

Sustainable Urban Corridors in Khartoum

Case of Mohammed Najeeb Street

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ABSTRACT

This article aims at measuring the sustainability of the streets of Khartoum using the Pedestrian Environmental Quality Index (P.E.Q.I.). This index has six categories: Intersection safety; traffic; street design; perceived safety; land use; and perceived walkability. Each category has several items. As a case study, Mohammed Najeeb main street is studied since it represents main streets in Khartoum. Results show that the sustainability standard of the studied street is below average (40%). Conclusions are written. And recommendations are drawn.

Keywords-- Measuring the Sustainability of the Streets of Khartoum, Pedestrian Environmental Quality Index, Mohammed Najeeb Main Street

I. INTRODUCTION

An urban street is defined as a public road with traffic signal control at least once every 2 miles [1]. Stakeholders must set goals for their streets to meet the requirements of sustainability. Measuring the viability of a street requires a multidisciplinary approach and methodology so that the required specification can be obtained. Streets have been evaluated based on the vehicular movement and the safety of drivers, but the actual mobility function of a street is to be measured by the safety of all street users. Each street must be taken as a project with certain goals such as; environmental and economic sustainability, health and safety measures, quality of life, comfort and easy mobility [2].

Streets are a physical social system encompasses many social, cultural, economic, and environmental features and activities. These various elements create the urban tissues of the city. Streets connect different physical locations and spiritual identities within the society or community. The surge in population size together with the economic challenges which result in heavy traffic and very active population movement especially in city centres spoil the integrity, functions, beauty, and efficiency of streets. Chaotic situations prevail in many big cities in the world produce pollutions, heavy traffic, traffic jams, and malodorous environment, Khartoum is no exception. The situation in Khartoum city is sub-standard. Every type of

traffic uses the same street; vehicular, transit ridership, carts, bicyclists, pack animals, and pedestrians. This congestion creates car accidents, polluted atmosphere and huge traffic jams. This prompts the need for more research on this topic to find appropriate solutions. This research hypothesizes that, by applying sustainable streetscape elements which are manifested in the built environment, it helps achieve sustainable urban design tissues, and thus contribute to establishing sustainable communities that form the city.

II. STATEMENT OF THE PROBLEM

Most of urban streets in Khartoum were not designed to be sustainable. They lack some basic elements of the quality and safety of the physical pedestrian environment needs and motorized vehicular traffic.

III. AIM OF THE RESEARCH

The aim of this research is to measure the sustainability of urban streets in Khartoum city using P.E.Q.I. that help the stakeholders to design strategies for sustainable streets in Khartoum.

IV. METHODOLOGY

The Pedestrian Environmental Quality Index (P.E.Q.I.) is used to measure walkability and pedestrian safety in Khartoum. The P.E.Q.I. is a quantitative observational tool that was originally developed in 2008 by the San Francisco Department of Public Health to assess the quality and safety of the physical pedestrian environment and inform pedestrian planning needs. Beyond assisting planning, P.E.Q.I campaigns can help build social capital and political visibility for neighborhoods and communities. The P.E.Q.I. has two survey forms and gathers data in six categories: intersection safety, traffic, street design, land use, perceived safety and perceived

walkability [3]. The P.E.Q.I. was modified for use in Los Angeles by Malia Jones, MPH. Key changes were made to the original instrument in order to make it

applicable to the Los Angeles Environment. Thus, to use the same tool for Khartoum also changes should be made to suit the environment of Khartoum. All changes made are explain in the limitations section.

A. Limitations

The choice of only one street as a case study is based on the fact that it represents all the main streets in Khartoum in terms of traffic characteristics, street design, perceived walkability, perceived safety, and intersection safety.

The surveys that should be carried out for the P.E.Q.I. were substituted by close observations performed by the author. This due to impossibility of finding volunteers or even paid personnel to perform the job.

It is difficult to use all elements of the six categories of P.E.Q.I. for measuring the sustainability of the urban streets in Khartoum city for, the current situation of the infrastructure in the country in general and in Khartoum in particular is sub-standard. This is due to the economic situation of the country. Only applicable P.E.Q.I. categories and elements were used in this research.

B. Definition of Sustainable Streets

Sustainable streets is defined by Environmental Protection Agency, in the US (EPA) as the Streets which maintain natural environment, healthy communities, and economic vitality [4]. It is a term used to describe the natural and built fabric of the street, and defined as the design quality of the street and its visual effect, particularly how the paved area is laid out and treated. It is consist of various elements [5]. A streets environment is the result of two things: the physical environment and the uses that take place within public space. To help shape the character of new areas that are in the development phase and protect the quality of existing neighbourhoods, the District's streets standards, guidelines, and policies guide changes to public space. Physical features that are reviewed for design include sidewalks, landscape, car parks, bicycle and handicapped roots, street trees, and other infrastructure like street lights and gutters. Uses that impact the character of public space include sidewalk cafes, vending, street festivals, and other temporary activities [6].



Fig 1 Riding bikes through a busy street [2]



Fig 2 City street in India [2]



Fig 3 Intersection Accra Ghana [2]

C. Objectives of Sustainable Streets

Sustainable streets should add to the built environment of the city a liveable space for all types of street users who interact and communicate with each other [7]. The objectives of sustainable streets then summarized as follows:

1. To maintain safe intersection: crosswalks, countdown signal, traffic signal, crossing speed, no turn on red, traffic calming features, pedestrian signs.
2. To organize traffic: Number of Lanes, Two-Way Traffic, Vehicle Speed, Traffic Volume, Traffic Calming Feature.
3. To maintain street design: sidewalk width, sidewalk surface, sidewalk obstructions, presence of curb, driveway cuts, trees, gardens, public seating, buffers.
4. To maintain perceived safety: illegal graffiti, litter, pedestrian-scale light, construction sites, abandoned buildings.
5. To cater for land use: public art, historic site, retail.
6. To maintain perceived walkability: visual attractiveness, feeling of safety, smells, noise.

D. Definition of Sustainable Streets

Sustainable streets can be defined as “multimodal rights of way designed and operated to create benefits relating to movement, ecology and community that together support a broad sustainability agenda embracing the three E's: environment, equity, and economy, and implementing sustainable urban streets can create more liveable communities [8].

E. Elements of Sustainable Streets

Sustainable streets elements are all those functional and decorative elements that are placed, laid, erected, planted or suspended within a public or communal urban space. They include public utilities and amenities, visible elements of service infrastructure, street lights, traffic signs and signals, street trees and other horticultural elements, general public furniture, advertising signs and decorations [9]. These elements are clarified as follows:

1. Intersection Safety:

It deals with crosswalks, countdown signal, traffic signal, crossing speed, no turn on red, traffic calming, pedestrian signs see Figs. 1,2,3,4,5,6.

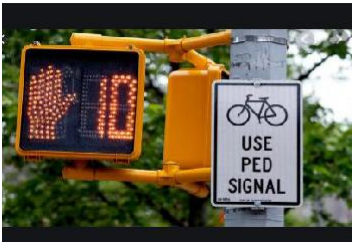


Fig 4 Cyclist to follow pedestrian [4]



Fig 5 Zebra crossing with flashing beacons [4]



Fig 6 traffic calming [4]

2. Traffic:

It deals with organizing traffic: Number of Lanes, Two-Way Traffic, Vehicle Speed, Traffic Volume, Traffic Calming Feature see Figs 7,8,9,10,11.



Fig 7 Traffic lanes [10]



Fig 8 Two-way traffic [10]



Fig 9 Speed limit [10]



Fig 10 Traffic volume [11]

3. Street Design:

It deals with maintaining street design: sidewalk width, sidewalk surface, sidewalk obstructions, presence of

curb, driveway cuts, trees, gardens, public seating, buffers, see Figs 12,13,14,15.



Fig 12 Sidewalks [12]

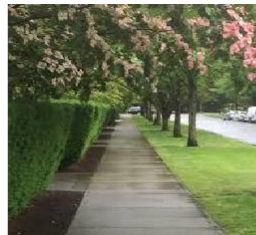


Fig 13 Trees, lawn, and drive cuts [12]

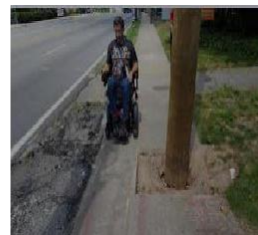


Fig 14 Power poles and holes [12]



Fig 15 Buffer, and public seating [13]

4. Perceived Safety:

It deals with illegal graffiti, litter, pedestrian-scale light, construction sites, abandoned buildings, see Figs 16,17,18,19.



Fig 16 pedestrian-scale light [13]



Fig 17 Construction site [13]



Fig 18 Litter on streets [13]



Fig 19 Abandon building & graffiti [13]

5. Land Use:

It deals with public art, historic site, retail, see Fig 20,21,22.



Fig 20 Public art [14]



Fig 21 Historical sites [14]



Fig 22 Retail places in Jeddah KSA [14]

6. Perceived Walkability:

It deals with visual attractiveness, feeling of safety, smells, noise, see Figs 23,24,25,26

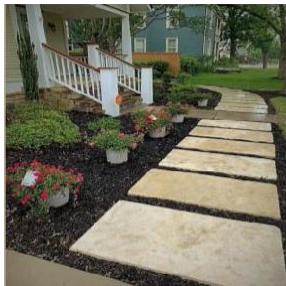


Fig 23 Visual attractiveness [15]



Fig 24 Feeling of safety [15]



Fig 25 Smell [15]



Fig 26 Noise [15]

V. THE CASE STUDY

The current population of Sudan is 44,103,404 as of Saturday, October 3, 2020, based on Worldometer elaboration of the latest United Nations data with 2.24% yearly rate of increase. 35% of the population live in urban areas. Khartoum, the capital city of the Sudan, consists of three cities Khartoum the administrative centre, Omdurman, the national capital, and Khartoum North, the industrial city. They are connected with by eight bridges. The population of the metropolitan capital in 2020 is 5,829,000 people. Its area is the largest in Sudan, the sixth-largest in Africa, the second-largest in North Africa, and

the fourth-largest in the Arab world. Khartoum is located at the confluence of the White Nile, and the Blue Nile, see the Figs 27, 28. From there, the Nile continues to flow north towards Egypt and the Mediterranean Sea [16]. Main streets in Khartoum represent the most beautiful, wide, busy, and congested in the country. Officials, business men, students, workers, shoppers, and other types of people move from place to place within the city from dawn to dusk earning living and seeking benefits. Mohammed Najeib street is chosen to represent the streets in Khartoum because it is a typical one. It is an old, wide, busy, central, takes a great volume of people from one side of Khartoum to the another side.

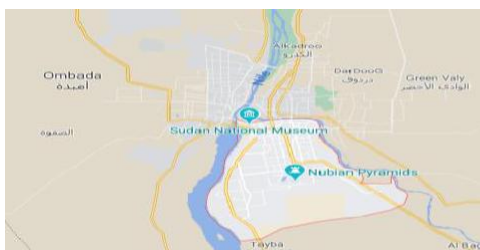


Fig 27 Metropolitan Khartoum [17]



Fig 28 The three cities are connected with bridges [17]

1. Intersection Safety:

This category contains the presence of crosswalks, countdown signal, see Fig 29, traffic signal see

Fig 30, crossing speed signal, no turn on red signal, traffic calming and slow down signal, pedestrian signs, see Fig 31.



Fig 29 Traffic signal [18]



Fig 30 countdown signal [18] Fig 31 pedestrian crosses [18]

2. Traffic:

It deals with organizing traffic: Number of Lanes, Two-Way Traffic, see Fig 32, Vehicle Speed, Traffic Volume, see Fig 33, Traffic Calming Feature.



Fig 32 Two way traffic [18]



Fig 33 Traffic volume [18]

3. Street Design:

This category contains; sidewalk width, see Fig 34, sidewalk surface, see Fig 35, sidewalk obstructions,

see Fig 36 presence of curb, see Fig 37, driveway cuts, trees, gardens, public seating, buffers.



Fig 34 Sidewalk surface [18]



Fig 35 cafe seating [18]



Fig 36 sidewalk obstructions [18]



Fig 37 curb [18]

4. Perceived Safety:

This category describe; illegal graffiti, see Fig 38, 39, 40, litter, see Fig 41, pedestrian-scale light,

construction sites, see Figs 42, 43, 44, 45 abandoned buildings.



Figs 38, 39 ,40 Illegal graffiti [18]



Fig 41 Litter [18]



Figs 42 ,43 ,44 , 45 Construction sites [18]

5. Land Use:

This category shows; public art, see figs 46, 47, historic site, retail, see Figs 48, 49.



Fig 46 public art [18]



Fig 47 Bus station [18]



48 Retail shops [18]



Fig 49 Retail shops and car park [18]

6. Perceived Walkability:

This category shows; visual attractiveness, see Figs 50, 51, feeling of safety, smells, see Fig52, noise, see Fig 53.



Fig 50 Flower beds [18]



Fig 51 Trees



Fig52 stagnant water [18]



Fig 53 Cars queues for petrol [18]

VI. RESULTS

In this section, I will compare, discuss, and analyse the situation of the case study with what is supposed to be according to P.E.Q.I. six categories' items.

Each item will have a weight of 1 point if it's result is sustainable and zero if not. The result will be the summation of the existing items out of the total number of the items. If it exists sometimes, 0.5 point will be given.

Table 1 Application of P.E.Q.I. categories on Mohammed Najeeb Street

Item	Category	Category's item	Existing situation	Points and comments
1	Intersection safety	Crosswalks	There no crosswalks	0
		Countdown signals	There are countdown signals	1
		Traffic signals	There are Traffic signal	1
		Crossing speed signals	There are no crossing speed signals	0
		No turn on red signals	There are no turn on red signals	0
		Traffic calming signals	There are no traffic calming signals	0
		Pedestrian signals	There are no pedestrian signals	0
Result				2/7 (low)
2	Traffic	Number of Lanes	There are three lanes but very faint	1
		Two-Way Traffic	There are Two-Way Traffic	1
		Vehicle Speed signals	There are no speed signals	0
		Traffic Volume	There is sometimes	0.5
		Traffic Calming Feature	There is no Traffic Calming Feature	0
Result				2.5/4 (aver.)
3.	Street design	Sidewalk width	The sidewalk is wide	1
		Sidewalk surface	Paved in some parts and earthy in the other	0.5
		Sidewalk obstructions	Partly obstructed	0.5
		Presence of curb	There is curb	1
		Driveway cuts	No drive cuts	0
		Trees	There are trees in part of the street	0.5
		Gardens	No gardens	0
		Public seating	No public seatings	0
		Buffers	There is no buffer	0
Result				3.5/9 (low)
4.	Perceived safety	Illegal graffiti	There illegal graffiti	0
		Litter	There is litter in the street	0
		Pedestrian-scale light	There is no pedestrian-scale light	0
		Construction sites	There are building sites	0
		Abandoned buildings	There is no abandoned buildings	1
Result				1/5 (low)
5.	Land use	Public art	There is no public art	0
		Historic site	There is no historic site	0
		Retail	There are many	1
Result				1/3 (low)
6.	Perceived walkability	Visual attractiveness	There is some	0.5
		Feeling of safety	There isn't there	0
		Smells	There is there sometimes	0.5
		Noise	There is there sometimes	0.5
Result				1.5/4 (low)
Total result				11.5/29 (low) (39.65%)=(40%)

VII. DISCUSSION

Results shown in table 1 explain the marks scored by the studied street in each item of the six categories of the P.E.Q.I. The street show very low standard of the safety of intersections. There are no crosswalks and pedestrian signal. People cross wherever they want to

cross, see Fig 31. This, exposed them to high risk of accidents. There are no traffic calming signals nor crossing speed ones. This will encourage driver to care less about speed and thus expose themselves and the crossing pedestrian to danger. No turn on red signals are not there but drivers do not turn in the presence of the traffic police. There are traffic signals and countdown ones which keep

the order and prevent accidents, see Figs 29,30. The overall rating of intersection safety category is quite low (2/7), see Table 1.

The studied street is double courage way with three lanes in each way. The white lines which separate these lanes are very faint to the extent that it is hard to see them, see Figs 32, 46. The absence of vehicle speed signals and the traffic calming feature may cause for definite accidents. It is customary to observe traffic volume during the rush hours where traffic reach bottle neck situation, see Fig 33. The street show an average standard on traffic category (2.5/4), see Table 1.

There are wide enough curbed sidewalks on both sides of the street. Their surface is partly paved and partly earthy. This situation causes nuisance during rainy season where the surface is completely muddy and slippery. Even the paved surface is covered with dust and dirt, see Figs 37, 47. Sidewalks are obstructed by parked cars, kiosks, bus station sheds, nurseries, earthen pot contain water for passers-by or by high tension towers, see Figs 29, 34, 35, 36, 38. There are no buffers neither gardens nor driveway cuts. There is a small green area in front of a military office. Of course public is not allowed to reach near this green area, see Fig 48. There are no public seating. Some bus stop shed has seats, also some coffee kiosks have uncomfortable seats. Of course if you don't buy a cup of tea, you will not be welcomed to sit, see Figs 35, 49. The street show a below average standard in street design category (3.5/9), see Table 1.

The street has no abandoned buildings which could be used as resort for criminals. There are some unoccupied houses but they don't last for long. There are graffiti on the side walls. Most of them related to political views of different parties, some are advertisements, see Figs 38, 39, 40. Litter is not always collected and removed. It is the responsibility of the local council but more often they run short of funds and encounter financial problems. Scattering trees' leaves, plastic bags, and waste paper are the common types of litter. Domestic garbage is collected in steel containers but more often the garbage exceeds its' container, see Figs 38, 41. The sides of the tar mac are always full of dust. The local council does not clean them. It blocks rainwater from being drained into the street gutters, see Fig 32. Because of the hot weather and the inexistence of a proper pedestrian walks equipped with special lights, people don't jog or even walk for good health. There are many construction sites by the two side of the street. This is due to the fact that people start to invest in building flats and shops for rent. This, in turn, leave rubble, debris of building materials on the street. It also obstruct the traffic and pose danger to the pedestrians, see Figs 42, 43, 44, 45. The street show a very low standard in perceived safety category (1/5), see Table 1.

There are no public art presents along the street apart from a small fountain built by the army in front of their office, see Fig 46. There is no historic building along the street. Types of buildings on both sides of the street are residential, military, amenity and commercial. There are many retail shops on both sides of the street. This because they serve the nearby residents and it is somehow serve the owner business. The street show a below average standard in land use category (1/3), see Table 1.

There are trees in some parts of the street which increase the beauty value of the street. Most likely planted by the owner of the houses facing them. This is a common place in the Sudan. The local council does not plant trees by the streets' sides. This is because it difficult for them to water the trees regularly. There are flower beds placed on the island of the street by the local council to participate to the beauty of the street, see Figs 44, 49, 50. There isn't any building show or reflect obvious safety that make passers-by feel it. Noise normally is caused by the traffic at the time of rush hours which are somewhat twice a day, when people go to work and when they come back. Because of the problem of petrol provision in the country in general, cars queues waiting to buy petrol cause a huge congestion and a lot of noise, see Fig 53. Water poured in the street if it is nor dried or moved, it will cause bad smell and be a host for mosquitoes especially in rainy season. The street show an average standard in Perceived walkability category (1.5/4), see Table 1.

VIII. CONCLUSIONS

The Mohammed Najeeb street represents main streets in Khartoum because it has all the characteristic features of main streets such as many intersections, old, wide, has trees, busy, central, takes a great volume of people from one side of Khartoum to the another side.

When I applied the twenty nine elements of the six categories of the P.E.Q.I. on the street in question, its' overall standard reveals a below average level (40%).

The second conclusion represents all main streets in Khartoum the capital city of the Sudan.

RECOMMENDATIONS

Crosswalks, crossing speed signals. no turn on red signals, traffic calming signals, and pedestrian signals should be installed in the street in question and in all main streets in Khartoum and in all cities in the Sudan.

Vehicle speed signals and traffic calming feature should be installed. Traffic volume can be reduced by organizing the heavy vehicles traffic not to be on road in the rush hours and to increase the street lanes if possible. Also to use one-way street type of traffic. The street lanes should be visible and regularly maintained.

Sidewalk surface should be cleanly paved, Sidewalk obstructions should be removed but necessary services should be preserved but located without obstructing the pedestrians. Trees and gardens should be prioritized in the planning stage and well maintained thereafter. Public seating should be provided in shaded places. Buffers should be provided between the busy street and the sidewalks.

Illegal graffiti should be prohibited by the local authority especially that on wall. Litter should be removed daily and proper covered container should be provided such as container placed under the ground surface with an inlet above the ground. Restricted rules should be enacted to control builders to contain all their material within their sites and pose heavy penalties on the violators. Pedestrian-scale lights should be installed to light the walkways.

To increase the attractiveness and beautification of the street for its' users, public art elements should be designed and installed. Historic site shouldn't be destroyed and altered. They must be preserved for the coming generations.

Noise should be reduced by organizing the traffic and by making buffer zones using trees or other obstructions. Tall buildings should be reinforced by extra supports to reflect safety to the passers-by to feel safe. Stagnant water and all causes of nasty smell should be avoided and removed immediately. Visual pollution should be avoided by all means. Instead, attractive features, green areas, pleasing sceneries should be constructed.

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