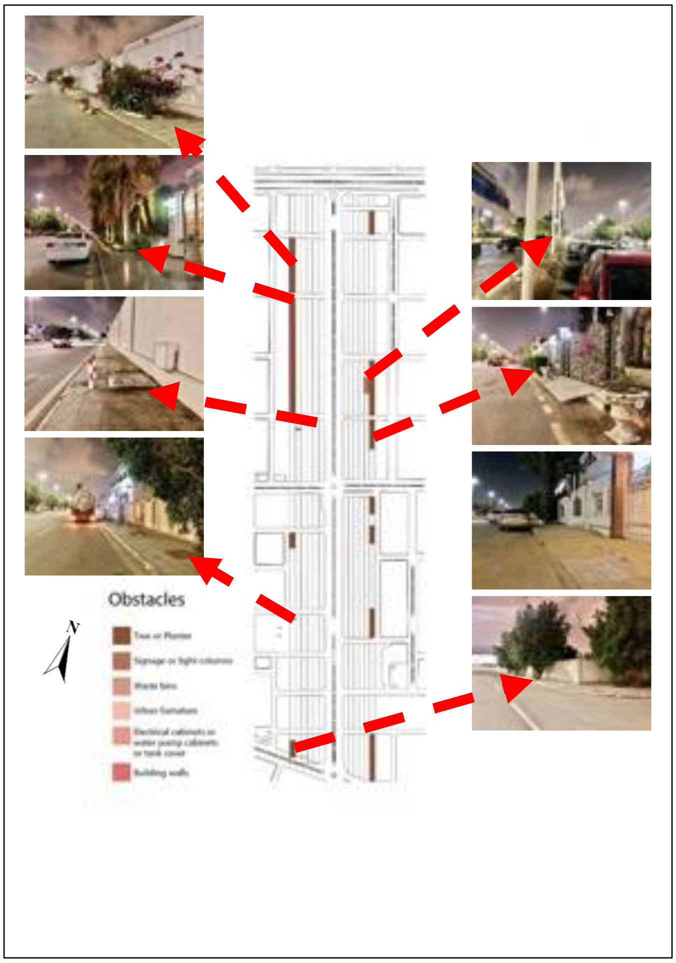


Fig. 2. Sidewalk obstacles field survey.

B. *Sidewalk Obstacles*

This measure assesses the presence of obstacles facing pedestrians on a sidewalk. The presence of more than one obstacle in a single block that has a sidewalk fails the criteria. The success measure of this assessment measure is a percentage of blocks with sidewalks and with one or no obstacles should be above 66%. The objects that are considered an obstacle include trees or planters, light or signage columns, waste bins, urban furniture, electrical or water pump cabinet or raised tank covers, or building walls blocking the sidewalk. On the east side of the street, only four blocks out of a total of 10 blocks had a sidewalk, and all of them had more than one obstacle. In other words, zero percent of the blocks were obstacle-free. On the west side, 6 out of 10 blocks had a sidewalk, and only 3 of them had one or no obstacles. Therefore, 50 percent of the included blocks were obstacle-free. However, this means both sides of the street failed to achieve the measure of success set for this walkability measure. Sidewalk obstacles field survey is shown in “Fig. 2”.

C. *Sidewalk Width*

The criterion for measuring proper sidewalk width has been adopted from the "Abu Dhabi urban street and utility design" tool [9]. For 40 meters wide streets, sidewalk width should be 2.7 meters or larger to be considered proper. The success measure is to have a percentage of sidewalks with a width of 2.7 meters of 66% of available sidewalks along the street. The east side of the street had two blocks out of 4 that had sidewalks with a width of 2.7 meters. On the west side, three blocks out of 6 have sidewalks with a width of 2.7 meters or more. Therefore, the percentage of sidewalks meeting the success criterion was 50 percent on both sides of the street. Thus, this concludes that both street sides did not meet the measure of success of appropriate sidewalk width. Sidewalk width field survey is shown in “Fig. 3”.

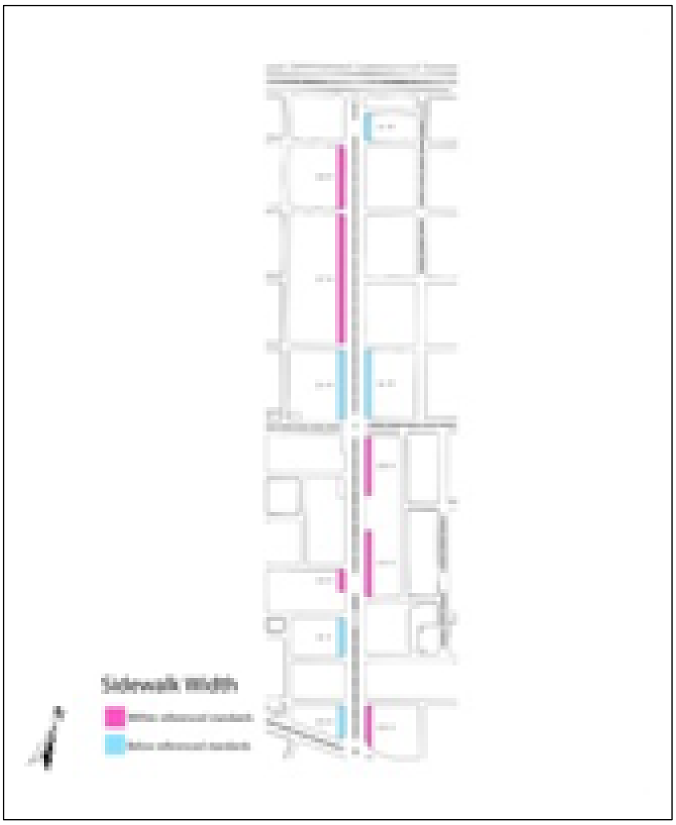


Fig. 3. Sidewalk width field survey.

D. Ground Floor Uses

"Ground floor uses" refers to the ground floor uses of properties facing a sub-commercial street. Three sub-measures were used to assess the ground floor uses. These uses are active or inactive, variety, attractive or unattractive. Ground floor uses field survey is shown in “Fig. 4”.

1) Active or Inactive Uses: Inactive uses refer to parking, vacant land, villas, and construction sites. The measure of success is to have 66 percent or more of ground floor interface width in meters of active uses along the street under study. On the east side, 51.3 percent of ground floor uses were active. While the "active ground floor uses" on the west side of the street were merely 27.88 percent. In other words, both sides of the street recorded a percentage less than the required cut-off needed for measurement success.

2) Variety, Attractive and Unattractive uses: The unattractive uses are a company or office buildings. Moreover, the variety of uses is any other ground floor uses that are active but neither attractive nor unattractive.

The success measure for both variety and attractive uses is the percentage of 66 of variety and "attractive uses" interface width in meters from the active ground floor uses along the street. However, the calculations yielded for the "variety of ground floor uses" on the east side only 10.92 percent, while 34.23% yield on the west side. The calculations indicate that there is not enough active variety of ground floor uses on both sides of the street. For attractive uses on the east side, 89.07 percent of ground floor uses found attractive, while the west side recorded a percentage of 33.85. The records indicate that the east side of the street met the criteria of success for "attractive uses" but not the west side.

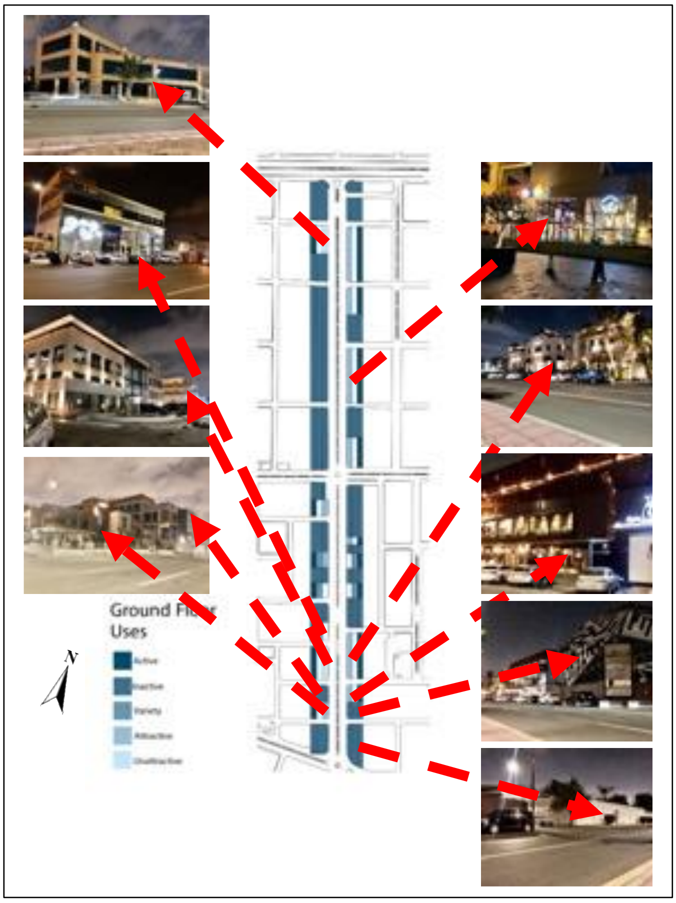


Fig. 4. Example of a figure caption. *(figure caption)*

E. Street Connectivity

Street connectivity refers to the connectivity of the street with the adjacent neighborhood. Street connectivity field survey is shown in “Fig. 5”. The measure of reference used to evaluate the street under study was Space Syntax Jeddah Unplanned Settlements project. Jeddah's local spatial accessibility analysis map generated by Space Syntax shows light blue color coding as depicted in “Map. 2” [10]. This color-coding refers to poor street connectivity. Therefore, for the street connectivity, a 33 percent score referred to low street connectivity was assigned for both east and west sides of the street under study.

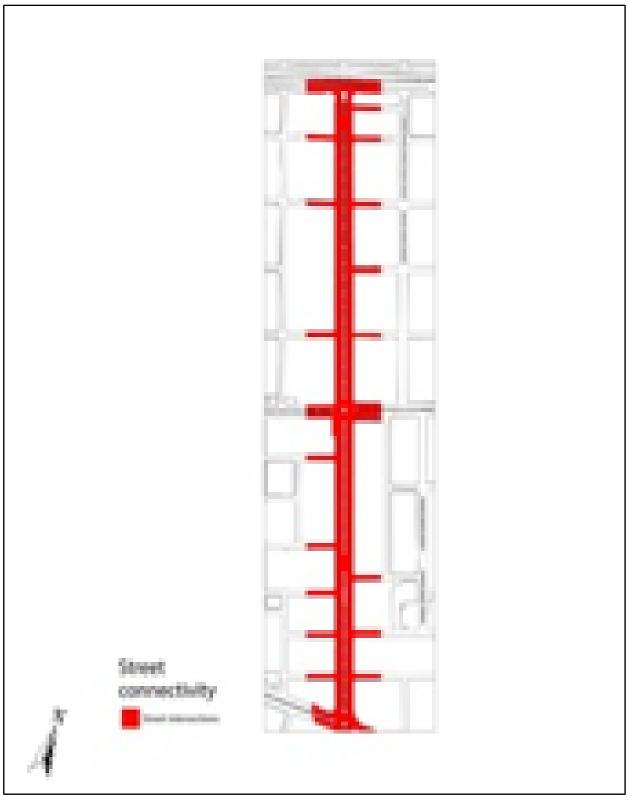


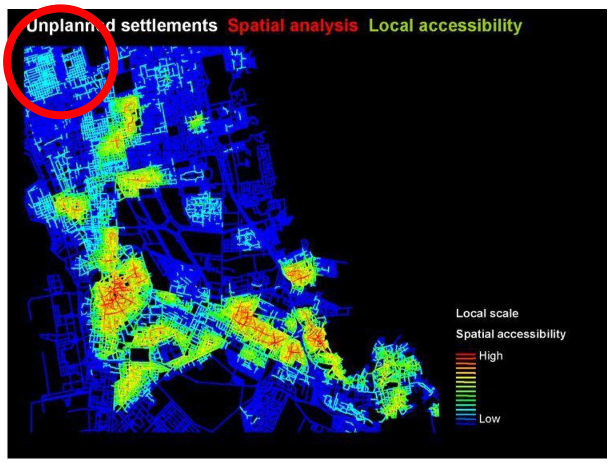
Fig. 5. Street connectivity field survey.

MAP 2: JEDDAH'S LOCAL SPATIAL ACCESSIBILITY ANALYSIS MAP DERIVED FROM SPACE SYNTAX.

In the map above, the circled area on the map derived from Space Syntax corresponds to Abdul Maqsud Khojah street. As shown by color coding, the entire area has low spacial accessibility. Hence, low street connectivity for Abdul Maqsud Khojah street (the under-study street).

F. Walking Facilities

This measure assesses the adequacy of walking facilities along the street. Six "Walking Facilities" were included in the survey (planting, waste bins, urban furniture, drinking fountains, temporary prayer spaces, and a sidewalk). In addition, three of the "Walking Facilities" (urban furniture, drinking fountains, and temporary praying spaces) were out of the evaluation as they were virtually absent from the site,



therefore, assigned a zero percentage. Walking facilities field survey is shown in "Fig. 6".

1) Planting: The measuring criterion is the continuation of planting equal to 10 m or more is defined as having planting. The measure of success for planting is a percentage of 66 or more of continuous planting from the total length of street blocks. On the east side of the street, only 25.86 percent have planted, and 46.8 percent on the west side. Therefore, this concludes that both sides of the street have inadequate planting along their length.

2) Waste bins: The measure of success for the adequacy of waste bins along the street is the availability of waste bins distributed systematically every 60 meters [11]. On both sides of the street length, only one waste bin on each side of the street was available, giving a percentage of coverage of zero for both sides. In other words, this indicates that both sides of the street have an inadequate number and distribution of waste bins.

3) Sidewalk: The sidewalk measuring criteria is if any block with a sidewalk less than half of its length would regard as having no sidewalk at all. The success measure of a street sidewalk is the percentage of available sidewalk length from the total length of the street's blocks per kilometer. On the east side of the street, from a total of 10 blocks, only four blocks had a sidewalk with an availability of 44.79 percent. On the west side, 6 out of 10 blocks had a sidewalk, with a percentage of availability of 48.75. Both sides of the street have availability of sidewalks of less than 66 percent. Hence, both sides have inadequate sidewalks compared to street length.

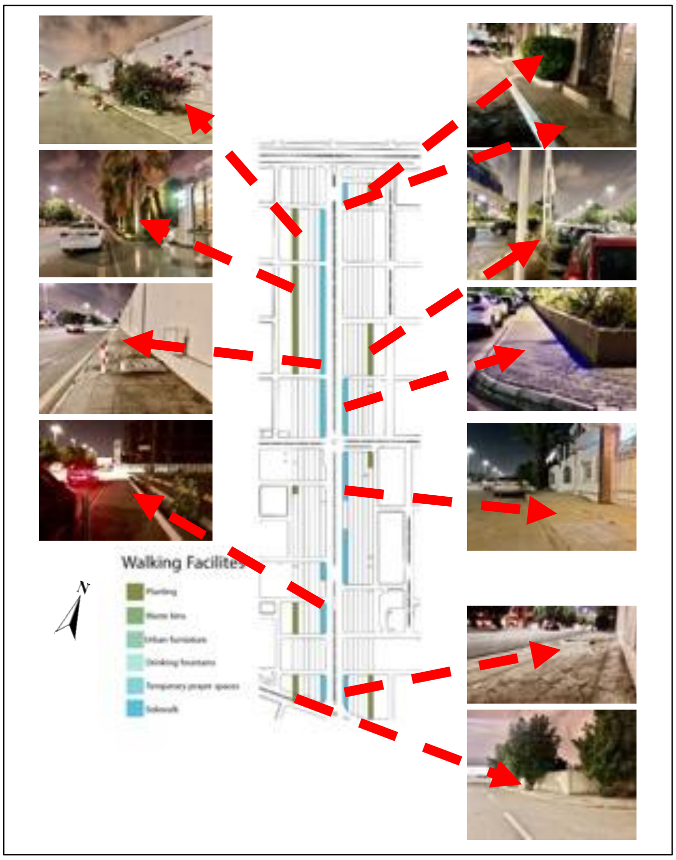


Fig. 6. Walking facilities field survey.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 12 Issue 02, February-2023

G. Walkway Accessibility

Walkway accessibility evaluates the presence of proper curb height, blind pathways, and sidewalk ramps to help with crossing street intersections for special needs individuals. However, there were no blind pathways or ramps to help with street crossings for people with special needs. Thus, these two sub-measures recorded zero percent. The measure reference for curb height was from the Chicago Department of Transportation Street and Site Plan Design Standards [12]. Standard curb height is between 7.6 to 22.9 cm high [12]. On the east side of the street, 50 percent of sidewalk curb height falls within the standard of the measure reference used, while on the west side, 66.66 percent of the total street length falls within the used standard. Therefore, the east side of the street failed to meet the measure of success for walkway acceptability, while the walkway of the west side of the street succeeded. Walkway accessibility field survey is shown in "Fig. 7".

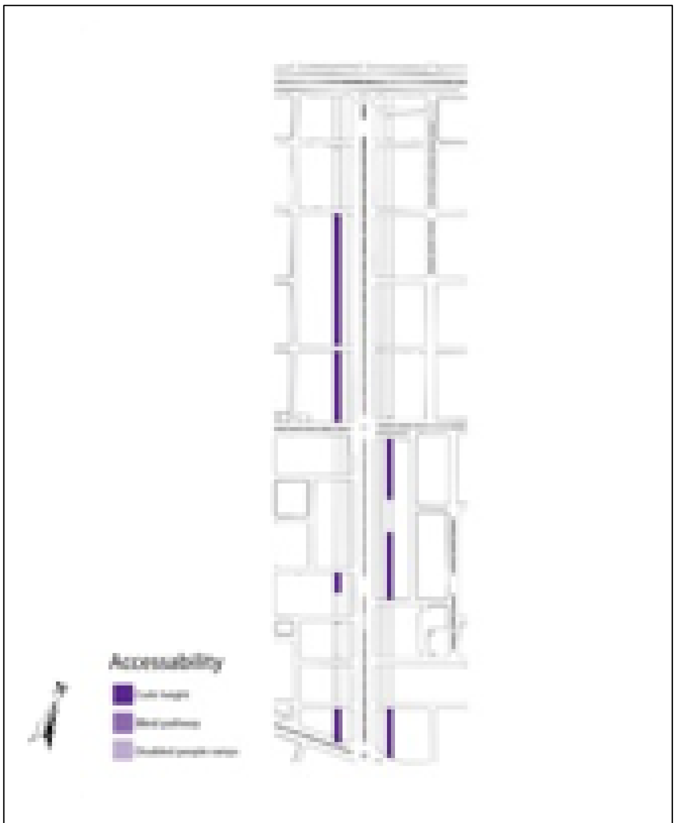


Fig. 7. Walkway accessibility field survey.

H. Pedestrians Traffic Safety

To assess the "Pedestrians Traffic Safety," we have used seven sub-measures. These sub-measures include car parking buffer zones, planting buffer zones, protection barriers, street lighting, ambient sidewalk lights, crossing protection signage, and traffic lights. Only a car parking buffer zone was available on-site, while the rest of the sub-measures do not exist on-site. Thus, zero percent is the result recorded for all of them. The measure of success for the car parking buffer zone is a percentage of 66 or above of its lengths from the total length of the street's blocks. On the east street side, the result recorded is 40.68 percent, while the west side recorded 26.73 percent. In other words, both sides of the street have insufficient car parking buffer zone and inadequate pedestrian traffic safety measures. Pedestrians Traffic Safety field survey is shown in "Fig. 8".

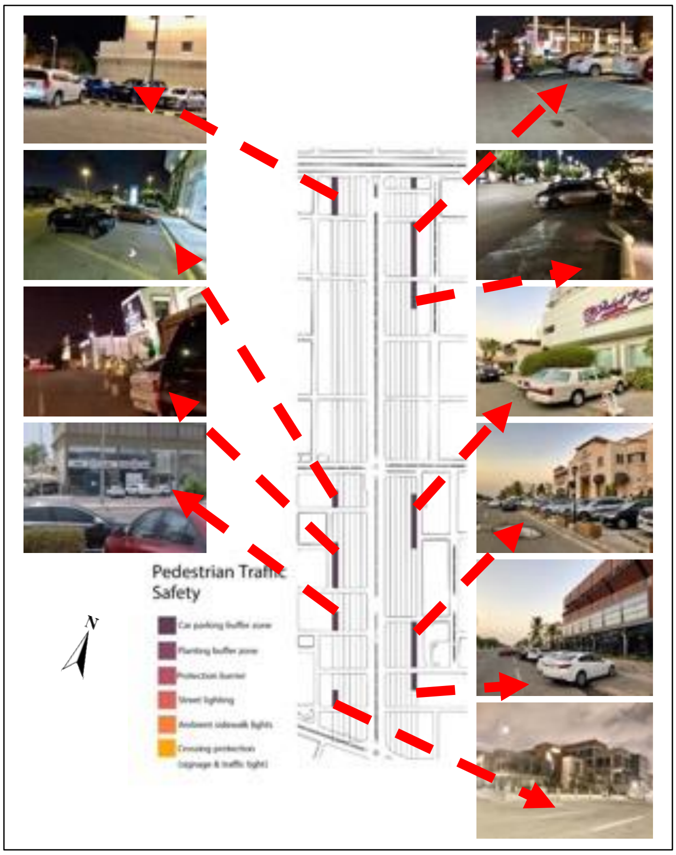


Fig. 8. Pedestrians Traffic Safety field survey.

I. Continuity of The Walkway

For assessing the continuity of the walkway, we used three sub-measures. These sub-measures are pedestrian crossing lines, crossings between both street sides, and discontinuity of the walkway by car parking or buildings. On-site, there were no pedestrian crossing lines along the street sides or crossing lines between the street sides. Hence, the latter two sub-measures results were zero percent. The success measure of this measure is the percentage of a continued sidewalk per block from the total street blocks having a sidewalk per kilometer. Any discontinuity of a sidewalk on a given block having a sidewalk will fail the success measure of this sub-measure for the assessed block. On the east side, 75 percent of sidewalks were continuous, while 100 percent of sidewalks were continuous on the west side. That means the sidewalks on both sides of the street have adequate continuity. Therefore, since there were no pedestrian crossing lines along the street sides or crossing lines between the street sides, it is inferred that the street under study has poor continuity of walkway. Continuity of the walkway field survey is shown in "Fig. 9".

International Journal of Engineering Research & Technology (IJERT)
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Vol. 12 Issue 02, February-2023

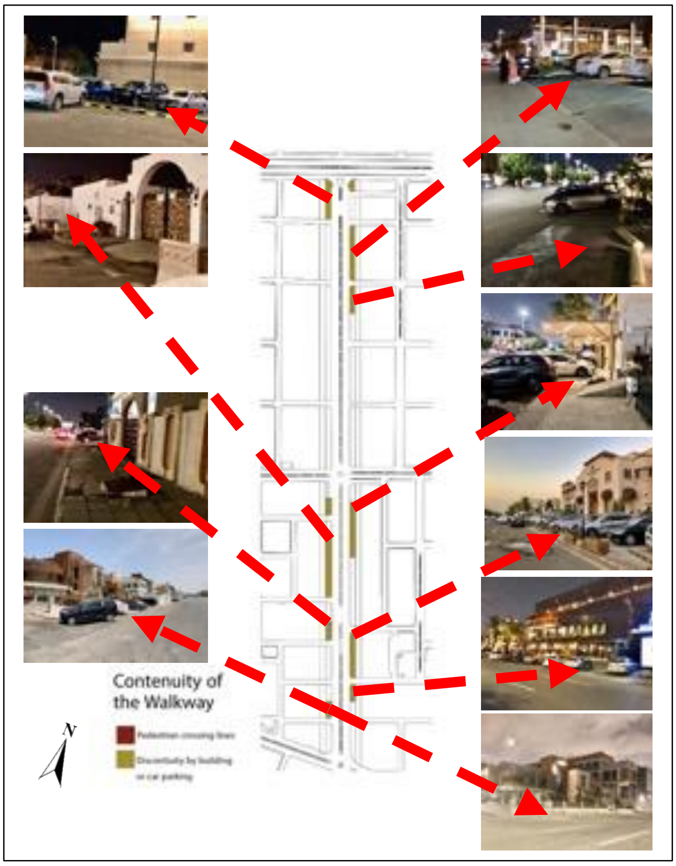

Fig. 9. Continuity of the walkway field survey.

J. Shadows

This measure assesses the adequacy of shadow coverage formed by buildings or trees over the pedestrian sidewalk in both the summer and winter seasons. Building heights and trees were recreated on SketchUp Pro 16 and resulted in a three-dimensional plan, which has been used in AUTODESK REVIT 2020 to analyze the produced shadows. AUTODESK REVIT entry data for summer was "20-July-2021 at 10:00 am", while for winter, it was "03-January-2021 at 04:30 pm". Furthermore, the coordinates of the street under study (21°33'59"N 39°09'00"E · 3.73 m) were also entered in "AUTODESK REVIT" for the data analysis. The measure of success of shadows is a percentage of 66% or more of shadow coverage by meter on the length of the available sidewalk/km along the street. In summer, the percent of shadows covering the east side was 64.95%, while the percent on the west side recorded zero percent. In winter, the percentage coverage was zero percent on the east side and 100 percent on the west side of the street. Thus, that means in summer, the east side of the street interface is covered moderately by shadows, while the west side is covered poorly. However, in winter, the east side of the street is covered poorly by shades, while the west side of the street interface is covered appropriately. Shadows field survey is shown in "Fig. 10".

Fig. 10. Shadows field survey.

K. Street Aesthetic

Street aesthetics refers to the visual scene of the shops' boards. However, the success measure for this measure is 66 percent of ground floor uses or more that follow the Jeddah municipality standards of shop boards along the street. This measuring criterion was agreed upon because there was no

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Vol. 12 Issue 02, February-2023

objective assessment tool from the literature review. Therefore, we chose the municipality standards to assess street aesthetics objectively. On the east side of the street, 95 percent of shop boards have followed the standards set by the municipality of Jeddah, while on the west side, 100 percent of shop boards have followed the standards. Thus, this concludes that the street aesthetics are up to the standards. Street aesthetics field survey is shown in "Fig. 11".

Fig. 11. Street aesthetics field survey.

To put things into perspective, the walkability assessment measures result for each of the east and west interface sides of the street were calculated. In the east side interface, only five measures and/or sub-measures met the criteria of success, including sidewalk surface slipperiness and Maintenance, the attractiveness of ground-floor uses, discontinuity of the walkway, and street aesthetics. The total sum of walkability measure results is 28.01 percent giving low street walkability overall. Similarly, the west side of the street interface had six measures and/or sub-measures that met the target for success. These were including sidewalk surface slipperiness, continuity of surface level, sidewalk curb height, discontinuity of the walkway, sidewalk shadows coverage in winter, and street aesthetics. The total sum of walkability results of the west side of the street is 31.83 percent, also giving low street walkability overall. Thus, both sides of the street interfaces have low walkability of an average of 29.92 percent.

VIII. Conlusions

This article has presented a review of the highly related and recent contributions exhibited in the literature about targeting the creation of asses of context-sensitive assessment criteria (11 criteria) and measures (criteria of success) for the assessment of the level of pedestrian friendliness of a commercial street in Jeddah.

The first objective of the current study was to evaluate spatial walking constraints regarding policies and regulations. Unfortunately, this objective was not met as there were poor walking facilities and/or the absence of some in the study area chosen, which made the evaluation of policies and regulations impractical.

The second objective was to identify factors contributing to safety walking whereby residents of all ages of adjacent neighborhoods are encouraged to walk. This object was achieved by literature review and by conducting interviews with the experts in the walkability field, which yielded 11 factors/measures that encourage walking, which have been detailed earlier in Table 2.

The third objective of the study was to propose possible pragmatic solutions that help enhance walkability and reduce car dependence's negative impact. We propose to take the 11 measures explained earlier and maximize their application. In doing so, the walkability of the street under study could be improved. In turn, this may invite residents and street visitors to assume walking as a method of transportation within the street rather than driving to get from one point to another within the same street.

The fourth objective was to address and improve accessing the daily needs and services of residents surrounding the street. Similarly, by meeting the standards set in the 11 walkability measures, this objective can be achieved. Furthermore, enhancing walkability in this case study and other areas for the same matter can raise the land value. Raising the land value may positively affect the socio-economic status of residents of the surrounding area, better residents' lives by promoting a healthier lifestyle, and provide safe access to daily needs and services, which all fall within the vision of Saudi Arabia 2030.

Several difficulties were encountered while conducting the current research. Although several walkability measures were adopted from the literature and implemented in our case study, none of them had specific measuring criteria or a specific measure of success to precisely evaluate the street under study. Therefore, we devised criteria for the measurement and their measures of success, which may need further validation. Moreover, online questionnaires developed to validate the 11 measures used had a low response rate. Therefore, face-to-face interviews were conducted with experts in the field of walkability to achieve this step of the study. Thus, this led to a delay in data collection and downstream sections of the research.

We encourage future research to validate the current methodology used to assess walkability in Saudi Arabian streets, including neighborhoods, local level, sub-commercial, commercial streets, etc. Also, it is important to explore inexpensive possible means to enhance walkability and collect reviews from end-users. These suggested future directives may help improve the living standards of residents of Saudi Arabia and aid in making vision 2030 a reality.

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I would like to express my sincere appreciation to Dr. Ibrahim Bahreldin for his believing in me and my ideas since the first days in this thesis until the end of this journey, he has always been a great mentor; also, Dr. Hosam abo-Alfotouh for his guidance through this field of academic research and help in achieving my goals and dreams, working with him was an outstanding experience. Finally, great appreciation for the writers community in Jeddah for their encouragement of me to write more, meet my goals, and achieve publication of my first research.

REFERENCES

[1] Forsyth A. What is a walkable place? The walkability debate in urban design. Urban design international. 2015 Dec; 20(4):274-92.

[2] Rogers SH, Halstead JM, Gardner KH, Carlson CH. "Examining walkability and social capital as indicators of quality of life at the municipal and neighborhood scales": Erratum.

[3] Yuan Y, Xu J, Wang Z. Spatial equity measure on urban ecological space layout based on accessibility of socially vulnerable groups—A case study of Changting, China. Sustainability. 2017 Sep;9(9):1552.

[4] Jamei E, Ahmadi K, Chau HW, Seyedmahmoudian M, Horan B, Stojcevski A. Urban Design and Walkability: Lessons Learnt from Iranian Traditional Cities. Sustainability. 2021 Jan; 13 (10):5731.

[5] D'Alessandro D, Valeri D, Appoloni L. Reliability of T-WSI to Evaluate Neighborhoods Walkability and Its Changes over Time. International Journal of Environmental Research and Public Health. 2020 Oct;17(21):7709.

[6] Sohn DW, Moudon AV, Lee J. The economic value of walkable neighborhoods. Urban Design International. 2012 May; 17(2):115-28.

[7] Azmi DI, Karim HA, Ahmad P. Comparative study of neighbourhood walkability to community facilities between two precincts in Putrajaya. Procedia-Social and Behavioral Sciences. 2013 Dec 3; 105: 513-24.

[8] Rahman MT, Nahiduzzaman K. Examining the walking accessibility, willingness, and travel conditions of residents in Saudi cities. International journal of environmental research and public health. 2019 Jan; 16(4):545.

[9] Department of Urban Planning and Municipalities. Abu Dhabi Urban Street and Utility Design Tool [internet]. Department of Urban Planning and Municipalities; 2010. Available from: https://usdm.upc.gov.ae/USDM/

[10] Space Syntax. Jeddah, Unplanned Settlements [internet]. Space Syntax; 2022. Available from: https://spacesyntax.com/project/jeddah-unplanned-areas/

[11] SF Better Streets. Sidewalk Trashcans [internet]. San Francisco: SF Better Streets; 2015. Available from: https://www.sfbetterstreets.org/find-project-types/streetscape-elements/street-furniture-overview/sidewalk-trashcans/

[12] Chicago Department of Transportation. Street And Site Plan Design Standards. City of Chicago. 2007 April; 10.