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RESEARCH ARTICLE

TOWARDS SUSTAINABLE STREETScape IN KHARTOUM, THE CAPITAL CITY A CASE STUDY OF ITS MAIN FOUR STREETS

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ABSTRACT

This manuscript examines the meaning of sustainable streetscape and how the criteria of this are implemented in four specific streets in Khartoum. Streets in Khartoum were not designed in the first place to be sustainable. They were designed for vehicular traffic only. A rigorous research has been carried out on this topic, reviewing the published articles, reports, books and interviews are also conducted. As a case study, four main streets have been studied based on the most commonly used guidelines or elements of sustainable streetscape: 1st street design, 2nd street environment, 3rd street maintenance, 4th street obstruction, 5th street beautification, 6th street preparedness, and. 7th upright signs. A questionnaire targeted the passing byers, traffic wardens, physical planners, local authority officials, and architects was conducted. Two hundred copies were distributed, one hundred and seventy out of them were completed. The results show that The items in the street design element of the four streets is above average (45-75%), the street environment is below average (5-75%), the street maintenance is also below average (20-65%), the street obstacles is below average (10-60%), the street beautification is average (5-100%), the street preparedness is below average (0-85%), the street upright signs is below average (0-85%). Recommendations have been drawn and guidelines for sustainable streetscape are put for the benefit of stake holders.

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INTRODUCTION

According to Merriam-Webster English dictionary, street is a thoroughfare especially in a city, town, or village that is wider than an alley or lane and that usually includes sidewalks and part of it reserved for vehicles and with abutting property. So, 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. This spoil the integrity, functions, beauty, and efficiency of streets. Chaotic situations prevail in many big cities in the world which produce pollutions, heavy traffic, traffic jams, and malodorous environment. Streets in Khartoum were designed in the first place to accommodate vehicular traffic only. When the designed vehicular traffic volume has multiplied in recent years, streets have become extremely busy. Recently, different types of traffic have started to use the streets beside the vehicular one, namely Tok tok (three wheel motor bike), carts, Amjad (small minibus), and of course pedestrian number has multiplied. This situation needs stringent measures by the traffic department in the local authority. It constitutes a real challenge to transport engineers. In this research concentration is based on the relationship between streets and the human dimension. In other words, how these streets become sustainable to offer comfort, pleasure, and healthy atmosphere to their users. For the streets to become liveable and to increase their walkability, they have to be measured against the streetscape elements which are mentioned in the relevant literature (1).

Definition of sustainable streetscape: Streetscape is a term used to describe the natural and the fabric of the street, it is the design quality of the street and its visual effect. It consists of various elements (2). A streetscape is the result of two factors: the physical environment and the activities that take place in public spaces.

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To help shape the character of new areas that are in the development phase and protect the quality of existing neighbourhoods, the District's streetscape elements, guidelines, and policies guide changes to public space. Physical features that are reviewed for the design include sidewalks, landscape, car parks, cyclists and handicapped routes, street trees, and other infrastructure like street lights and gutters. Activities that found in streets are sidewalk cafes, vending, street festivals, and other temporary activities (3).

Objectives of sustainable streetscape

Sustainable streetscape 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 (4). The objectives could be summarized as follows:

-) To provide a comfortable and safe place for the passing byers, pedlars, and accommodate waiting areas.
-) To create a hygienic atmosphere, street lights, rubbish bins, clean paved surfaces, and efficient surfacedrainage (5).
-) To accommodation for all types of traffic such as vehicular, cyclists, joggers, walkers, pedestrians.
-) To obtain the eligibility in the form of the existence of buildings, trees and shrubs on both sides of the street, sidewalks, stalls, and parking areas (6).
-) To install upright signs in a way not to obstruct vision of drivers nor the pedestrians.
-) To create an attractive beautiful features along the street.
-) To make available other services such as firefighting fittings, street maintenance tools (7).

Statement of the problem: Most of streets in Khartoum lack liveable atmosphere, attractiveness features, beautification, and safety measures. People in Khartoum suffer when using them and face catastrophic consequences.

Aim of the research: The aim of this research is to increase the performance and quality of streets and organization of accessibilities and to develop guidelines that help the stake holders to design strategies for sustainable streetscape in Khartoum.

METHODOLOGY

A rigorous research is carried out on publications, books, reports, and manuals. Many site visits and interviews are taken place. A questionnaire survey is conducted. Two hundred copies are distributed to the passing byers, traffic wardens, physical planners, local authority officials, and architects. One hundred and seventy copies are filled and then analysed by the researchers. Results are shown in graphs and a table. Recommended guidelines for sustainable streetscape are drawn. In this section all streetscape elements, which constitute the reference data for this study are shown.

Definition of sustainable streets: Sustainable streets is 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).

Elements of sustainable streetscape: Streetscape 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:

Street design: This element deals with firstly, the degree of the curvature of the street and how it affects the traffic (Figure 1, and 2). Secondly, the suitability of the breadth of the streets with the volume of the traffic.



Figure 1. Acutely Bent Street (10)

Street environment: This element deals with firstly, the obstacles that affect the driver's vision such as, parking cars and signs. . Secondly, the delay and traffic jams caused by big trucks and heavy traffic (Figures 3, 4). Thirdly, Pedestrians crossing (Figure 5). Fourthly, noisy streets. Fifthly, the presence of big trees by the side of the street that hinder the driver's vision.



Figure 3. Big trucks cause speed delays (11)



Figure 4. Traffic jams (11)



Figure 5. Pedestrian crossing (13)

Street maintenance

This element deals with firstly, damages in the street that cause accidents (Figure 5, 6). Secondly, smooth street surface that causes vehicles to slip.



Figure 5. Damages in streets (13)



Figure 6. Damages in streets in Cleveland (13)

Street obstruction: This element deals with firstly, the presence of building material debris and rubble in the street (Figure 7, 8). Secondly, the absence of alert signs beside holes and cracks in the street



Figure 7. Debris and rubbles in streets (13)



Figure 8. Debris and rubbles in streets (13)

Street beautification: This element deals with firstly, the implanting of shaded trees along the sides of the street (Figure 9). Secondly, the presence of green areas, flowers, plants and waiting couches which provide a psychological comfort to the passing byers (Figure 10). Thirdly, the presence of installs and kiosks (Figure 11), the presence of guiding clear signs which show places and land marks. Fourthly, clear traffic lights (Figure 12). Fifthly, covered side trenches (Figure 13). Sixthly, electricity and telephone poles in the pedestrian sidewalk (Figure 14).



Figure 9. Big trees beautify streets (13)



Figure 10. Street Furniture (31)



Figure 11. Street Kiosk in Athens (13)



Figure 12. Street Signs (13)



Figure 13. Storm water trenches (13)



Figure 14. sidewalk obstruction (31)

Street preparedness: This element deals with firstly, lanes for cyclists, handicapped, and pedestrians (Figure 15). Secondly, the street lights (Figure 16). Thirdly, public transport that run along the street and bus shelters (Figure 17). Fourthly, longitudinal or right angle car parks along the street (Figure 18). Fifthly, Petrol stations in the street (Figure 19), sixthly, street islands (Figure 20), and seventhly firefighting equipment (Figure 21, 22).



Figure 15. Typical bicycle lane (31)



Figure 16. Streetlight (31)



Figure 17. public transit (31)



Figure 18. Car parking in the city (31)



Figure 19. Filling station (13)



Figure 20. street island (13)



Figure 21. firefighting equipment (28)



Figure 22. Red street hydrant (13)

Upright signs: This element deals with firstly, warning, directive signs such as overtake prohibition, maximum headroom height, and vehicle weight limits (Figure 23). Secondly directive and guided signs (Figure 24). Thirdly, street signs such as lines to show where to stop, streets side limits, right or left turning, compulsory turning, street shoulder and U-turn (Figure 25). Fourthly, traffic lights at intersections, feeding side streets, inclinations, and speed limits (Figure 26).



Figure 23. Street signs (13)



Figure 24. Guiding signs (13)



Figure 25. Compulsory turning (31)



Figure 26. Street intersection (12)

The case study: Four main streets are chosen according to criteria set by the authors. Many visits were paid to these streets and photos were taken. The first criterion is that these four streets are the only streets which link all parts of Khartoum city from North to South and from East to West. The second criterion is that the bulk of the inhabitants use them daily for their movements. The third criterion is that they represent old and new streets in Khartoum. The following part of this article will reflect the result of examining the superimposing of the sustainable streetscape elements on each of the four streets.

The Al Steen Street: It is one of the newest streets in Khartoum. It connects some old neighbourhoods such as Al Jeref with some new ones such as Al Mansheeya and Al Riyadh. It runs North-South. It is a double carriage way with two shoulders on its sides, has four lanes in each direction and islands. Its' length is around eight Km and its' width is sixty M. There are two unpaved sidewalks one on each side. Some main ten streets cross it which reflects its' importance (Figure 27).



Figure 27. an aerial photo of Al Steen Street (12)

The street design: This street is wide enough and nearly straight. Unfortunately storm water does not drain properly and causes problems. This is because there isn't adequate street trenches (Figure 28).



الوصفصور الارشيف

Figure 28. the Street in the autumn (34)

Street environment: Because the street is wide, trucks do not cause either traffic jams, noise, or delays. The pedestrian crossing signs are not maintained. Traffic lights are only for cars. Some shops encroach on the street by using part of it as show cases (Figure 29). Directive signs are hanged overhead, so they do not cause obstruction to pedestrians traffic. There are no big trees to obstruct driver's vision.



الوصفصوير الش

Figure 29. Earthy sidewalks and encroaching shops (34)

Street maintenance: The street surface is not slippery but the earthy part of it is slippery especially during rainy season. Stagnant storm water causes the tarmac to disintegrate.

Street obstruction: Unfortunately, building construction materials for any new building are kept in the street. This of course cause obstruction to the pedestrians and the motorist alike.

Street beautification: The directive signs do not obstruct the vision (Figure 30). There is a storm water trench (Figure 31). Electricity poles, high tension towers, and telephone poles are sited properly (Figure 32). There are neither trees nor green spaces in the street. There are small number of stalls and kiosks along the street.



Figure 30. Overhead directive signs (34)



Figure 31. Storm water trenches (34)



Figure 32. H. T. towers in the St. Island (34)

Street preparedness: The street has neither cyclist lane nor a lane for the handicapped. There is an unpaved sidewalk which causes slipperiness and dusty air. There is a public transport root along the street and some petrol stations. The street is lit properly. There is no designated car parks but some residents have their cars parked in front of their houses or offices (Figure 33). There are firefighting equipment.



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Figure 33. Private car park (34)

Upright signs: There are traffic lights at the intersections but there is no traffic signs or warning signs.

The Nile Street: The Nile Street is a single carriage way runs East West alongside the Blue Nile (Figure 34).



Figure 34. the Nile Street (12)

It was built during the British colonial era but has been developed through time. It runs across Khartoum from East to West. It has buildings on one side, the other side is the Blue Nile. Eleven streets intersect with it. It connects Omdurman city with Khartoum city.

The street design: This street is almost straight but it is not wide enough to accommodate heavy traffic. Because it is near the Blue Nile, there isn't difficulty in storm water drainage.

Street environment: No big trucks use this street. No upright signs or big trees obstruct the driver's vision. No big noise created by the vehicles. Because buildings are on one side of the street, not much pedestrian crossing is there. Thus there are no pedestrian crossing signs.

Street maintenance: The street surface is not slippery nor there is much damage in the street.

Street obstruction: No building materials debris and rubble in the street because all buildings are old and it is seldom to find a new one by its side. There are no warning signs in it.

Street beautification: There are big shaded trees on both sides of the street (Figure 35). In some parts there are green public parks. There are no traffic lights or guiding signs. Storm water trenches are not completely covered (Figure 36). There aren't electricity or telephone poles obstructing the driver's vision. There are no stalls or kiosks.



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Figure 35. THE NILE STREET (34)



Figure 36. Street trenches are not all covered (34)

Street preparedness: There are pedestrian sidewalks but no handicapped lane in this street. The street is lit properly (Figure 37a, b). There are no petrol stations in it nor is public transport run. There are car parks on one side. No cyclist lane. Firefighting equipment is available.

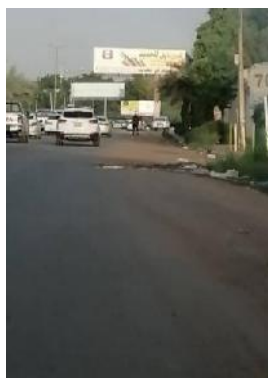


Figure 37a, 37b. Lighting poles in the street (33)

Upright signs: There aren't traffic lights in the street intersections nor there are traffic or warning signs.

The Gamma Ave: It runs East West parallel to the Nile Street and lies south of it. Its length is about forty one km. It was constructed during the colonial time. It has buildings on both of its sides. More than ten streets intersect it (Figure 38).



Figure 38. the Gamma Ave. (12)

The street design: This street is almost straight but it is not wide enough to accommodate heavy traffic. There is no difficulty in storm water drainage because there is a storm water trenches.

Street environment: No big trucks use this street. No upright signs or big trees obstruct the driver's vision. No big noise created by the vehicles. There are no pedestrian crossing signs.

Street maintenance: The street surface is not slippery nor there are much damage in it.

Street obstruction: No building materials debris and rubble in the street because all buildings are old, and it is seldom to see new construction of a building in it. No traffic warning signs there.

Street beautification: There are big shaded trees on both sides of the street but there are no green public parks. There are no guiding signs. Storm water trenches are not completely covered. There are no stalls and kiosks. There aren't electricity or telephone poles obstructing the driver's vision (Figure 39).



Figure 39. Big trees in Gamma ave.. (34)

Street preparedness: There are sidewalks but no handicapped or cyclist lane in this street. The street is lit properly. There are no petrol station or firefighting equipment. Public transport runs along it. There are car parks on one side of the street.

Upright signs

There are traffic lights at the intersections but there are no warning signs.

Africa Street (Al Matar St.)

It is relatively a new street. It runs North South passing by the Khartoum international airport linking the city center with southern part of the city which is connected with Wad Madani high way which leads to central Sudan and ends in the southeast of the country. Thirteen streets insect it. It is a treble carriage way with four lanes in each way and has a service lane along one side. Their lanes are separated with two islands (Figure 40).



Figure 40. Africa Street (Al Matar St.) (12)

The street design: This street is almost straight and it is wide enough to accommodate heavy traffic. As for storm water, not enough efforts are done because it has been enlarged recently but the old drainage trenches are kept unchanged.

Street environment: Big trucks use this street because it leads to the Wad Madani high way. No upright signs or big trees obstruct the driver's vision. There is noise created by the vehicles. Because this street is wide, not much pedestrian crossing is happening. Thus there no crossing signs (Figure 41).



Figure 41. Clear vision in the street (34)

Street maintenance: The street surface is neither slippery nor there is much damage in it.

Street obstruction: No building materials debris and rubble in it because buildings are not continuously found on its' both sides. It is seldom to find a building under construction on its sides. No warning signs in there.

Street beautification: In this street there are no big shaded trees or guiding signs. Storm water drainage is not highly efficient because of the big width of the street. There are no stalls or kiosks. There are no electricity or telephone poles obstruct the driver's vision.

Street preparedness: There are sidewalks but no handicapped or cyclist lane in this street. It is lit properly. There are some petrol station in it. There are public transport roots run along it. There are car parks on one of its sides. There are no firefighting equipment (Figure 42).



Figure 42. Traffic and guiding signs (34)

Upright signs

There are traffic lights at the intersections but there are no warning signs.

The questionnaire survey: A questionnaire survey was designed to rate the opinion of concerned people on how the chosen four streets are conform to the seven sustainable streetscape elements. They are 1. The street design, which consists of firstly, the degree of the curvature of the street and how it affects the traffic. Secondly, the storm water drainage. Thirdly, the suitability of the breadth of the streets to the volume of the traffic, 2. The street environment which consists of firstly, the obstacles that affect the driver's vision such as, parking cars and traffic signs. . Secondly, the delay and traffic jams caused by big trucks. Thirdly, The pedestrians crossing. Fourthly, noisy streets. Fifthly, the presence of big trees in the street that hinder the driver's vision. 3. The street maintenance which consists of firstly, damages in the street. Secondly, smooth and slippery street surface 4. The street obstruction which consists of firstly, the presence of building material debris and rubble in the street. Secondly, the absence of alert warning signs in the street 5. Street beautification which consists of firstly, the presence of shaded trees along the sides of the street. Secondly, the presence of green areas, flowers pets and waiting couches which provide a psychological comfort to the passing byers. Thirdly, the presence of guiding clear signs which show places and land marks. Fourthly, clear traffic signs. Fifthly, storm water trenches. Sixthly, electricity and telephone poles in the pedestrian walkways. Seventhly, the presence of stalls and kiosks in streets. 6. Street preparedness which consists of firstly, existence of lanes for cyclists, handicapped, and pedestrians. Secondly, the existence of lights in the Street. Thirdly, The presence of public transport. Fourthly, the existence of longitudinal or right angle car parks along the street. Fifthly, the existence of petrol stations in the street. Sixthly the presence of street islands. Seventhly, the presence of firefighting equipment in the street. 7. Street upright signs which consists of firstly, the existence of warning, directive signs such as overtake prohibition, allowable head room heights, and allowable weight limits. Secondly the existence of directive and guiding signs. Thirdly, the existence of streets limits, right or left turning arrows, compulsory turning signs, street shoulder and U-turn signs. Fourthly, the existence of reflective signs at street intersections, feeding streets, and inclinations.

The population of the survey is composed of physical planners, passing byers, traffic and road engineers, traffic wardens, city council officials, and architects. Two hundred and twenty copies were distributed, One hundred and eighty ones were completed. Prior to the main survey, a random pilot survey was distributed to twenty university architecture teaching staff members. Accordingly, it was evaluated and amended. The evaluation of each item on each street's elements is based on its merits expressed in percentage.

RESULTS

Results are shown in Graphs (43, 44, 45, 46) and in (Table 1). They depict percentage of the seven sustainable streetscape elements scored by each street. The seven elements are 1. Street design, 2. Street environment, 3. Street maintenance, 4. Street obstruction, 5. Street beautification, 6. Street preparedness, 7. Street upright signs. Also the average score of the seven elements is shown for each of the four streets in (Table 1).

Al Steen Street: The Al Steen Street results show low standard in the street environment and beautification elements, where show average standard in street design, maintenance, obstruction and preparedness elements (Figure 43). They show high standard in upright signs element. Its total average score is 53% (Table 1).

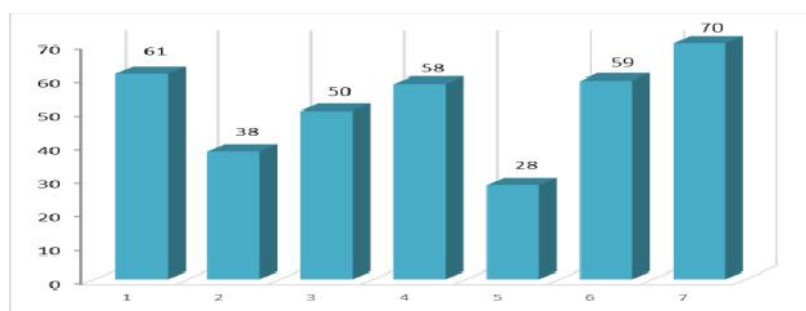


Figure 43. results of Al Steen Street on the seven elements

The Nile Street: The Nile Street results show an average standard in street design element, and low standard in all of the remaining six elements (Figure 44). Its average score is 36% (Table 1).

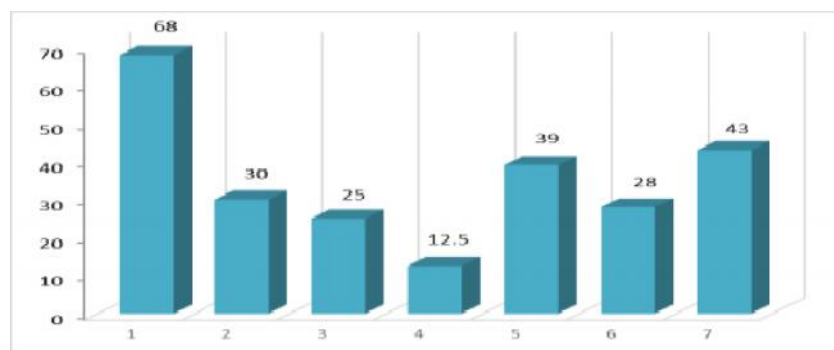


Figure 44. results of the Nile Street on the seven elements

The Gamma Ave: The Gamma Ave. results show an average standard in street design and in upright signs elements where show low standard in street environment, maintenance, obstruction of the driver's vision, preparedness, and beautification elements (Figure 45). The total average score is 40% (Table 1).

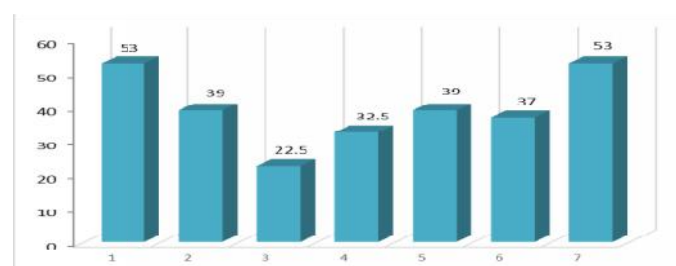


Figure 45. Results of the Gamma Ave. on the seven elements

Africa Street: The Africa Street results show an average standard in street design and in preparedness elements where show low standard in environment, maintenance, obstruction the driver's vision, beautification, and upright signs elements (Figure 46). Its average score is 40% (Table 1).

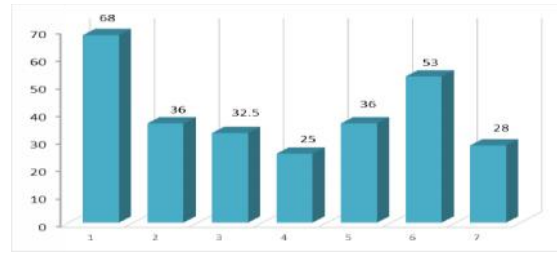


Figure 46. Results of the Africa Street on the seven elements

DISCUSSIONS

As for the street design element, the curvature in the four street is average (56%). The storm water drainage in them is not efficient (36%). Both the Nile street and the Gamma Ave. are not wide enough to accommodate heavy traffic but the Al Steen and the Africa Streets are wide enough to accommodate heavy traffic (Table 1). Concerning the street environment element, the four streets have no obstruction to the driver's vision (25%). Trucks do make traffic delays in the Al Steen Street because it is connected to Wad Madani high way (60%). Because big trucks do not run along the Nile street and the Gamma Ave., delays are not found in them (0%, 10%). No jams caused by truck are found in the Africa Streets because no big trucks do run along them (10%). The pedestrian traffic is not organized in all of the four streets so, they cross at any time anywhere (55, 75, 75, 70 %). Noise comes from traffic is average in two streets, the Al Steen St. and The Gamma Ave. (50%, 60%) where, it is low in the Nile Street (15%) because no public transport run along it and high in the Africa Street (75%) because a lot of public transport run along it. No driver's vision obstruction is caused by big trees in the Al Steen and the Africa Streets, (5%, 5%) because there are no trees in them. There are big trees on both sides of the Nile street and the Gamma Ave. but they make little obstruction because of their situation by the edges of the streets (25%, 25%) (Table 1). As for the maintenance element, damages are average in the Al Steen Street (65%) because of the inefficient storm water drainage, where they are low in the Nile St., the Gamma Ave., and the Africa Street (25%, 25%, 25%), because storm water is efficiently drained. Slipperiness is not found in all of the four streets because they are well taken care of during their construction (Table 1).

Table 1: The percentage of each item within each element of the sustainable street scape for the four streets

Streetname	Ave.%	St. design					St. Environment					St. Maint enance		St. Obstruction					St. Beautification					St. Preparedness					St. Uprightsigns			
		1st	2nd	3rd	4th	5th	1st	2nd	3rd	4th	5th	1st	2nd	1st	2nd	1st	2nd	3rd	4th	5th	6th	1st	2nd	3rd	4th	5th	1st	2nd	3rd	4th		
Al SteenSt.	53	49	55	80	20	60	55	50	5	65	35	60	55	30	15	45	65	10	5	45	70	65	40	75	45	80	75	80				
Nile St.	36	60	80	65	35	0	75	15	25	25	25	15	10	10	10	15	40	35	65	10	30	0	67	59	45	0						
Gamma Ave.	40	55	45	60	25	10	75	60	25	25	20	55	10	85	10	20	70	5	45	40	85	40	20	0	25	85	50	50				
Africa St.	40	60	65	80	20	10	70	75	5	35	30	35	15	30	20	10	70	55	39	40	75	50	15	85	20	60	15	15				

NB: The sequence of the element's items appeared in the second row correspond with items of the seven elements of the sustainable streetscape mentioned above.

Concerning obstruction element and building material rubble and debris, they are average in both the Al Steen street and the Gamma Ave. (60%, 55%) because there are some new buildings under construction in them, where the percentage of same item are low in the Nile and the Africa Streets (15% 35%) because new buildings are rarely found in them (Table 1). As for beautification element, The Nile street and the Gamma Ave. have big shaded trees by their sides which create a comfortable atmosphere especially in the first one (100%, 85%), where there are few trees in the Al Steen and the Africa Streets (30%, 30%). The Nile Street has green spaces and waiting couches on some of its sides (60%) where, there are few on the sides of the Al Steen and the Africa Streets (15%, 20%). There are average percentage of guiding signs in Al Steen Street (45%) because there are heavy traffic and many intersections in it where the percentage is low in the Nile Street, the Gamma Ave., and the Africa Street (10%, 20%, 10%). There are many traffic lights in the Al Steen Street, the Gamma Ave., and the Africa Street (65%, 70%, 70%). This is because they have many intersecting streets and the areas on their sides are fully populated. Low percentage of storm water trenches in the Al Steen, the Nile Streets, the Gamma Ave. (10%, 15%, 5%), where an average percentage in the Africa Street. The obstruction of the pedestrian traffic by electricity and telephone poles in the Al Steen Street is minimal (5%) where it is average in the Nile Street, the Gamma Ave., and the Africa Street (40%, 45%, 30 %) (Table 1). Concerning preparedness element, the provision for pedestrian and cyclist traffic are below average in all of the four streets (45, 35, 40, 40 %). In fact, both traffics use the same track which is often an earthy path way. All the four streets are lit properly (70, 65, 85, 75%). An average percentage of public transport runs along the Al Steen and the Africa Streets (65%, 50%) but to a less extent in the Gamma Ave. (40%) and to a lesser extent in the Nile Street (10%). There are car parks at an average percentage in the Al Steen Street (40%), at low percentages in the Nile Street and the Gamma Ave. (30%, 20%).

This is due to the narrowness of these streets. Car parks are at a lower percentage in the Africa Street (15%). This is because not much residential areas are living around this street. Car parks are available in streets off the Africa Street. There are many petrol stations in the Al Steen and the Africa Streets (75%, 85%). This is due to the fact that public transport runs along them and they are almost busy streets. There isn't a single petrol station in either the Nile Street or in the Gamma Ave. (0%, 0%). The reason is that they are narrow and busy streets (Table 1). As for upright signs, the Al Steen and the Nile Streets have an average percentage of warning signs such as overtaking, heavy loads and maximum overheads (45% 67%). The Gamma Ave. and the Africa Streets have low percentage (25%, 20%). The Al Steen Street and the Gamma Ave. have big percentages in directive and guidance signs (80%, 85%). This because many main streets intersect them. The Nile and the Africa Streets have average percentages (59 %, 60%). The Al Steen Street has high percentage of traffic signs (75%). This is because it is wide, has heavy traffic, and it leads to the Wad Madani high way. The Nile Street and the Gamma Ave. have average percentages of (45%, 50%). This is because they are not wide and have a few intersecting streets. The Al Steen Street has a big percentage in having signs to indicate intersections (80%). This is because many streets intersect it. The Gamma Ave. has an average percentage (50%). This is because of presence of some intersections. The Nile and the Africa Streets have minimum percentages (0%, 15%). This is because of the absence of or having minimum intersections with other streets.

Conclusion

All of the four streets have no acute curvature that might cause accidents. Storm water drainage in only one of the four streets is efficient (The Nile St). Two out of four streets are narrow (The Nile Street and the Gamma Ave.). Traffic lights in all of the four St. do not obstruct the driver's vision nor are the big trees do. Big trucks cause traffic delay in only the Al Steen St. All of the four St. lack pedestrian crossing lights. Noise is not causing any problem in all of the studied St. There are some damages in Al Steen St. only. All of the studied St. do not have slippery surfaces. There are building materials rubble and debris in only Al Steen St. There are not enough warning signs. There are no big trees or green areas by the sides of the Al Steen and the Africa St. The Nile Street and the Gamma Ave. have big trees on their sides. There are guiding signs in the Al Steen St. but not enough. All the other three St. need guiding signs. Storm water trenches are not enough and even when they are there they are not efficient in all of the four St. Electricity and telephone poles do not create any problem to the pedestrian traffic in all of the studied streets.

cyclist, pedestrian and handicapped roots are not taken care of properly in all of the St. Street lighting is acceptable in all of the four St. It might needs fluorescent reflectors. Public transport are in three of the four St. except the Nile St. but there are no attractive bus stops shades. There are not enough car parks in all of the four St. Petrol stations are available in two of the four St. the Al Steen and the Africa St. Warning signs concerning overtaking, heavy loads, and maximum head rooms are found in Al Steen St. but not enough. They are not available in an acceptable level in the rest of the St.

Recommendations for the four streets

From the preceding research, analysis and public process these recommendations emerged to guide the transformation of the four streets into a welcoming, visually cohesive, sustainable, safe and engaging place. Storm water drainage has to be solves by planning and implementing a network and a pond in central Khartoum connecting all streets in the area included the Al Steen St., the Gamma Ave. and the Africa St. To increase the width of the Gamma Ave. historical buildings have to be destroyed which is not logical and to increase the width of the Nile St. an extension has to be built over the Blue Nile which is costly. The possible solution is to adopt a one way traffic direction. Heavy trucks in the Al Steen St. should be given times to run out of the rush hours. Damages in the Al Steen St. should be repaired swiftly. Building material rubble and debris should be removed from the Al Steen Street swiftly and from all the other streets as well. Warning signs should be placed where ever there is damage or danger. Rules should be enacted concerning how to keep building material on construction sites. Violators should pay heavy penalties. Shaded trees and green areas should be planted on the sides of the Al Steen and the Africa streets. Guiding and directive signs should be placed properly in all the four streets. Stalls and kiosks should be built where ever suitable to serve the pedestrians and all the passing byers without obstructing the pedestrians. Pedestrians, cyclist, and handicapped lanes in all of the four street should be introduced properly. Fluorescent reflectors should be provided to enhance the guiding signs and improve the street lighting. Attractive bus stop sheds should be provided in both the Al Steen and the Africa streets. Properly designed car parks should be constructed on the sides of the Al Steen and the Africa streets. Firefighting equipment should be provided in suitable places along the four streets. Warning signs concerning overtaking, heavy loaded trucks and maximum overhead headroom should be placed in all of the streets especially the Al Steen and the Africa streets because of the presence of heavy trucks. Sidewalks surfaces should be paved but not with impermeable surface so as to retain some moisture to absorb the incident solar radiation and thus to attenuate the adjacent air temperature (13). There should be water ponds to which the heavy storm water should be discharged and then make use of it for irrigation or recycling (13). Figures 47, 48, and 49 show the streetscape elements as should be found in Khartoum's streets.

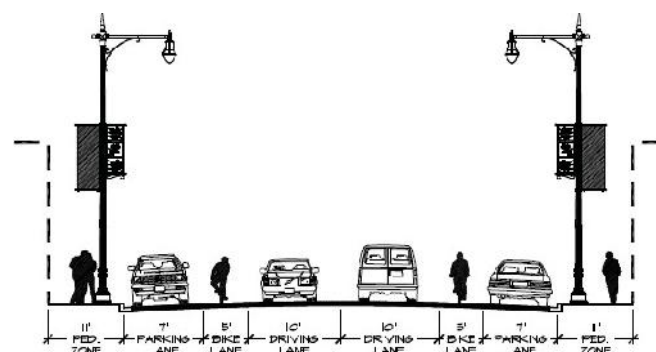


Figure 47 streetscape elements (35)

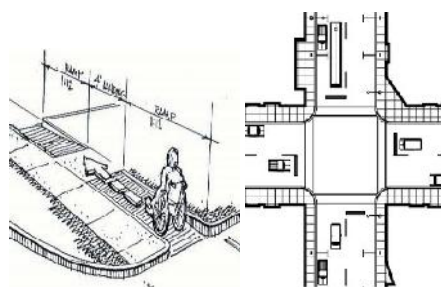


Figure 48 and 49 Streetscape elements (35)

Sustainable streetscape guidelines for Khartoum's streets: All streets have to have gutters or trenches to drain storm water as quickly as possible. This is because accumulated water damage the tar mac and cause the vehicles to default. Consequently accidents and traffic delays happen. Traffic in narrow streets has to be one way direction to avoid traffic jams and accidents. Also to accommodate pedestrian, cyclist and handicapped traffic. Trucks traffic has to be given times to run, namely off the rush hours. Stringent rules have to be implemented against the violators. Any damage in any street should be repaired swiftly avoiding the rush hours times. Clear warning signs should be placed beside the damaged area to avoid accidents. Heavy penalty should be imposed on whoever obstruct streets with building materials of leave rubble and debris in the street. Regulations should be enacted to regulate the process of constructing of buildings along the street's sides. Shaded trees should be implanted along the sides of streets either by the authority or by the residents or by both. Green spaces should be considered at the stage of physical planning. Guiding and directive signs should be placed overhead. Stalls and kiosks that serve the passing byers should be placed in suitable places without causing any obstruction to the pedestrians. Couches and waiting areas should be provided in adequate places. Pedestrian, cyclist, handicapped paved lanes, paved car parks, convenient bus stop sheds, firefighting equipment should be considered at the stage of planning of any street. Fluorescent reflectors should be used extensively to help drivers' vision. Warning signs and street demarcation as for street limits, overtaking, maximum carried loads, and maximum head rooms should be placed in noticeable places.

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