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New strategic approaches for implementing intelligent streetscape towards livable streets in City of Riyadh

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ABSTRACT

Streetscape can be considered as a term "which can be used to clarify and explain the street's built-in and the basic structure, also it is known as the design of the visual appeal and quality of the street effect. A good tool for improving urban quality and establishing a feeling of place is design of streetscape. People's requirements for public areas have changed as internet usage has continued to expand. The numbers of people who use cars has increased a lot in Riyadh city. This leads to some problems in a direct and an indirect way, such as car accidents, traffic overcrowding, lack of services for bicyclists and pedestrians, weak social relationships between the people, and high obesity levels. Reconsider design of streetscape in Riyadh city especially in the era of digital information technology will revitalize regions by providing reshaping the urban experience toward higher livability that respond to and connect with onlookers in order to increase understanding of onlookers' activities in the streets, promote their sense of place, and improve safety and livability in urban areas.. The presented study focuses on the qualitative approach that is according to the related theoretical exploration and research; so, this paper combines the design of streetscape with digital information technology, with new ideas of intelligent streetscape's design for enhancing Riyadh city to make the user's life livable. The current paper ended with proposed strategic approaches and suggestions to enhance the city of Riyadh's streetscape style as an outcome of the theoretical research. Results indicated that streets, which contain a close combination with the resident's daily life activities and the important consequences on their mental comfort, have not attracted any care in terms of academic research. This resulted in a failure in providing solid strategic approaches for intelligent design of streetscape in Riyadh city.

Keywords: Urban Street design, Livability streets, Streetscape, Smart city, Intelligent streetscape, Saudi Arabia, Riyadh.

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1. Introduction

The percentage of the people who live in cities is bigger when compared to the number of people who live in rural areas. Nearly 60% of a typical city is full of road right-of-ways that are normally dominated by personal vehicles [1]. Riyadh is considered as one of the world's large capital cities, as well as its urban design has been impacted by a quick type of rapid population increase and urbanization. The huge urban amplification affected the human dimension negatively. In other words, the streets now are being more devoted on transportation than being a comfortable integrated urban space [2]. The street takes an important role in establishing the society's life and it is vital in forming the social, cultural, economic, and political functions of the city. It is considered as a distinguished part that controls and determines the characteristics of a place [3].

Streetscape denotes to what is called an urban roadway design and the situations that affect the users of the streets and the residents who live nearby. Streetscaping takes into account that the streets are the places where people are involved in numerous activities [4]. design of streetscape is increasingly acknowledged as a tool for improving traffic safety and livability in urban settings [5]. Many architects, urban designers, and streetscape creators view the streetscape features as attractive, healthy, and focal points in their designs. Actually, the researchers' efforts to elucidate the significant impacts of streetscape features on people's health, social activities, spirit, business, environment, and the psychology of human behavior were successful, as is seen from their study trajectory [6]. In this context, Riyadh has started to take an active role in setting up streets towards livability. Through the creation of urban spaces and constructed environments, the local governments in Riyadh have made significant progress in reestablishing the human aspect in streets [2]. Regarding the 2030 Vision to be realized, the Council of Economic Affairs and Development approved a set of 12 programs. By enhancing peoples' lifestyles and their quality of life, the Quality-of-Life 2020 Program seeks to make Saudi Arabia a very suitable city to live in.

Increasing the interests in urban livability demands that geographers and planners more precisely define as what constitutes a livable streetscape, an important building block of urban places [4]. A modern design of streetscape with the capacity to exist in the twenty-first century will be developed with the aid of the idea of livability [7]. The traditional urban planning and the management model cannot satisfy the needs of modern people. More and more cities are becoming smart cities. This is an important part regarding the urban planning and the technical basis for urban development [8]. The occurrence of smart cities is not only considered as an effective mean of urban planning but also urban development. A lot of financial and material resources in the process of development are invested to build a smart city streetscape. The nonstop growth of streetscape structure has played a positive role in stimulating the development of smart cities [8].

Intelligent streetscape aims to make a mix between the basic elements of cyber-physical systems and the traditional elements of the public realm [9] . However, intelligent streetscape includes a huge diversity of the possible infrastructural objects and the services; this includes physical layers, users need, efficient management of space, structural health, some traffic management, monitoring of the environment, and waste management, amongst others [4]. Correspondingly, urban is being increasingly combined with city and it is applicable equally.
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1.1. Urban street design

Streets are considered as a major factor of urban form in a person’s perspective of the city—that is a kind of intellectual map of the city[10] . We all use the streets to know the city and to travel. This indicates the used and organized techniques in which the various urban factors including pavements, cars, buildings, and pedestrians. The mentioned factors play a major role in managing the crowd problems vs. density issue [11].

Historically streets have been designed by engineers whose main goal was to transfer traffic as fast as possible, little attention was given to “attracting people to linger in shared public space” [12] . Over the years, however, the relationship between people and their streets have changed drastically. Urban streets today are seen as a place of social and commercial encounters and exchanges. urban theorists would develop a concept of the safety and physical comfort of the street to “encourage participation” to make it the “most desirable place to be”[12] . All the streets should be designed through taking into consideration the ease, affordability, safety, accessibility, and mobility to all users. Streets are contributed to economic, social, and environmental benefits to the city. Streets ought to be planned with keeping in mind a cohesive approach regarding the surrounding built mass on both sides of right of way and streetscapes (Global Designing Cities Initiative, & National Association of City Transportation Officials. 2016).

The deep understanding of applying the context-based approach in designing and building perfect and complete streets in certain cite requires having a design of a practical and a functioning street [13]. Since the context of an area is understood, the purpose of each street can be recognized, and design parameters can be selected to achieve a balance between street design and the use of the land. Typical street fundamentals might include street furniture, pavement markings, lighting, street trees, medians, signage, landscaping, paving material, and parking. These elements can afford function and help in contributing the character of the street [6]. Urban design and streetscape should be considered together to form a good form and function of the place. All strategies should have a joined approach to bridge the gap in the policies, codes, guidelines, and bye-laws for smooth and coordinated working of the system.

2. Material and methods

Livability streets, Livability is an immeasurable feature. It is not possible to measure the quantity and the quality of the urban life. A livability city is a city in which people prefer to live and can afford all their necessities to live. The livability of a city and the criteria vary between different people according to their cultural and national background, traditions, personality and expectations [14]. The streets in our cities should also be adapted to arrange human health. Basically, it is known that the increase of walking is directly linked to improve the health of people. Unfortunately, in the recent years, our cities have been planned to decrease walking. There are a lot of memorable and benchmark examples that exist, from the European cities and their medieval streets (celebrated by Allan Jacobs in Great Streets) in which they were designed far before the car, to the active city blocks of Manhattan that Jane Jacobs struggled and fought to preserve [1].

The life in the city affects its reputation and ability to attract visitors. Social connection is abundant on a street where there is a thriving homeless population. People feel protected and at ease, in addition to a feeling of ownership and community, in successful areas. Four basic principles must be considered in a great street design: legibility, convenience and safety, attraction, and vibrancy [7].

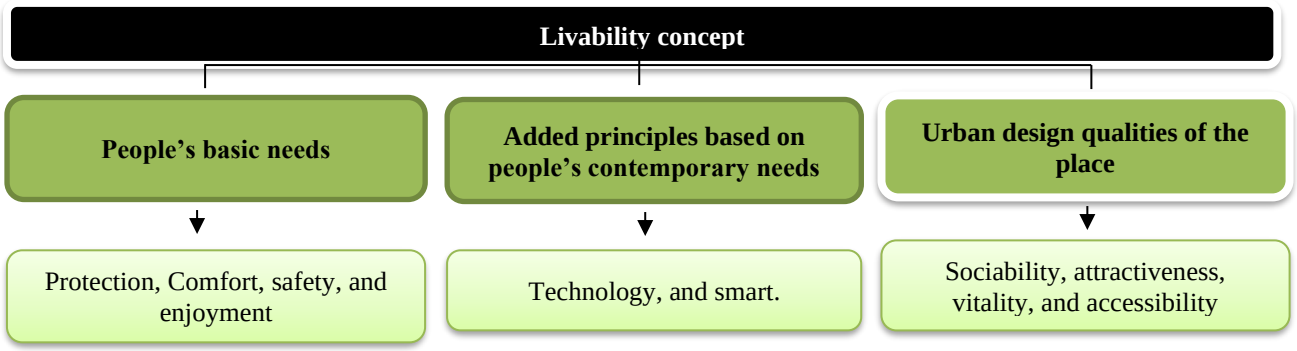


Figure 1. The concept of livability

2.1. Smart city

Smart city or intelligent city has appeared along with the continuous growth of information technology and science [15]. An urban area that is clever area that employs business models, techniques of communication and data, and many solutions to increase operational efficiency, transferring information with the public and improve the citizen welfare and quality of services). Smart cities can be sustainable through various types of technologies; including ICT – Information and communications technology IoT – and they are linked to physical devices through employing the Internet of Things network GIS – Geographical information systems each work mutually are accumulated and contextualized through massive counts of capacities that can be used to raise and expand the mechanisms and schemes that running inside a city [6].

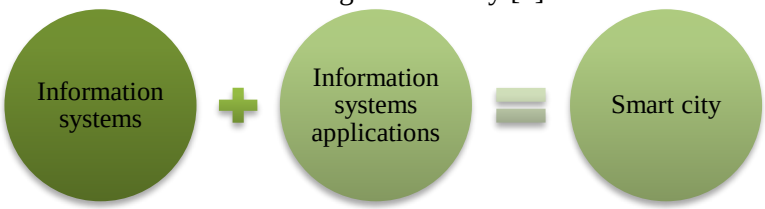


Figure 2. Defining an urban environment with the aspects of people, technologies, and organizations

2.2. Streetscape

Since the 1500s design of streetscapes have developed within the planning movements and the city forms starting from the narrow winding roads of the organic city to the wide motorways of the modern era. In reality, streets are vital components and they will continue to be as this in the physical design and social success of our societies [16].“Streetscape is a utilized term defining the street built fabric and natural, and it is definite as the street design quality and its visual magnitude, specifically on the way the area that paved is laid and treated. This including the surface of street, buildings and the fittings and fixtures which ease their utilize from signage

and bus shelters to schemes of planting". Now, design of streetscape is recognized to be the streets design with all of its planting of landscape, sidewalks, roadbeds, and the nature of the nearby planted setbacks or building façade. Streetscapes are considered of being a major public realm factor (spaces of public in which people interact usually); this helps in defining an identity of community, quality as aesthetic, health, activity of economic, opportunity and social cohesion. In other words, streetscapes are not only limited for mobility, it includes all the previously mentioned factors [17].

2.3. Design of streetscape elements

Depending on the style of street, the landscape elements are viewed as a set; each street has a specific role or function as well as distinct situations, such as service roads, freeways, pedestrian walkways, highways, main roads, and secondary roads[9] . Each streetscape component's structure must guarantee and improve the city's readability as well as meet and exceed all user expectations and requirements. Additionally, it must be aesthetically acceptable, appealing, and constructed to produce livable areas where individuals may gather and communicate. Streetscape Management Section, 2007). The primary elements of a street's urban structure are its streetscape characteristics.

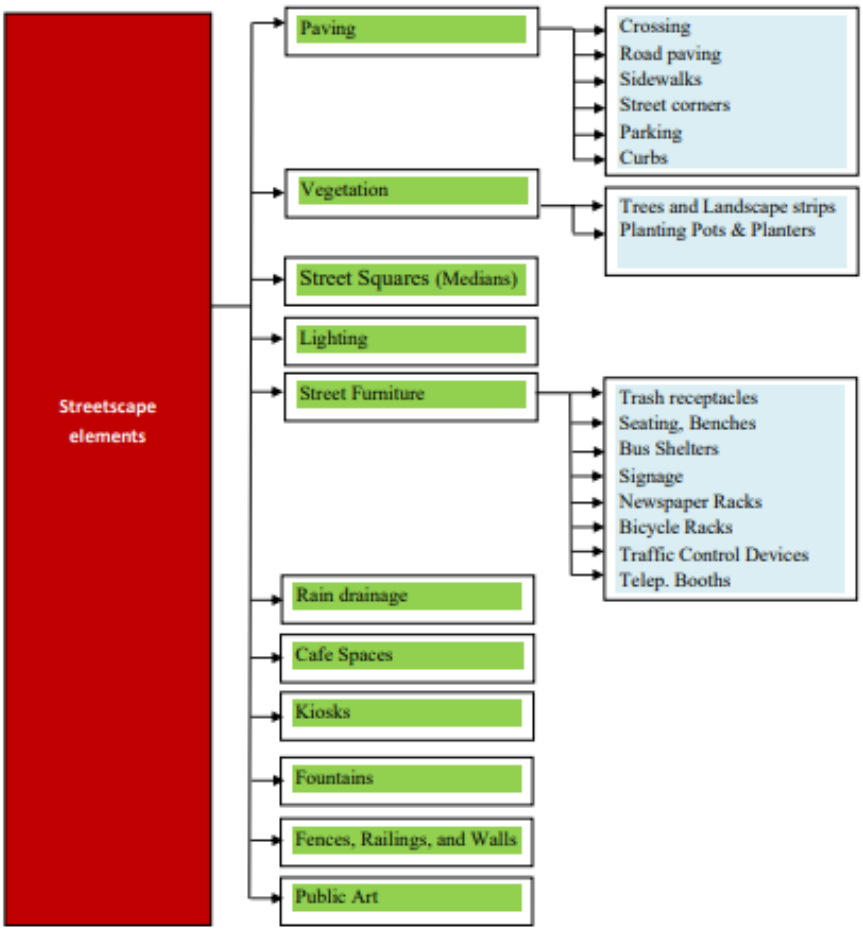


Figure 3. Streetscape elements, [18]

3. Results

3.1. Intelligent streetscape

Streetscapes have offered a long-standing interest in a lot of fields. Recently, there has been a rebirth of the attention on streetscape issues, especially in the age of information technology [17] [19]. Along with applying architectural oversight in smart cities building under Industry, Urban streetscapes with clever design have attracted a lot of attention.[20] . Cities all across the world are attempting to create fresh approaches to deal with the problems of the twenty-first century [7].

Incorporating user demands, green spaces, fundamental street operations, as well as numerous web services, the Things Internet, and virtualization technologies into the active streetscape design systems is essential. Life,

individual traveler safety, and social security all need to be secured under the basis that the fundamental services provided by roads are guaranteed. This creates the requirements for the speedy, thorough, scientific, urban street landscape management, as well as aesthetic development [20]. The intelligent streetscape system is based on intelligent infrastructure and intelligent service as shown in the following figure:

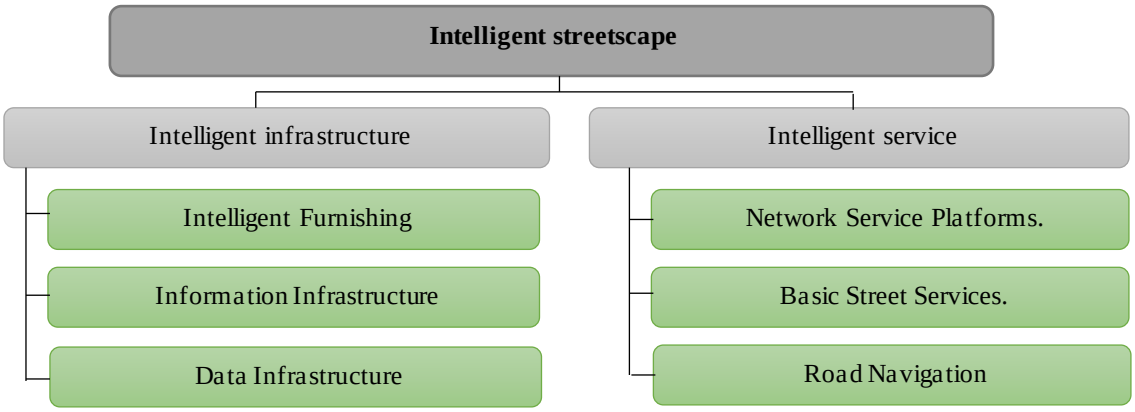


Figure 4. Intelligent streetscape

3.2. Intelligent furnishing

is the actual foundation and core of intelligent street landscape designs. In addition to performing all of the essential tasks, the architecture of streetscape intelligent designs will proactively provide the needed data and services.[21] Lately, furniture of street, including seats, bins, sidewalks, and Lighting poles, have tend to be smart since it has been armed with the sensors of environment, processors, modules of wireless, and micro-controllers [22] [23] Consequently, furniture being smart is anticipated to be crucial Internet of Things parts and one of the future smart towns drivers.

3.3. Sidewalks

Using devices that convert people's existence and motion into various forms of engagement, the pavement can be made better. For instance, a sidewalk that becomes lighter when someone walks on it or urban furnishings whose color varies depending on how people using them [7].

Figure 5. Smart sidewalk

3.4. Smart benches and kiosks

By including outlets where individuals can plug simply in their chargers USB to power their devices whenever they want, clever benches can be enhanced. The rocking rocker with solar power “SOFT Rocker” generated by Sheila Kennedy, Architecture Professor at MIT, is a fantastic representation of such [24] [25]. Smart kiosks, provide open access to two fast-charging USB ports, a phone feature, a variety of maps, and data access for all consumers via the integrated touch screen tablets.[13] . Smart kiosks have built-in sensors that can control quality of air and have the capacity to collect data of real-time on things like traffic statistics, walker counts, quality of air, and other environmental factors (Ibid).

(A) (B)

Figure 6. A-Smart bench, B-Smart kiosks

Lighting can be made smarter to serve as streetscape features. "Intellistreets," is a system of interconnected LED streetlights created and commercialized by Illuminating Ideas, was invented by Ron Harwood. The fundamental features of IntelliStreets offer prospects to dramatically increase accessibility for people with impairments while also offering cheap urban illumination [26].

Figure 7. Intellistreets

Advertising and signages boards are able to be enhanced through utilizing digital screens in passive or dynamic broadcasting modes that show a collection of videos and animation, or by permitting the mobile phone combination through QR codes, Bluetooth, and SMS [27].

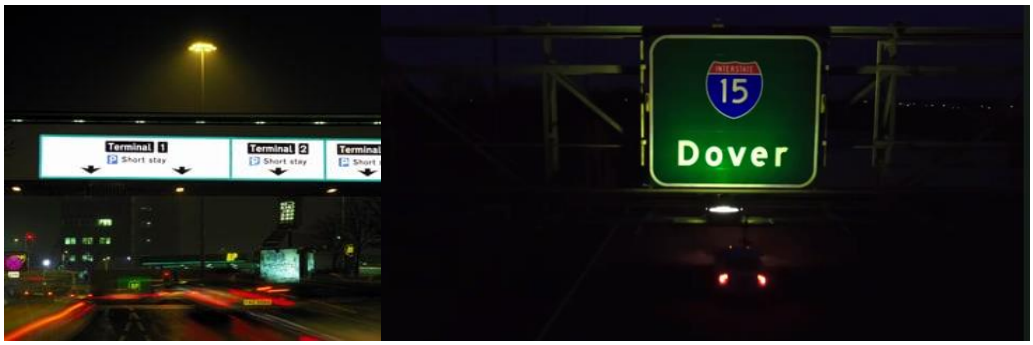


Figure 8. Smart signage

Water elements - The inventive devices utilized can enhance. The “Digital Water Curtain (DWC)” is an innovative fountain that has been modified to meet modern urban landscaping standards while also serving as a playful, refreshing, environmentally conscious, and recognizable landmark in the cityscape [24].

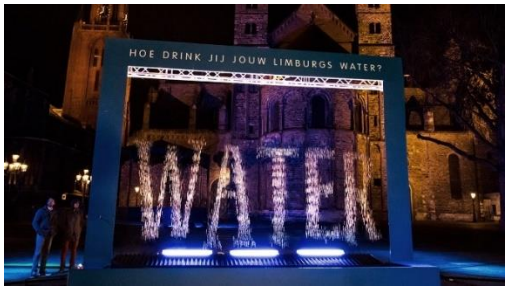


Figure 9. Digital water curtain

3.5. Information infra-structure

is the intelligent basis of street landscape that covers the electric information screen, multimedia touch screen terminal intelligent monitoring, security facilities, , help facilities, intelligent broadcasting and landscape performance facilities (such as parking blocks, road entrances) to ease the provided service i.e., the important requirements of easy and information inquiry satisfy all the documentation and suitable use[20].

3.6. Infrastructure of data

is used to assemble and combine information for the scene on the street, allowing for the building of intelligent street landscapes by giving users and management full and logical information due to the incorporation examination of data from many sources (fundamental databases). For precisely positioning the intelligent landscape, the basic information defines the geographical location and every aspect of the urban streetscape [28][25].

3.7. Intelligent service

The building of a system as intelligent service relies on functions of Internet; this able to be understand the active needs corresponding of the user. In terms of quantitative or qualitative data, directors can be given with opinions, honest feelings, and suggestions that are created by the public's use of the service. With the assistance of active features examination of smart infrastructure, a dependable technique for the provided request forecast management. (Public participation can attain, as well as the quality of the service expands unceasingly [28].

3.8. Platforms of network service

Platforms of network service form the foundation of the smart service and the intelligent linkage guarantee with the other services and facilities. (Many services, including e-maps, traffic alerts, travel advice, bus schedules, and local service calls, will be protected during the construction of gateways for the general public. Additionally, the mobile-based development of systems of network service (such as mobile applications and accounts of WeChat public) must be prioritised in order to guarantee actual content updates and give all mobile users adequate knowledge of the street services using shared website resources.

3.9. Basic street services

Lighting, traffic, as well as other basic but essential services are examples of fundamental street services. Based on data gathered from the parking buildings and using a number of intelligent terminals to navigate locations including smartphones, real-time observation of the parking lots is accomplished by the intelligent parking management system, which also makes wise recommendations regarding the available parking spaces [29] .

Figure 10. Smartphones in streets

Public system of transportation must guarantee the timely bus information announcement and many certain roles (such as complaint of passenger, a customized bus signal technology for the intelligent bus terminals and the key bus corridors, along with a multimedia data release [18].

Figure 11. Multimedia touch screen terminal

3.10. Bike racks

To promote the usage of motorcycles, carpark must be made safe and convenient. A San Francisco-based begin called "bikeep" makes the right bike racks that can improve parking safe and secure environment by connecting the rack to a mobile application. If anybody attempts to move the motorcycle without having the required permission through the application, the rack also sends a message to the phone. *Bus Shelters* employing touch-sensitive digital displays that provide users with a range of services such bus route directions, smart urban maps, direction search, and traffic broadcast television, can be enhanced. Additionally, you can order and buy things while moving by scanning a (QR) code on displays that depict an online store.

3.11. Navigation of road

By using smart terminals (such as screens smartphones, multimedia touch) and terminals that are multi-language for the self-service triangulation must be employed to make the introduction of picturesque spots and plants utilizing QR codes and Radiofrequency Identification technology, making it simpler to find streets, nearby e-maps, and arrange tours [27] .

3.12. Saudi Arabia

SA is trying to improve the cities quality of life by improving the cities livability [5]. The streets design quality is considered as one of the greatest mutual research subjects in the planning field and urban worldwide (Carmona, M. 2019). In cities of SA, the livability concept has been overlooked recently. Most of the designed streets are of a priority for only cars; sidewalks and streets are not convivial and do not fulfill all needs of users. In reality, there are a lot of streets that are missing streetscape factors design, i.e., signs and planting, and several of them do not get any maintenance being satisfactory [5].

Fig. 12. Examples of sidewalks and streets in Saudi Cities [5].

4. Discussion

4.1. Riyadh City

Due to urbanization and population increase, Riyadh City has gone through changes during the previous three decades that are significant and abrupt urban development. From 1987 to 2017, the population of Riyadh expanded from 1,389,500 to 6,506,700. [2]. Urban populations are focused on the roadways coming into Riyadh,

and the city's expansion is seen as a horizontal spread (Royal Commission for Riyadh City (RCRC), 2014). The development of urban Riyadh region is 3,115 km^2, and as of 2017, 1820 km^2 of that land, or 58% of the whole urban development region, were planned for development (RCRC, 2018). This shows that Riyadh's horizontal growth has contributed to its cars dominance over other facilities of transportation. Additionally, the roadways stopped serving as livable streets and instead were devoted to serving the vehicles.

Figure 13. Examples of streets and sidewalks in Riyadh City, [2]

4.1.1. Proposed strategic approaches for implementing intelligent Streetscape towards livable streets in Riyadh City

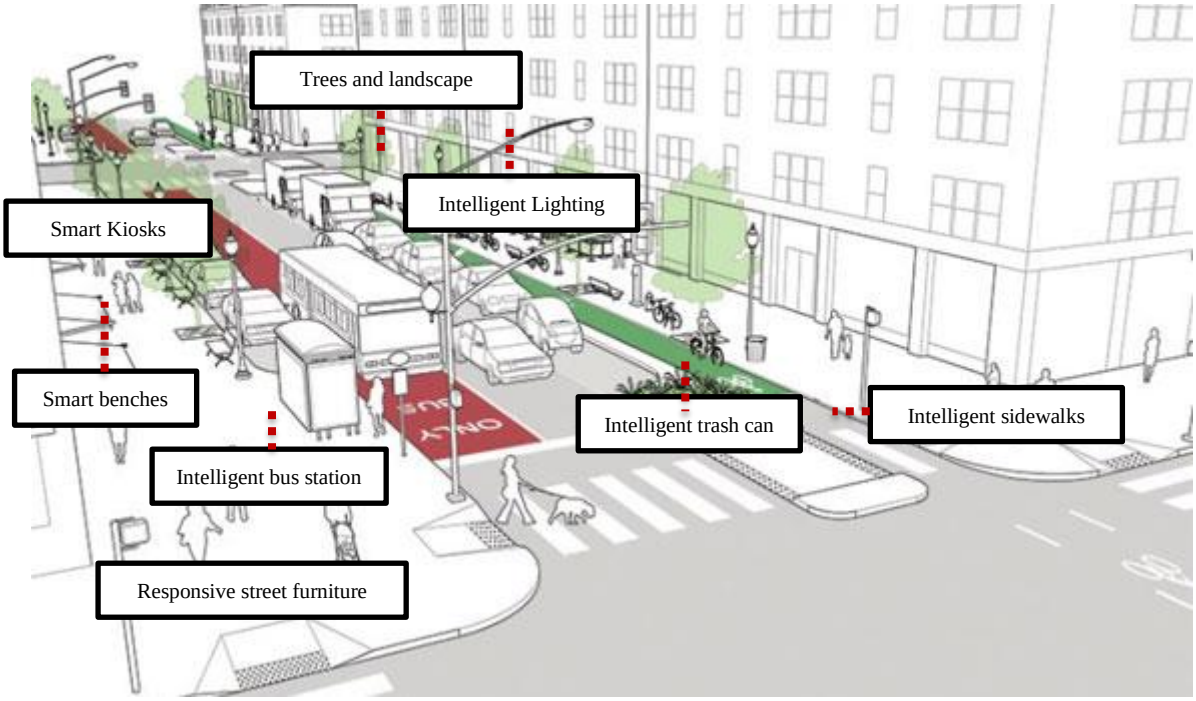
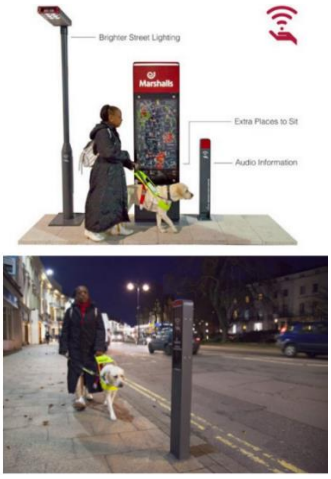


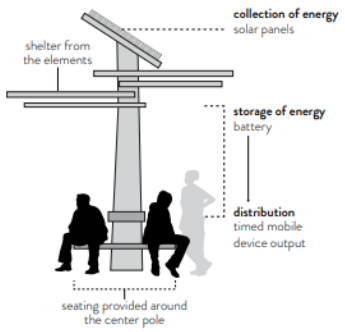
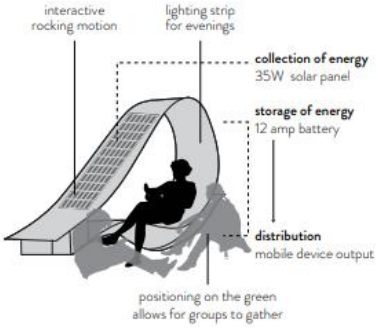
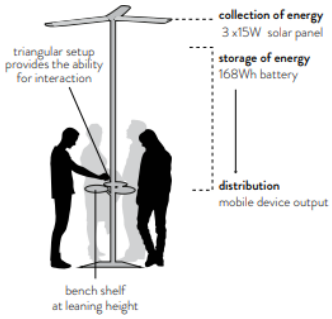
Figure 14. Future vision for intelligent streetscape towards Livable Streets in Riyadh City

Table 1. Proposed strategic approaches for implementing intelligent streetscape towards livable streets in Riyadh City

Strategy Of intelligent streetscape	**Method**	**Example**
Intelligent Sidewalks	Implementing Interactive pavements such as “the Piano Stairs” is a musical dynamic stairway that when individuals stop on it makes a gigantic piano sound.	 Figure 15. Intelligent Sidewalks, The Piano Stairs.

Strategy Of intelligent streetscape	**Method**	**Example**
Smart kiosks	The kiosk software and hardware feature set include various features for enhancing the experience of user and aid promoting a safer environment. Smart kiosks are giving information relating to nearby retail, restaurants, transportation of public and events. Also, the kiosks offer hot spots of free Wi-Fi.	 Figure 16. Smart Kiosks.
smart rubbish	Sensors that track when trashcans are loading up and notify the sanitation crew to remove them before they become full can enhance trashcans. This usually results in waste collection that is considerably more effective, which saves time and money on sanitation.	 Figure 17. An Example Of A Smart Rubbish Bin, [30]
Digital public art	Public Art can be enhanced in various ways with the use of digital technologies, moving it away from the enhancing features and toward the practical considerations. Water curtain walls are only one example of how street public projects can be modified to make it safer and simpler for individuals with disabilities to travel.	 Figure 18. Interactive Public Sculpture Respond To Human Touch  Figure 19. Digital Water Curtain.
Smart Stations for Buses	They are used to include technology of 4G, connecting Wi-Fi to support the carrying providers with an extra revenue source in terms of advertisements as digital through the company's outdoor media. The bus station as device being cloud that including screens which display information of real-time regarding bus trips and movements and touch-screens which can offer a contact to local news, collaborative maps, tourist information besides a USB charging port that are used for advertising and mobile devices.	 Figure 20. Smart Bus Station.

Strategy Of intelligent streetscape	**Method**	**Example**
Responsive street furniture	Utilizing digital technology, reactive street furniture makes it easier for people to move throughout the city for a variety of causes. It increases the digital devices versatility as the iPad by enabling them to be customised to best meet each person's needs. These modifications include of audible information, better lighting on the streets, more spots to utilize, and additional time for crossing the road.	 Figure 21. Responsive Street Furniture.
Smart Lighting	Street Lamps of Solar LED Energy: With the energy increasing crisis, countries seek to explain the crisis through establishing, a road to seek renewable and new energy utilize; solar panels that reduces the consumption of the energy, or aggregated efficiency of energy. The Street lighting as LED is an integrated light-emitting diode (LED) light fixture which is utilized for street lighting that able to be utilized for major roads, sub-major roads, and highways. It is long-lasting environmentally, extremely efficient, friendly and as well controlled inherently.	 Figure 22. Smart Lighting.
Trees and Landscape Strips	It is possible to make trees into a source of artistic expression and culture in public areas. Trees able to be lighted through various colors at night as a public art form that draws more consideration to public areas and roads using string LED lighting or up-lighting systems [21]. Virtual projection can be utilized to create dynamic spaces through altering the appearance of area, colors, dynamics, etc., as well as on trees [31]	 Figure 23. Digital Projection On A Tree By Clement Briend, Source: [33]  Figure 24. Using String LED Lighting, Tokyo Street.

Strategy Of intelligent streetscape	**Method**	**Example**
Smart benches	Strawberry tree: such intervention tries to offer an amenity of free charging within the environment of urban in which it would usually be hard to find.[32]	 Figure 25. Strawberry tree, [26, 33]
	Softrockers This model is designed by engineering and architecture students and responds directly to the environment where it is placed, and the user's type which would engage with it at the installation time. The campus green offers the intervention with the capability to adapt to group activity owing to its relaxed environment field. Also, additional lighting permits the intervention to be utilized at any time, night or day. The intervention offers 3 outlets for devices, but the seat size and integrating balance design intention only permits 1 individual to engage directly with it.	 Figure 26. Strawberry tree.  Figure 27. Soft rockers,[33]
	Street charge The design is of potentiality to be directly placed more within the dense urban streets, but such designs are yet to be in locations being alternative.	 Figure 28. Soft Rockers.  Figure 29. Street Charge, [33]

Strategy Of intelligent streetscape	Method	Example
		 Figure 30. Street charge.

4.1.2. Conceptual framework for an intelligent streetscape in Riyadh City

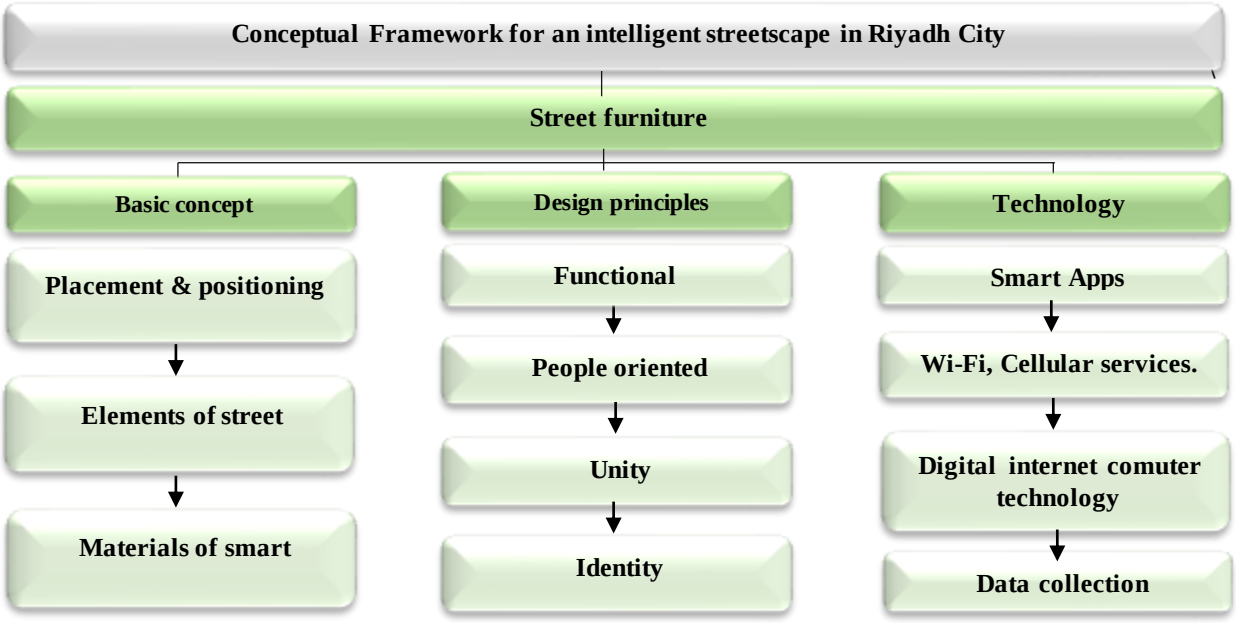


Figure 31. Conceptual Framework for an intelligent streetscape in Riyadh City, source: [34].

5. Conclusion

This study provides that Streetscape is able to require an important consequence on the way people identify and cooperate with community. If streetscapes are safe and inviting to walkers, people are more likely to walk It could encourage overall economic development, promote public health, draw residents, make towns more attractive, and enhance the surrounding environment by making it more appealing, healthy, fun, safe, and intriguing. Cities being intelligent can offer marvelous opportunities for livable cities future, not just through the internet data and technology utilize, nonetheless likewise through increasing the urban street flexibility by better efficiency and the innovation development. Applying intelligent design of streetscape has the important role to make street livable especially in Riyadh city, so intelligent streetscape can greatly contributors toward:

- Increasing Pedestrian Safety.
- Creating Circulation Network Connectivity.
- Reducing out of motorist confusion and direction travel distances.
- Providing many direct roads to destinations.
- Providing Economic Vitality.
- Improving Accessibility.
- Increasing property values.

- Creating attractive places and making urban identity.
- Improving public health.
- Improving the human lifestyle quality

The research of the future can intricate a lot of methodologies to enhance the urban cities through using intelligent-streetscape elements in cities especially in Riyadh city, it will necessarily contain an emphasis on intelligent-streetscape factors that meet the life quality and its sustainability. Additionally, a need is there for examining the intelligent streetscape impact on the utilizers in cities of Saudi to comprehend their all the streets value and insight.

Declaration of competing interest

The authors declare that they have no recognized non-financial or financial competing interests in any materials conversed in the current work.

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