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FULL LENGTH ARTICLE

Sustainable streetscape as an effective tool in sustainable urban design

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Abstract Sustainable streetscape plays an important role in forming the visual image of sustainable cities, as it is one of the most important factors which helps in city success, and tourist attractions. However, there are many cities whose visual image is lacking the presence of correct and sustainable streetscape, which negatively affects the visual image of these cities, and consequently the place of those cities globally. In this context, the research aims to activate the role of sustainable streetscape as an approach to provide an attractive and safe sustainable urban environment, and to sustain the development process for the visual image of cities, especially in Egypt, through focusing on the elements and basic principles of sustainable streetscape that should be taken into account to define sustainable streetscape. So that, the analytical study covers some international examples in applying the basic principles of sustainable streetscape in order to use it to develop streetscape of one of the main urban streets in Egypt. The research concludes the importance of developing urban environment visual image in Egypt, through directing urban planners and designers to the important role of streetscape in achieving sustainable development, in addition to identify the methods of application of sustainability in streetscape.

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Introduction

Sustainability in the streetscape is one of the most important strategies for sustainable urban design. Most of the streets in Egypt lack good streetscape which adversely affects the behavior of users and esthetic aspects of built environment, and thus deterioration of the visual image of most Egyptian cities. So the research aims to find sustainable solutions to streetscape of urban environment.

Research problem

Lack most of streets in Egypt to good and sustainable streetscape which negatively affect on achieving sustainable urban design, the functional and esthetic aspects of built environment, and then deterioration of the visual image of most Egyptian cities. So this research is directed to answer the following questions:

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– What is the definition of sustainable streetscape, and what are the elements of streetscape?
– What are the principles of sustainable streetscape?
– What are the applications on sustainable streetscape in sustainable cities?

Research objectives

This paper aims to develop guidelines for sustainable streetscape. This is achieved through a combination of sub-objectives as follows:

– Development of the visual image of cities by highlighting the importance of sustainable streetscape, to consider the operations of urban design, and to provide an attractive and safe urban environment for all categories of users.
– Identify the main principles that should be considered to define sustainable streetscape.
– Formulate a set of recommendations for developing streetscape of one of the main axes in Egypt to fit the criteria for sustainable urban design.
– To reach sustainable urban design through the achievement of environmental efficiency and economic operations of streetscape.

Research hypothesis

This paper assumes that, by applying sustainable streetscape which covers the architectural, environmental, social and economic aspects, it can help to achieve sustainable urban design processes, and thus to reach sustainable city.

Research methodology

Research methodology is based on three approaches; theoretical, analytical and applied study. The theoretical study tends to identify the concept of sustainable streetscape, sustainable streets, and then the elements and principles of sustainability in streetscape. This is followed by an analytical study of some international experiences in application of the principles of sustainable streetscape. This is followed by an applied study of one of the axes in Egypt, and analyzed in terms of its application to the elements and principles of sustainable streetscape. Then the paper concludes that the most important recommendations to develop streetscape of this axis to suit the main components of sustainable streetscape are derived from the theoretical study, in order to develop this theme to achieve sustainable urban environment.

Definition of sustainable streetscape

"Streetscape 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 includes buildings, the street surface, and also the fixtures and fittings that facilitate its use – from bus shelters and signage to planting schemes" [1]. "The unification of the elements of streetscape can help in the success of visual experience" [2]. "Sustainable streetscape ensures that spaces are long-lasting and function as a part of the greater ecosystem employing technologies that manage stormwater runoff and reduce carbon footprint. And it helped create better places for present and future residents" [3]. So the sustainable design of the streetscape is one of the determining factors in the success of the city.

Objectives of sustainable streetscape

Streetscape must create a good environment for people to visit and gather. Social and economic interactions are communal goals of a good streetscape design. So sustainable streetscape aims to:

– Improve environmental quality by "improving air quality, reduce heat island effects, improve water quality, and reduce light pollution" [4].
– "Sustain social well-being by making the streets fit enough for public walking and gathering places where social interaction can occur on a regular basis" [5], and encourage outdoor activities [3].
– "Sustain economic vitality by reducing consumption of material resources.
– Sustain limited natural resources regionally by reducing energy use, water use, and stormwater runoff by increasing permeable surface area and landscaping.
– Sustain urban fabric by improving the visual image for any city.
– Contribute to improved public health by facilitating and encouraging walking and other recreational activities within the community" [5].

Definition of sustainable streets

Sustainable streets can 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" [6], and implementing sustainable urban streets can create more livable communities [7].

Elements of sustainable streetscape

Elements of sustainable streetscape are main components of streets' urban design, and are summarized as follows:

Sidewalks

Pavement is an essential component of any streetscape. "Sidewalks should be designed to provide safe, attractive, interesting and comfortable spaces for pedestrians by providing well designed and coordinated tree planting, lighting and street furnishings" [8]. To achieve sustainable streetscape paving materials should be selected for reflectivity, green manufacturing, local sourcing and permeability" [9] (Fig. 1).

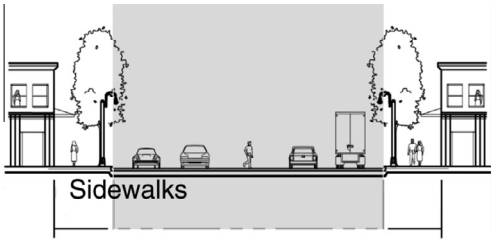


Fig. 1 Sidewalks. Ref. [10]

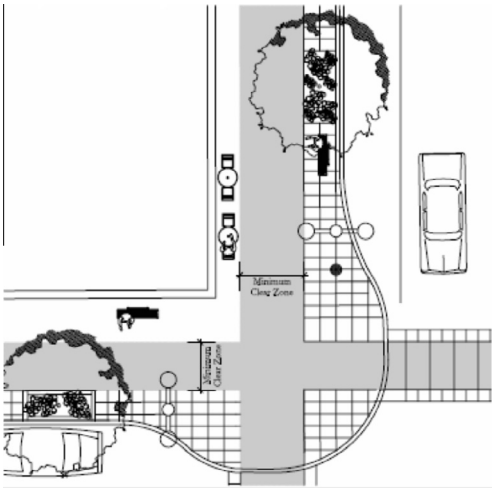


Fig. 2 Street corners. Ref. [10]

Street corners

"Street corners provide increased pedestrian space and opportunity for social interaction through the placement of benches and site furnishings as well as a safe refuge while waiting to cross the street. They also provide shorter crossing distances for pedestrians" [10] as seen in Fig. 2.

Trees and landscape strips

"Landscape strips are an effective treatment between sidewalks and streets to create a buffer from moving vehicles and street noise, and help pedestrians feel more comfortable walking along the street" [10]. They help streetscape to be sustainable by establishing raingarden.

Raingarden

A raingarden is a garden bed which is designed to treat stormwater. As water falls onto and enters the garden it is passed through a filter media which is planted with vegetation. Treated stormwater is then fed back into the drainage system or left to infiltrate into the ground below. When integrated into streetscapes, raingardens can provide a greener solution to treating stormwater and reduce the demand on potable water to water the plants" [11] as seen in Fig. 3.

Planters

"Planters add color, texture and interest to a streetscape and can help define and separate spaces. They help define primary building entrances, and enhance esthetic value. Planters placed on walkways should not create congestion or block pedestrian traffic, and placement on street corners should not obstruct driver's view. They can be installed at seating areas, along the edges of parking lots, in pedestrian plazas, and in clustered furnishing areas" [10]. "Stormwater planters also play an important role in sustainable urban design by minimizing stormwater runoff, reducing water pollution, and creating a greener and healthier appearance of the built environment by providing space for plants and trees near buildings and along streets" [4].

Street furnishing

"Street furniture shall be consistent and coordinated in design, materials, colors and styles that will be complementary to the architectural style. The placement and design of the elements should be coordinated to avoid visual clutter. These elements may include Lighting Fixtures, Waste Receptacles, Benches, Signage, and Bicycle Racks" [9].

Benches

Benches are important public resources that contribute to make the city an enjoyable space for pedestrians" [12]. "The purpose of seating is for waiting and resting and areas along walkways provide welcome relief to pedestrians, and a place to sit together, interact, and observe. Seating on street corners must not obstruct driver's views" [10]. "Benches are usually placed at bus stops" [13]. It is preferred to be made of sustainable materials or recycled materials in order to achieve economic efficiency and sustainable streetscape.

Lighting

"Lighting is an important element in streetscape, as it should contribute in creating safe and esthetically pleasing public spaces" [14]. "All pedestrian areas should be lit at night, and lighting should be used to confirm the elements of landscaping, decoration, and important buildings" [15]. All lighting fixtures should be energy efficient and provide minimal light emissions to prevent night sky pollution.

Trash receptacles

"Trash receptacles may be the most used streetscape element and should be conveniently located for pedestrian traffic near benches, bus stops, and other activity nodes. At a minimum, one trash receptacle should be placed at every corner" [10]. Materials that are utilized in trash receptacles should be sustainable, or recycled materials to achieve sustainability in streetscape.

Signage

"Signage plays an important role in creating a comfortable urban environment by establishing a visual guide and orientation tool for both pedestrians and drivers" [16]. "The signage style should be clear, and timeless and flexible. Solar sign should be used in streetscape, because it has long lifetime, and spreads

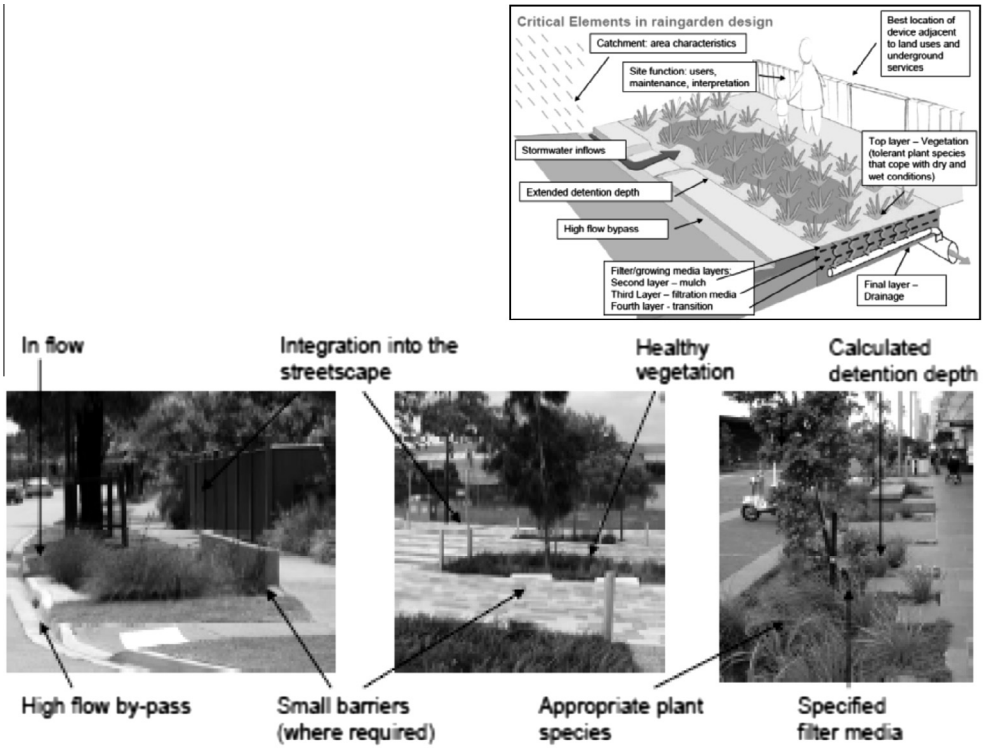


Fig. 3 Good design elements in raingarden. Ref. [11]

the information more effectively'' [17]. ''Signage will describe sustainable technologies and practices within the streetscape and raise awareness of their associated environmental benefits. Signage system should be designed to utilize environmentally friendly materials and simple construction methods'' [18].

Bus shelter

''Bus shelters are structures located at some bus stops to protect passengers from weather. All bus stops should be marked by bus stop signs and provided with benches and trash receptacle'' [19]. ''The sustainable approach of streetscape encourages the addition of a green roof to each bus shelter to have a larger effect on environmental quality, and makes it with recycled materials'' [18].

Medians

''Medians are an effective method of making a streetscape more pedestrian friendly'' [20]. ''Landscaped medians can dramatically alter the visual character of street for both motorists and pedestrians'' [5]. ''Medians serve three primary purposes: to separate opposing traffic, to provide space for planting, and to provide a refuge for pedestrians crossing the road''. [14] Medians can contribute toward achieving sustainable streetscape by establishing raingarden in green area, using sustainable materials in pavement, or using solar street lights.

Curbs

''Curbs are defined as the edge of the sidewalk where they meet the street and act as a barrier to prevent vehicular traffic from riding up onto the sidewalk. Curb ramps provide a connection from the sidewalk to street for people in wheelchairs, people pushing strollers, children on bicycles, and delivery services. Curb ramps are required at all intersections and crosswalks, including mid-block crossings'' [13].

Bicycle facilities

''Designing sustainable streets should include identifying needs and accommodating bicycles just as for other vehicles in the traffic mix. Streets should be designed and constructed to safely accommodate known and encourage bicycle use. The fundamental needs of bicyclists are twofold: safety while moving in traffic and convenient, safe and secure parking''. [4] Bicycle facilities can be determined as follows:

Bike lanes which can achieve a streetscape experience between the sidewalks and parking lane. The impact of a bike lane on a neighborhood may be to reduce traffic congestion and pollution'' [13].

''*Bicycle racks* are important amenities that will encourage bicycle ridership and promote alternative modes of transportation. Bike racks should be installed at convenient locations along streets, typically near building entries'' [2].

Crossing

Crosswalks are a critical part of the pedestrian network. ''Enhanced crosswalk paving can make motorists more aware of pedestrian activity'' [5]. ''Streetscape should be enhanced by special paving at crosswalks to designate safe pedestrian circulation'' [2].

Public art

"Public art can make an invaluable contribution to local identity, and providing multiple and layered expressions. It can become a local landmark, or simply add richness to a building or landscape. Public art can tell complex stories about communities and their histories. These reinforce community identity, and provide a basis for community pride and ownership" [5]. "One of the ways to expand the opportunity for art is to take it beyond the decorative elements to the functional elements. Streetscape elements, such as light poles, manhole covers, sidewalks, tree grates, tree guards and street furniture are all suitable elements for artistic expression" [20].

Cafe spaces

"Outdoor cafés provide an active street frontage and natural locations for arranged and spontaneous social interactions. Even narrow sidewalks can accommodate café-style seating. Corner cafés should be placed against the building edge, rather than at the outer edge of the sidewalk, to maintain visibility at intersections" [10].

Fig. 4 shows cross section representing the elements of streetscape.

Principles of sustainable streetscape

Many requirements and design considerations must be taken into account in sustainable urban design for streets. There are four main principles of sustainable streetscape.

Urban principles

It includes many elements as the following:

Legibility

"Legibility is a characteristic whereby a city is easily understood by residents and visitors and allows them to move about in the city with ease. Important streets and squares must therefore look important – they must be surrounded by stately buildings and lined by tall trees, must have wide roadways and sidewalks, special street furniture and ample light at night" [15].

Comfort and safety

"Each streetscape must be functional. This means that it must be responsive to the needs of all its users, motorized and non-motorized alike. In other words, it has to be designed and furnished for comfort and safety of all: pedestrians, drivers, strollers, street café patrons, shoppers, sightseers, etc." [15].

Attractiveness

"All streetscape elements should be esthetically pleasing [15]", to improve the visual image for any city, and to achieve sustainability. This will not be achieved without applying the suitable design rates at the level of urban design.

Social principles

To achieve sustainable urban design of the streetscape, the principle of liveliness should be taken into account.

Liveliness

"Streets must not function as mere movement and infrastructure corridors. Depending on their role in a broader urban context, they must be designed as lively spaces where people can see other people and be seen, where they can meet and interact. The image of the city and its attractiveness to visitors to a large extent depend on its street life" [15].

Supports healthy urban communities

Healthy urban communities could be reached by providing comfortable separation of pedestrians from vehicular, trash receptacles, benches, and pedestrian lighting.

Economic principles

In order to achieve sustainability in streetscape at the economical level the following points should be considered.

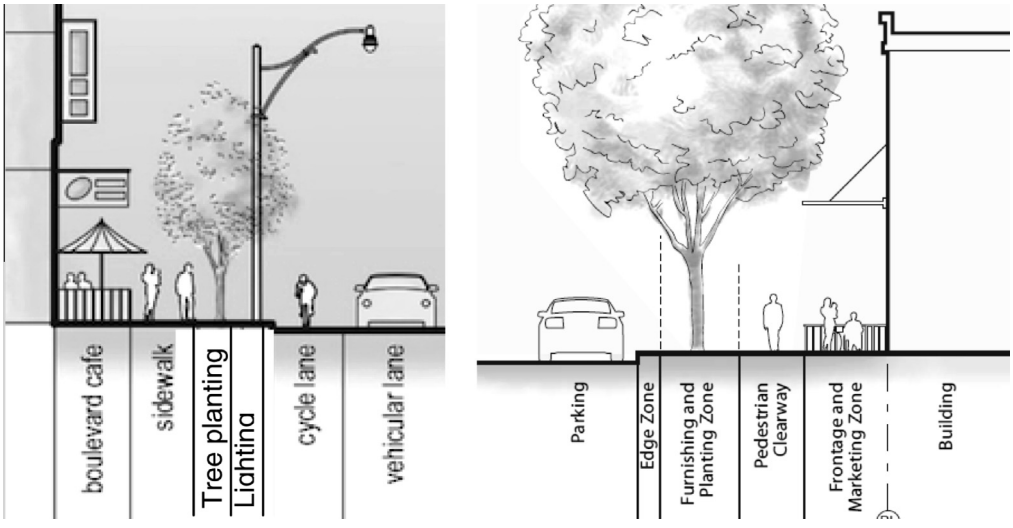


Fig. 4 Cross section represents streetscape. Ref. [21]

Sustainable materials

"Sustainable materials are manufactured with concern for toxicity, sustainability of sources and the amount of energy required for production. Using sustainable materials reduces energy use and conserves natural resources. Sustainable materials are made from renewable resources" [19]. So "materials that are utilized in the streetscape should be sustainable so that replacement and excessive maintenance are not required, when utilizing materials that are not durable" [22]. Paving materials may be selected for reflectivity, green manufacturing, local sourcing and permeability" [4].

Reduce consumption of material resources

"This category includes design solutions that reduce consumption of material resources. Design options that use recycled materials in construction, require fewer infrastructures in the solution, or increase durability" [7].

Environmental principles

Streetscape must meet environmental efficiency to achieve sustainable streets, as follows:

Reduce impacts on environmental resources

"There are solutions that reduce impacts on environmental resources, and minimize impacts on the natural environment, encourage and support biodiversity, and reflect historical and cultural context" [7]. "It can be achieved by enhancing the Pedestrian Environment, where the streetscape design can achieve improved air quality by encouraging people to walk rather than drive, resulting in fewer greenhouse gas emissions" [4]. "Planting trees reduces the urban heat island effect by shading sunlight from hard surfaces. Reflective paving and roofing materials also help reduce urban heat islands. Of typical paving materials, concrete is somewhat more reflective than asphalt" [19].

Improve water quality

"This sustainable strategy considers minimizing the quantity of storm water runoff that enters into storm drains unchecked, washing pollutants into the water system. "Rain garden" planters must absorb storm water and filter it with plant material before it is then drained into the storm drain system" [22].

Reduce energy consumption

C"This category includes options and project solutions that reduce energy consumption, such as solutions that support non-motorized travel, solutions that support energy efficient movement of people and goods, and solutions that use resources with lower operations and maintenance requirements" [7]. It can be obtained by energy efficiency, "as a direct means of improving energy efficiency within the scope of the Streetscape is the installation of energy efficient lighting" [22].

Reducing light pollution

"The 'sky glow' produced by over-illumination of urban areas negatively impacts wildlife and produces glare that affects the safety of motorists and pedestrians. In addition, light that is unnecessarily cast upward or outward represents wasted energy. Full cut-off light fixtures will ensure that light is directed downward, where it is most needed to illuminate sidewalks, without producing excess light" [22].

Case studies for sustainable streetscape

This section will focus on some cities, which applied sustainability on streetscape. The aim of these cases is to create better places for present and future residents.

Sustainable streetscape of Chapel Hill, North Carolina, USA

Sustainable materials: "Portland represented opportunities to use recycled materials along sidewalks. The materials installed within these sidewalks bring a new visual language to the streetscape without interrupting the continuity of the standard streetscape design. The current standard tree grate is manufactured from recycled scrap metal and is made from durable cast iron. These tree grates had a lasting presence within the streetscape without need for continual replacement or maintenance. In addition, the trash receptacles are refurbished and reused, as are the bench frames" [22] (Fig. 5).

Biodiversity: "Plantings had a consistent visual character, included large canopy trees, while being particularly well adapted to the harsh conditions of urban environment (Fig. 6).

Planting urban-tolerant canopy trees was important in mitigating the urban heat island effect, which referred to the rise in temperature in urban areas as a result of solar heat absorbed by large areas of pavement. By providing ample shade in the spring and summer, canopy trees helped to keep the sidewalks cool and minimize the negative impact of the street on climatic conditions" [22].

Surface water: "The long-term approach to streetscape design in Chapel Hill considered the implementation of storm water runoff filtration. These "rain gardens" could improve the esthetics of the sidewalk by including lush plantings with varying colors and textures. An ideal placement for these rain gardens was along sidewalks, where they could capture runoff from roads and sidewalks" [22] as seen in Fig. 7.



Fig. 5 Recycled paving materials, the pavers above are made from recycled glass, tree grates contain recycled materials, and Chapel Hill standard receptacle. Ref. [22]



Fig. 6 Planting trees, in sustainable streetscape of Chapel Hill. Ref. [22]



Fig. 7 Surface water in Chapel Hill. Ref. [22], p. 121

Energy efficient: "A direct means of improving energy efficiency within the scope of the streetscape and lighting is the installation of energy efficient lighting. This town has mercury vapor lamps which produce less light output per wattage than the more common metal halide lamps. Though conversion to metal halide fixtures will carry an initial cost, the environmental benefits and long-term energy savings are also important considerations. In addition, the existing Lumec fixtures that have become the town standard can be refitted to utilize LED lighting technology. This conversion would reduce energy utilization by over fifty percent over both mercury vapor and metal halide lamps" [22] as seen in Fig. 8.

Reducing light pollution: "Many urban areas in the U.S. have taken on 'dark sky' initiatives that seek to reduce light pollution through a number of means. The most common is to install full cut-off light fixtures, which prevent light from being cast upward and outward. These types of fixtures also have the benefit of reducing glare that can pose hazards to motorists, pedestrians and cyclists" [22] as seen in Fig. 9.



Fig. 8 Energy efficient option in Chapel Hill. Ref. [22], p. 121

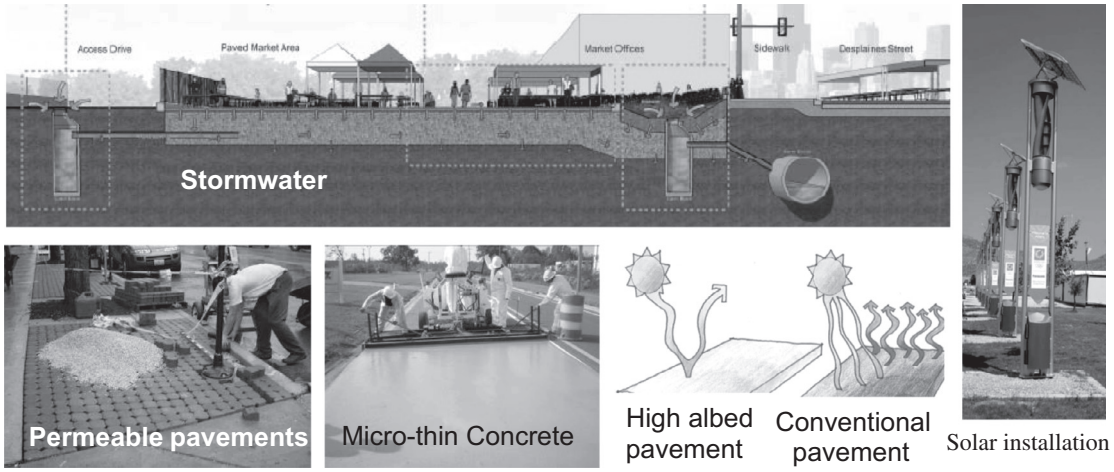


Fig. 9 Sustainable streetscape of Chicago. Ref. [23]

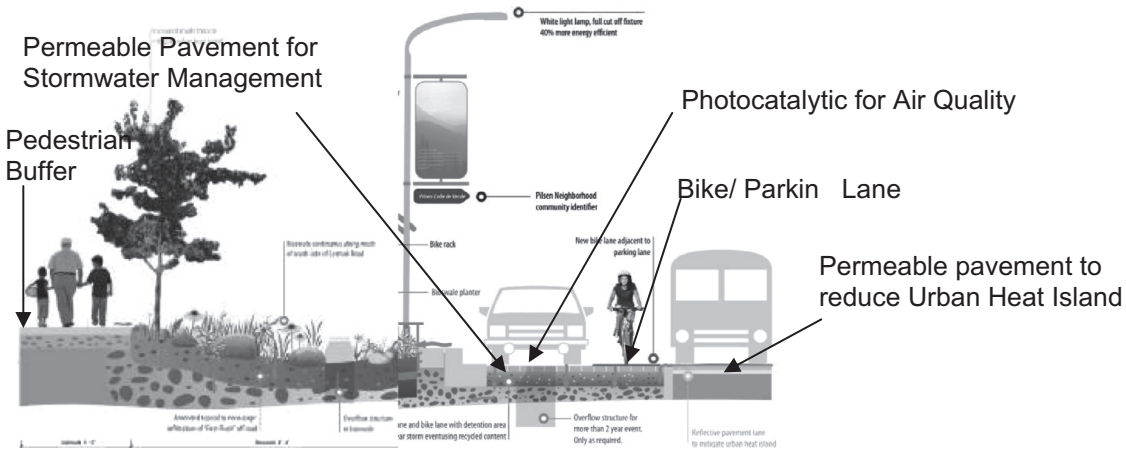


Fig. 10 Cross-section in street. Ref. [23]

Sustainable streetscape of Chicago, USA

"Chicago Department of Transportation is building the city's first sustainable streetscape. The project uses several environmentally friendly techniques in its design and construction, as seen in Figs. 9 and 10. It includes sustainable features such as:

- *Stormwater management:* Divert 80% of the typical average annual rainfall and at least 2/3 of rainwater falling within catchment area into stormwater best management practices.
- *Water efficiency:* Eliminate use of potable water for irrigation, specify native or climate adapted, drought tolerant plants for all landscape materials.
- *Energy efficiency:* Reduce energy use. 40% below a typical streetscape baseline use reflective surfaces on roads/sidewalks, use dark sky-friendly fixtures. Min. 40% of total materials will be extracted, harvested, recovered, and/or manufactured within 500 miles of the project site.
- *Recycling:* Recycle at least 90% of construction waste based on LEED NC criteria, Post/Pre-Consumer recycled content must be min. 10% of total materials' value.
- *Urban heat island:* Reduce ambient summer temperatures on streets and sidewalks through the use of high albedo pavements, landscaping, photocatalytic cement, sidewalk concrete with slag, micro-thin concrete overlay, and permeable pavements" [23].

As case studies show, cities that successfully revitalize the streetscape find that particular attention to sustainable streetscape is necessary to create sustainable cities to live, work, and entertain. All these cases applied many ways for achieving sustainability in streetscape, as:

- Stormwater management
- Use of sustainable materials
- Lighting & dark skies
- Landscaping & urban heat island

Case study of the El-Ahram Street, Egypt

This section is the analytical study of the El-Ahram Street case study, Giza, Egypt. Its aim is to analyze the most important negative points that can be developed through the application of sustainability on the operations of Streetscape to this axis.

The importance of the El-Ahram Street

This is the main street in Giza district, Egypt. And it contributes effectively to the formation of visual image of the built environment in Egypt in general.

In addition, it is considered as an important tourist axis that leads to the pyramids plateau as seen in Fig. 11.

Documentation of the elements of streetscape of the El-Ahram Street

This part of the research deals with the monitoring of current elements of streetscape and will sign observations and negative aspects.

Sidewalks

Most of sidewalks made of steel create tiles and interlock blocks, which are considered as unsustainable materials. All finishings vary along the street and do not have a



Fig. 11 The image of the El-Ahram Street. Ref.: Google Earth

standard format. There is a danger to pedestrians because of the lack of separation between them and vehicle movement, and it is not provided with any elements of seating as seen in Fig. 12.

Street corners

The pavement in this part is not suitable for disabled people or elderly movement that is due to the lack of ramp as seen in Figs. 13 and 14.

Trees and landscape strips

Tree spacing is not determined, and there are no landscape strips, which negatively affect the traffic movement as seen in Fig. 15.

Planters

Planters confined only in median negatively affect environmental aspects and urban image.



Fig. 12 Sidewalks. Ref.: Google Earth



Fig. 13 Street corners. Ref.: The researcher



Fig. 14 Un-designed street corners Ref.: The researcher



Fig. 15 Trees and landscape strips. Ref.: The researcher

Benches

Benches in the El Ahram Street exist only at bus stations, and thus adversely affect the social relations (Fig. 16).

Lighting

Streets are well lit, but lighting elements cannot be considered sustainable because they are not energy efficient.

Trash receptacles

Lack of sufficient numbers of trash receptacles along the street is noted. These are randomly distributed , degraded, and unusable as seen in Fig. 17.



Fig. 16 Poor distribution of benches Ref.: The researcher



Fig. 17 Un-designed trash receptacles Ref.: The researcher

Signage

Distribution of signals places is unfortunate. They are found in sites, which impede pedestrian traffic as well as deteriorating for lack of sustainable maintenance (Fig. 18). There are signs for pedestrians without pedestrian lines as seen in Fig. 19.

Bus shelter

Bus shelters are characteristically in pharaonic style. However, they lack many of the contemporary elements such as trash receptacles, signage, and lighting units, and lack of follow-up maintenance operations has led to its degradation because they stick out with some images that negatively affect urban image as seen in Fig. 20.



Fig. 18 Pedestrian points. Ref.: The researcher



Fig. 19 Pedestrian areas. Ref.: The researcher



Fig. 20 Bus shelter. Ref.: The researcher

Median

Their one of the distinctive elements is visually attractive plants such as palm, but they lack large diameter trees, which help to provide shade and thus reduce summer temperature.

Bicycle facilities

Bicycle facilities are important elements of streetscape design. The El Ahram Street lacks these facilities, which negatively affect in achieving a sustainable and unpolluted streetscape.

Crossing

The street lacks pedestrian crossing, putting pedestrians at risk while crossing the street, in addition to the non-defined areas of intersections (Fig. 21).

Public art

Public art is limited on the entrance of Al-Ahram Plateau only, and it contains some distinctive graphics. But all over the street there are no distinctive graphics but just random ads or graphics.

Cafe spaces

Cafe spaces exist but do not follow the correct design principles for streetscape. In most cases there are impeding pedestrian movements on the sidewalk.

Recommendations

There are set of recommendations which can be drawn from the theoretical study, and the analytical study of a group of international case studies in the field of sustainable streetscape. In order to convert the El Ahram Street into a sustainable street, the following principles and elements of sustainable streetscape are applied.

Sidewalks

Paving materials should be selected for sustainable manufacturing, and permeability.

- All damaged stone, metal and concrete elements should be replaced immediately. All graffiti should be removed. Using durable materials will help to reduce maintenance costs.
- Providing separations between sidewalks and street channels.



Fig. 21 Crossing. Ref.: The researcher

- Material and texture should reinforce distinctiveness and improve the appearance of the area.
- Use Cool Pavements wherever possible to reduce the Urban Heat Island Effect.
- Use locally sourced paving materials manufactured with sustainable practices to reduce life-cycle environmental impacts.

Street corners

- Each street crossing should have a barrier free ramp.
- Street corners should provide amenities such as landscaping, trash receptacles, seating, and lighting.

Trees

- Street trees should be large enough to provide, shade for pedestrians and parked cars.
- Street trees should be hardy enough to withstand pollution, heat, glare and other urban conditions.
- Strips: Well-defined edges between pedestrian and vehicle domains.
- Coordinate tree locations with street lighting, underground utilities and other streetscape elements.

Planter

Planter location should consider all other streetscape elements, such as, street lighting, underground utilities, and benches. Avoid planting too close to buildings and sidewalks.

Street furnishing

- Street furnishings should be governed by the actual width of the sidewalk.
- Use locally produced recycled and/or renewable materials and energy efficient products wherever possible.

Benches

- Benches should provide comfortable, low maintenance seating. It should be built of sustainable, non-abrasive materials that withstand cracking. Nails or wire should be avoided in construction or repair of benches in the streetscape.
- Locate benches near lighting and plantings, making them more useful.
- A seat wall/planter should be used.
- Users should be able to reach benches directly from public sidewalks. Benches should be convenient and in an accessible from, but not obstructing the pedestrian pathway.

Lighting

- Solar lighting should be used to achieve sustainability.
- Lighting should serve architectural aspect – The unique architectural details on the street can be highlighted with lighting. Landscaping aspect – Greenery and flowers can be enjoyed at night when it is well lit. Identity – The lights on the street bridges and monuments give an identity to the street.
- The location and design of light features should consider the impacts of light pollution, energy efficiency, and any potential negative impacts.
- The concept of "dark skies" should be considered, because it minimizes extraneous light and directs light to areas and surfaces that should be illuminated.
- All light outages should be repaired. Metal elements should be reviewed yearly.

Trash receptacles

- All trash receptacles should be screened.
- To achieve sustainability: material used in steel bar production should be post-consumer, post-industrial recycled scrap steel, or sustainable material.
- Receptacles should be anchored to the ground and located near lighting and near shops.
- Ongoing maintenance and emptying of containers should occur.

Signage

Signage should be made of sustainable material, it should not be located in the walkway zone, and should have a pharaonic style.

Bus shelter

- Accessibility: Provide a barrier-free ramp at the point of entry to the bus.
- Sustainability: Materials should be made of recycled materials.
- The study encourages the addition of a green roof to each bus shelter.
- All bus stops should be marked by standard signs. Signs should be cleanly designed and maintained, and should be provided with bench, lighting units, and trash receptacle.

Medians

- To achieve sustainability, irrigation should be using gray water.
- Consider using pavers in the median surface with sustainable materials or recycled materials.
- Ornamental lighting, or art elements, these elements should not encroach the traffic lanes.
- Medians should use materials that do not require irrigation.

Bicycle facilities

- Provide bike paths along the street which can help in achieving sustainable streetscape.
- Locate bicycle racks near major building or center entrances. Do not obstruct entrances or pedestrian paths.
- Lanes should be clearly and simply marked.

Crossing

- Each street crossing should have a barrier free ramp. This corner option should be used in areas of higher pedestrian traffic.

– Design crosswalks to highlight their visibility by constructing them of materials other than asphalt, and mark them with a change in color, texture or grade.

Public art

– Coordinate for the placement of more public art throughout the street recognizing the history and pharaoh's character.
– Sustainable public art should be considered, and durable materials should be used that will maintain their appearance and integrity over time.

Cafe spaces

– The sidewalk needs to be of sufficient width to allow for a clear walkway around the café.
– All furniture should be constructed of sustainable materials and properly maintained.

From above, these modifications will contribute to meet sustainable Streetscape as follows (Table 1).

A proposed design strategy

The proposed design strategy for the El Ahram Street offers an opportunity to improve the street. The modifications would contribute to meet sustainable streetscape principles and are important to achieve a more complete streetscape design (Figs. 22–25).

Table 1 The objectives to convert El Ahram Street into a sustainable street.

- All bus stops should be Elements of streetscape	Sustainable Streetscape principles				
	Improve Air Quality	Reduce Heat Island Effects	Improve Water Quality/ Efficiency	Improve Energy Efficiency	Reduce Light Pollution
Porous paving		■	■		
Solar lighting				■	■
Landscaping	■	■			
Planters	■	■			
Bicycle Rack	■				
Recycling Bins				■	
Street Trees	■	■		■	■
Continuous Planting Strips	■			■	
Bicycle Lanes	■			■	

Ref. [4].

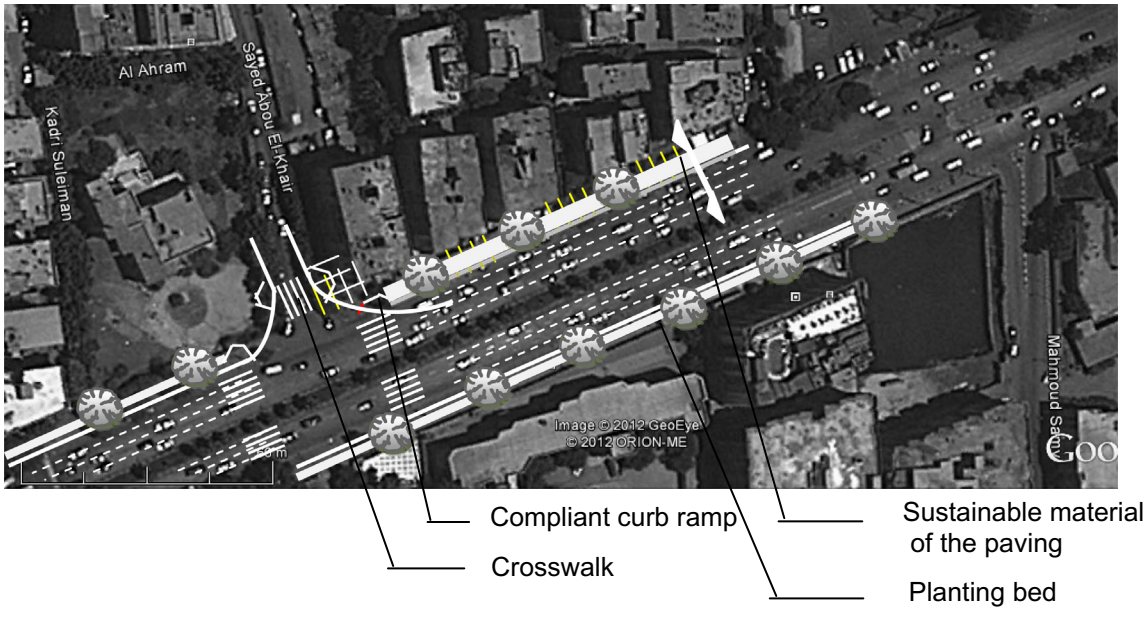


Fig. 22 Conceptual design. Ref.: The researcher

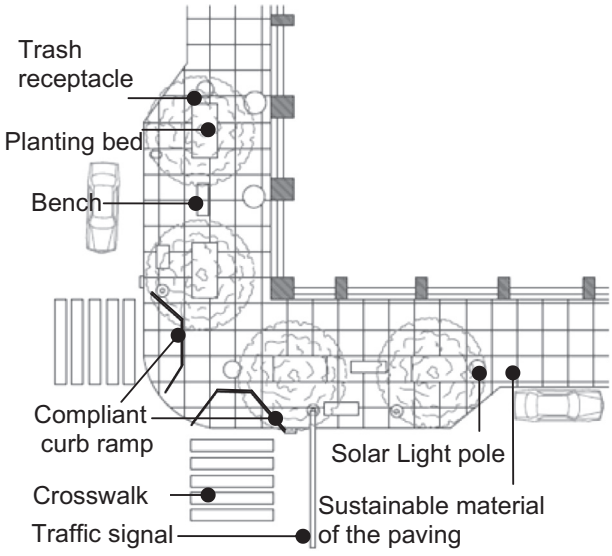


Fig. 23 Conceptual plan: street corner. Ref.: The researcher

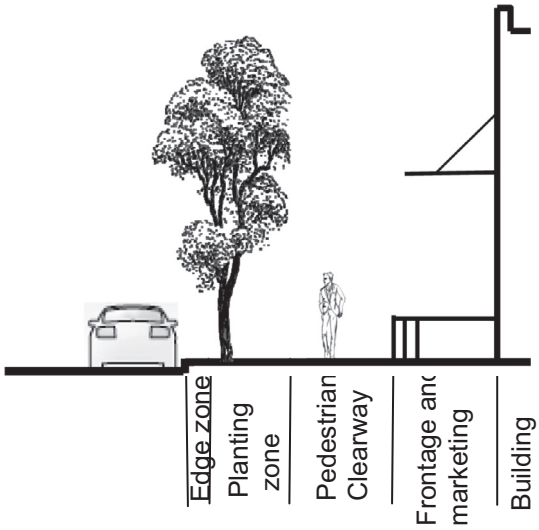


Fig. 25 Cross section of sidewalk. Ref.: The researcher

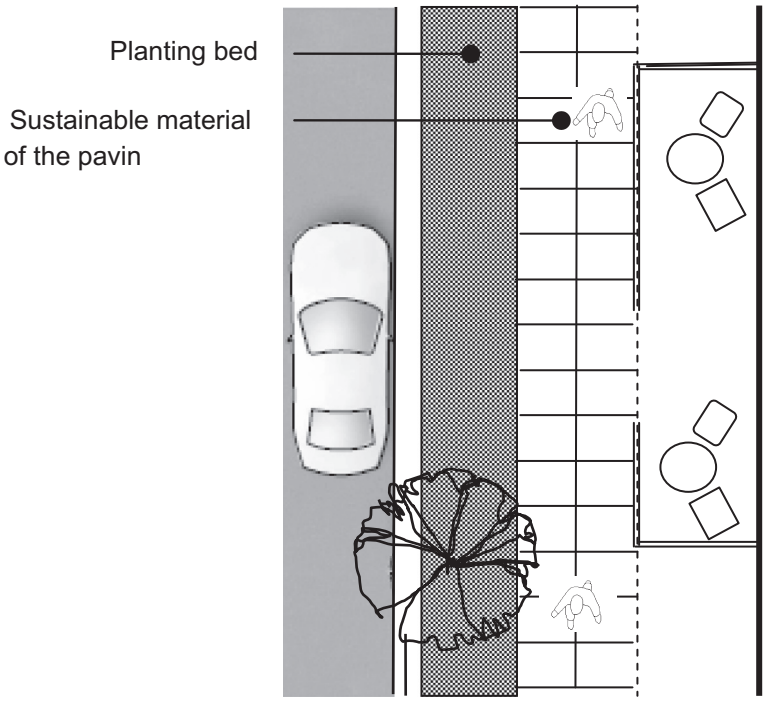


Fig. 24 Conceptual plan: sidewalk. Ref.: The researcher

Conclusion

Sustainable design for streetscapes is one of the ways to achieve sustainable cities. So to establish a sustainable streetscape, principles of sustainable streetscape should be taken into account including stormwater management, use of sustainable materials, lighting & dark skies, and landscaping & urban heat island. As shown in the applied study the research concludes the proposal for developing the streetscape of the El Ahram Street to become a sustainable streetscape.

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