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Green Transportation Corridor (Designing Green, Environmentally Friendly Transportation Networks)

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Abstract

Green corridors, as one of the emerging aspects of urban design, play a pivotal role in driving sustainable transportation and shaping the visual and functional aspects of cities. This project begins by defining sustainable transportation as systems that provide mobility with low environmental impacts, while enhancing social, cultural, and economic aspects. Where sustainable transport does not only include technology and infrastructure, but also strategic planning, policies, and community engagement that support its development. The concept of streets was introduced as a crucial element in this project, defined as the visual and physical character of street spaces, including their arrangement, appearance, and interaction with human activity. Then the importance of green corridors was explored in detail. As linear streets or networks of green spaces, they provide pathways that not only facilitate human life movement but also ease non-mechanical human transportation, contributing to the multifunctionality of urban landscapes. Green corridors serve as the veins of the city, providing environmental benefits by preserving biodiversity and acting as a sustainable alternative to transportation. Through the review of previous studies and proposals, the benefits of green corridors in enhancing the city's identity, increasing both social and economic activity, reducing pollution, and encouraging active transportation methods such as cycling and walking have been highlighted. And also the reference to how well-designed street views contribute to the overall sustainability of transportation by improving accessibility, safety, and community well-being. However, these studies have been characterized by their inability to provide clear and sufficient knowledge regarding the design of environmentally friendly green corridors in the local context of the city of Diwaniya. Based on this, the project's problem was identified as the lack of comprehensive and clear knowledge of the components for designing environmentally friendly green corridors at the local level of the city of Diwaniya. The project aims to provide more comprehensive knowledge for designing environmentally friendly green corridors that can be effectively adopted by designers in general, and specifically serve the local experience of the city of Diwaniya. Achieving this goal required the adoption of a set of indicators for designing environmentally friendly green corridors, which were reached based on previously presented knowledge and studies. And redesigning one of the vital streets in the city of Diwaniya according to these indicators in an attempt to move towards sustainable transportation. Reaching the final conclusions Emphasizing the importance of integrating green corridors into urban planning. He emphasizes the need for multidimensional planning approaches that align street design aesthetics with the functions of sustainable transport networks, suggesting that future research should focus on developing quantitative and qualitative measures to assess the impact of green corridors on urban sustainability.

Keywords: *Green Environment, Sustainable Tranportation , Transport Network, Street Space, Green Corridors.*

Introduction

Sustainable transportation and environmental design

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Transportation often denotes the conveyance of individuals or commodities from one location to another. This can be accomplished by several modalities including roads, rails, aviation, waterways, or pipelines, frequently utilizing conveyances such as automobiles, trucks, trains, aircraft, vessels, and bicycles.

Sustainable transportation prioritizes the mitigation of environmental, social, and economic consequences of transportation systems while fulfilling mobility requirements. This encompasses advocating for transportation modalities that diminish emissions and energy usage, optimizing resource efficiency, advancing public health, and guaranteeing accessibility to transportation systems for all individuals. Sustainable transportation plans may encompass the utilization of renewable energy, urban planning that minimizes long-distance travel, enhancement of public transport usage, and promotion of active transportation modes such as cycling and walking.

Sustainable urban planning is the process of designing the urban environment, incorporating its physical and natural elements, in accordance with sustainability principles that promote social cohesion, local economic opportunities, and environmental protection, while ensuring safe and convenient access to housing and workplaces and minimizing dependence on private car transportation.

Consequently, a basic definition of ecologically sustainable transport may be articulated as transportation that does not jeopardize public health and ecosystems while fulfilling mobility requirements in line with:
A- Utilizing renewable resources at a pace inferior to their replenishment rates.
B- Utilizing non-renewable resources at a pace that is inferior to the advancement rates of renewable alternatives.

Environmental Design and Sustainable Transportation

Transportation routes constitute integral components of open urban spaces and should be systematically arranged and enhanced to enhance the city's aesthetic appeal and attractiveness. A transition to sustainability may be attained by mitigating congestion-inducing elements, selecting eco-friendly and energy-efficient transportation modes that prioritize pedestrians, designing the streetscape with sustainable materials, and utilizing alternative energy sources. The environmental design of roads is a strategy intended to minimize energy consumption, enhance the utilization of renewable energy and resources, and mitigate waste and ecological harm through efficient energy usage, material reuse, and recycling.

The reasons for the shift towards sustainable transportation include :

Environment:

One of the main reasons for the shift towards sustainable transportation is environmental preservation. Sustainable transportation works to reduce carbon dioxide emissions and air pollution caused by traditional means of transport.

Cost:

Cost can be another factor that drives people towards sustainable transportation.Sustainable transportation may be more economical in the long run due to fuel savings and the money spent on maintaining traditional cars.

Health:

Sustainable transportation enhances public health.When more individuals switch to sustainable transportation methods such as bicycles or walking, it contributes to enhancing physical fitness and reducing traffic accidents and related fatalities.

Urban mobility:

In large cities, sustainable transportation especially helps reduce traffic congestion and improves the quality of life in the community. This may include enhancing public transportation networks and promoting the use of bicycles and pedestrians.

Technology:

Sustainable technology, such as electric cars, offers high-density and reliable public transportation, which enhances the shift towards sustainable transport.

Legislation and policies:

There may be government legislation and policies that support sustainable transportation, such as encouraging the use of electric cars by exempting them from taxes, which motivates individuals to shift towards sustainable transportation .

The proper management of open spaces with an environmental design approach for the design and management of urban open spaces is the key to sustainable cities. Environmental design involves a careful study of energy and material use in the system it is designed for, where environmental design strategies for street furniture include long-lasting manufacturing systems, energy efficiency, multifunctional unit systems, and the use of recycled materials. At the same time, in addition to providing solutions to climate, transportation, and public health issues by planting the appropriate trees in the right place and at the right time for shade, as shown in the plan. (Al-Astal, W. N., 2015)

Streetscape Concept

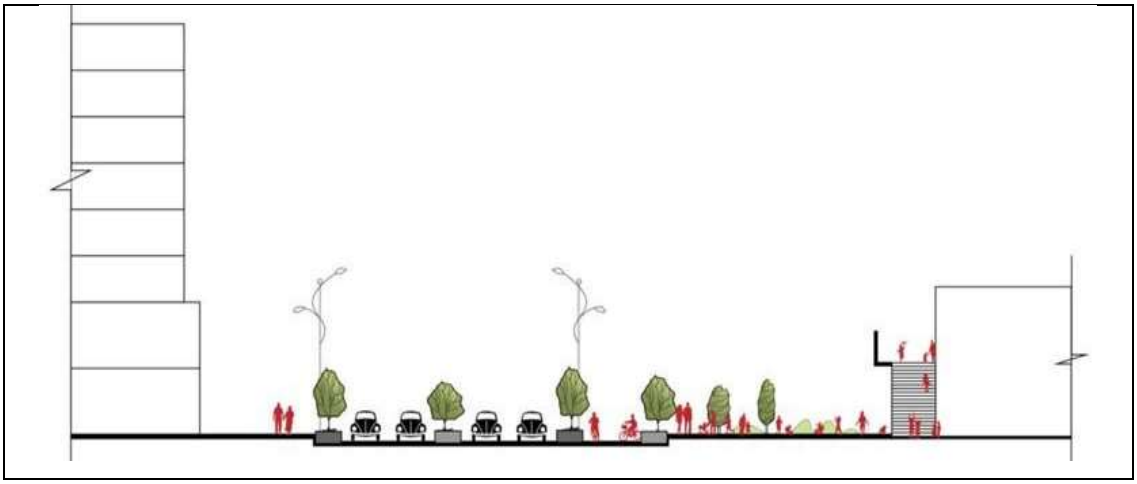
The street serves as a conduit between two locations and is regarded as public land situated between structures, regardless of their public or private status. It may be paved, consist of bare earth, or be elegantly embellished with flowers.

Street architecture serves as a communal amenity accessible to diverse individuals and is a significant component for experiencing the locale. It offers an area for strolling, cycling, or engaging in various activities, utilized by individuals of all ages, including adults, children, and the elderly. Nonetheless, it is a significant aspect of the lives of street vendors, merchants, and passersby too as shown in figure(Ali, A., 2021).

Figure (2): Shows Streetscape Sample,

ref. https://thedesigngesture.com/street-architecture/

The streetscape is the form and appearance of the street, and the term streetscape is used to describe the natural and artificial structures in the street, in addition to the quality of the street and its visual impact. The engineering of streetscape affects the user's perception of the area and their perception of its quality. The term "street space design" is also one of the important elements of urban design that has the ability to transform a mere path into a place of events, as illustrated in the form. (Al-sakli, I., 2021)



Figure(3): Shows A Section in a Streetscape

ref. https://thedesigngesture.com/street-architecture/

The streetscapes and their visual experiences significantly affect the places where people move and interact. Streets have many aspects, as they are used by many people and serve various functions. Streets should effectively create an inclusive, safe, and comfortable environment for users with different activities. And social and economic interaction is the common goal of good streetscape design.

Street furniture in public spaces is an important element that contributes to the city's image. It includes benches, trash bins, signs, lighting, fountains, and other elements that make people feel comfortable. Where the elements in street furniture can be integrated to make them look attractive and functional as part of the city's public space.‘ So that it becomes part of the city's aesthetics and identity formation and is directly linked to its human users, the quality and arrangement of street furniture in urban public spaces are a sign of urban space quality.

Therefore, the use and placement of street furniture in the street corridor must be planned correctly because it will provide a visual experience for those who see it. This will create a good or bad perception of the city's image.

It is clear from the above that the street space is a term that shapes the form and appearance of the street and constitutes the identity of the city with its physical and natural components. The streetscape creates an effective urban environment that affects the visual and security aspects for the user, increases interaction between the user and the street space, and enhances social and economic interaction.

Green Corridor Concept

Green corridors in the context of sustainable transport refer to transport routes designed to reduce environmental impact and enhance the efficiency of transporting people and goods. These corridors often use strategies to reduce pollution, energy consumption, and greenhouse gas emissions, while encouraging the use of clean transportation. The purpose of green corridors is to create transportation routes with less harmful environmental impacts compared to traditional roads. (Dinić-Branković et al., n.d.). Where the aim is:

- Enhancing connectivity while preserving ecosystems.
- Facilitate the use of low-emission vehicles, such as electric or hydrogen-powered vehicles.
- Improving logistical efficiency to reduce unnecessary travel and delays.
- Encouraging multimodal transport solutions that integrate rail, road, and maritime transport more effectively.
- Supporting urban planning that reduces the need for long commutes.
- Strategies for creating and maintaining green corridors include the following:
- Encouraging the use of environmentally friendly vehicles through subsidies or tax exemptions.

● Implementing strict emission standards and encouraging the shift to renewable energy sources.
● Developing infrastructure that supports the rapid movement of goods while reducing traffic congestion.
● Establishing regulatory frameworks that encourage sustainable transportation practices.
● Encouraging the use of technology and innovation to improve roads and enhance vehicle efficiency.

Green corridors are often part of larger strategies for sustainable urban development and transportation systems, which not only aim to reduce the environmental impact of transportation but also improve the livability of cities and the well-being of their residents, under the framework of what are called sustainability categories represented by green infrastructures, mobility, social structure, and cost.

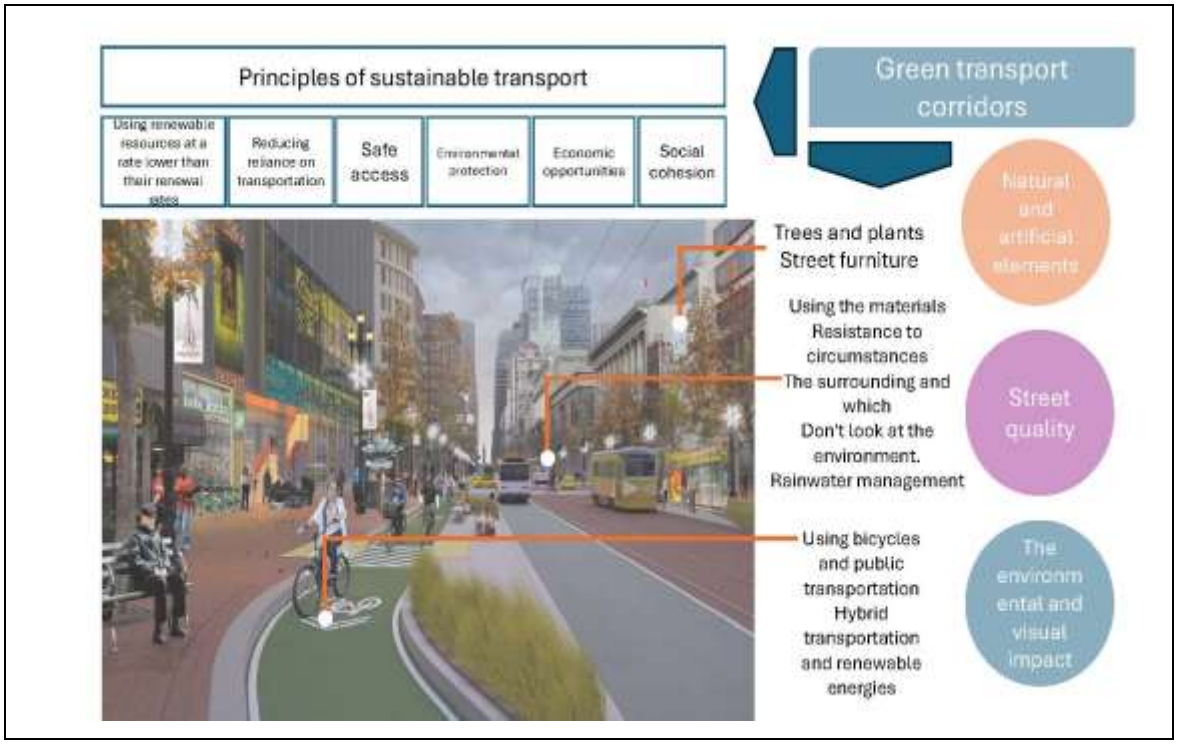
As shown in the plan (Al-sakli, I., 2021). They also complement sustainable urban transport strategies by preserving green spaces that can serve as barriers to urban pollution and can host non-motorized transport routes such as walking and cycling paths.

(Chart 3): It Illustrates the Possibility of Achieving Sustainability Categories in Corridors, Source: (15). P.2

Corridors	Green infrastructures	Mobility	Social structure	Cost
	It can be achieved through The green infrastructure of the streets and roads, for example Gardens and open spaces on the sides of the road and the vegetation Vegetation and trees on The sidewalks and medians.	Streets serve as a framework that defines important places and landmarks. For the place, the grid streets ensure a specific view at their end, while the streets Curved streets focus the gaze on distinctive landmarks of the sector.	Achieving the safety factor in The road encourages more residents to frequent it, and Planting trees along the road and separating Pedestrian and bicycle traffic And vehicle traffic can It achieves beauty, biodiversity, and safety.	The corridors can be They are the heart of the urban area. Commercially and marketing-wise, and if If studied carefully and provided It has spaces and points Attractions and necessary services For the neighborhood.

Based on the above, green corridors can be defined as linear streets or networks of green spaces that provide pathways not only for facilitating human movement but also for non-mechanical human transportation, contributing to the multifunctionality of urban landscapes. Green corridors function as the veins of the city, providing environmental benefits by preserving biodiversity and serving as a sustainable alternative to transportation.

It is clear from the above that the components of green corridor design depend on sustainable transport principles, which involve shaping the urban environment with its physical and natural components, as well as street quality and environmental and visual impact, which can be summarized in (Diagram 4):



(Diagram 4): Components of Designing Green Corridors

Source: Researchers

Literature Review

The study of Ali, Ali, 2021,

(Planning and Design the Sustainable Streets within Iraqi Urban Centers: Grafting Public Space–Street)

The study addressed the importance of streets in urban centers, particularly in the context of Iraqi cities. And it emphasizes the need to reconsider the role of streets beyond merely being channels for cars, suggesting that streets should be viewed as vital public spaces with multiple and interactive uses. The study emphasized the necessity of moving away from the obsession with modernization that neglects the social, cultural, and historical aspects of urban planning, in an attempt to present a sustainable approach that values heritage while embracing modernity, ensuring that streets enhance civic life and community participation.

The study identified three fundamental principles for understanding the city's architectural identity, which are the dynamic nature of identity, the idea that identity cannot be invented but rather evolves through interaction with the environment, and the concept that identity is not just about self-awareness but is also shaped by our interactions with others. The study also focused on encouraging the Iraqi community to view urban streets as spaces with economic and recreational potential. And limiting the random expansion of commercial complexes and malls that negatively affect the urban environment and social life. And adapting architectural and planning strategies to revitalize the streets and alleys of contemporary urban centers, and to promote sustainable urban formations that the community can embrace. Leading to the creation of vibrant and well-designed streets that effectively contribute to the well-being of the community and align with the cultural and historical fabric of Iraqi society. The study showed that sustainable and inclusive street design serves as a unified space for people, reflecting and nurturing the unique cultural and historical identity of Iraqi urban centers. This is achieved by proposing sustainable and smart planning and design strategies that treat the street not just as a space for movement but as the pulse of the city and a fundamental element in social life. It is evident from the above that the role of sustainable street design is to create an urban environment with vibrant corridors that positively impact the enhancement of cultural identity, the economic aspect, and the well-being of the community.

The Study of Wafa Naji Al-Astal 2015

The impact of pedestrian street design on the sustainability of urban areas: A case study (Khan Younis city center)

The study focused on providing a safe environment for pedestrians in the city of Khan Younis, located in the Gaza Strip, due to the area's planning and design problems for movement corridors caused by a lack of energy sources and small space. By using integrated planning and design principles for movement corridors, which have an impact on improving the quality of life and achieving sustainability in urban areas, movement corridors have played an important role in negatively affecting the urban fabric within cities, making it difficult to provide a clean, safe, and sustainable environment for work, residence, and recreation in any urban space.

The study focused on the importance of urban planning according to the principle of public transportation and providing integrated pedestrian pathways, which play a significant role in reducing energy consumption and creating a sustainable urban design that belongs to its surrounding environment, reduces the phenomenon of global warming, and increases economic, environmental, and social development.

The study emphasized the necessity of allocating numerous measures that regulate the design and planning conditions for the sustainability parameters of pedestrian pathways, and providing pedestrian areas, which contribute to achieving sustainability in urban areas.

It is evident from the above that providing safe pedestrian pathways is important for improving the quality of life and achieving sustainability in urban areas by creating a clean, safe, and environmentally sustainable space, as well as enhancing the economic, environmental, and social development of the city.

The study of Iman Al-sakli, 2021

The Cognitive Fabric of Urban Scenes and Their Designs (Street Furniture as an Example)

The study focused on drawing inspiration from the proposed model for urban design in the Western environment to serve our Arab cities.

The study addressed the concept of street furniture and examined the factors and reasons that lead to changes in the Western urban landscape and its influence by the new way of thinking.

The study showed that the street furniture aligns with the evolving needs and values of communities in terms of usability that correspond

The study showed that street furniture aligns with the evolving needs and values of societies in terms of usability, which corresponds to their lifestyles and practices on one hand, and is based on their cognitive and legal advancements and developments on the other hand. This is reflected in the social, economic, and political structures alike. This has resulted in a succession and recurrence of the emergence of renewed and more advanced furnishing components that are compatible with the vital areas of the city.

The study discussed contemporary solutions for improving the design tactics of street furniture, such as employing visual perception (Gestalt theory), which relies on the principle of integration between form and background, such as the law of proximity, similarity, and continuity, and effective design that influences the sensory perception of the recipient. Which opened up new horizons for rethinking the design of contemporary city corridors and solving their long-standing problems, as well as the value that urban furniture can hold in the world. This has made it the most important factor in contributing to the transformation of the city's overall landscape and practices, and in the flourishing of the science of design, a field that continues to evolve and renew itself.

It becomes clear from the above, the urban advancement in the development and design of corridor furniture in Western countries and how to benefit from it in developing our Arab regions, in addition to utilizing cognitive design ideas and methods that influence the recipient's visual and sensory perception.

Defining the Project Problem and its Objectives

It is evident from the overall previous studies that addressed green corridors, there is a variety and diversity in the aspects they presented, as shown in (Table 1). However, they were characterized by

their inability to provide clear and sufficient knowledge about the design of environmentally friendly green corridors in the city of Diwaniya, despite the contemporary global trend of adopting them.

Table 1: Aspects Raised by Previous Studies

The Studies	Sustainable transportation	Reducing environmental impact	Security and safety	Green spaces	Enhancing the economic, social, and cultural aspects	Corridors furniture	Entertainment and wellness
The study of Ali, Ali, 2021	.		.		.		
The Study of Wafa Naji Al-Astal 2015	.	.	.	.	.		
The study of Iman Al-sakli, 2021		.		.	.	.	.

Thus, the project problem can be identified as:

The lack of comprehensive and clear knowledge regarding the components of designing environmentally friendly green corridors at the local level in the city of Diwaniya.

Thus, the project's objective is defined as follows:

Providing the most comprehensive knowledge for designing environmentally friendly green corridors that can be effectively adopted by designers in general and specifically serving the reality of the local experience in the city of Diwaniya.

Achieving this goal required adopting a descriptive approach in analyzing previous studies and practical experiments according to the following steps:

● Adopting a set of indicators for designing environmentally friendly green corridors, which were reached based on the knowledge and studies previously presented.

● Implementing the indicators for designing environmentally friendly green corridors on a selected model in the city of Diwaniya.

● Reaching a set of conclusions and recommendations regarding the redesign of a selected street in the city of Diwaniya, and the possibility of adopting them in future local projects.

Designing Eco-Friendly Green Transport Corridors

The First Indicator: The Art of Integrated Design for Green Spaces

The design of integrated and environmentally friendly green corridors highlights the importance of understanding the relationships between users, site conditions, transportation systems, and the urban context to develop designs that consider the context. It testifies to the complexities that affirm it cannot be effectively achieved through templates or standardized metrics alone, but rather the need for

comprehensive solutions that take into account broader transportation networks, the community, and civil systems, integrating movement design with place design, considering factors such as topography, hydrology, the environment, land use, and transportation networks. This approach aims to achieve all functional objectives in street planning through a careful study of energy and materials, and by using strategies such as longevity, energy efficiency, multifunctionality, the use of recycled materials, and the recyclability of products. Emphasizing the combination of different elements in a physically constrained space to create integrated and sustainable urban areas, as illustrated in Diagram (Urban Street and Road Design Guide, n.d.).

(Diagram 4) The First Indicator: The Art of Integrated Street Design

source: Researchers

The importance of designing green corridors lies in considering people, alongside the street network as a fundamental framework for safe and livable communities. It emphasizes that everyone is a pedestrian at some point and that streets are public spaces that should provide a comfortable, safe, interesting, and attractive experience for all users, including the most vulnerable groups. With an emphasis on the necessity of meticulous attention to detail in providing these conditions within the street that prioritizes pedestrian safety and comfort.

Designing green corridors requires flexibility in accommodating transportation methods, and designers need to innovate, test, and document the design of these corridors. They should use evidence-based methods, observation, and measurement to identify corridors that meet all functional objectives. This approach encourages moving away from traditional designs and offering better designs for the corridors. Achieving this requires:

3.1.1 various transportation modals

This concept indicates that main corridors should have sufficient space to accommodate different forms of public transportation, as shown in (Figure 4), such as buses or light rail, in addition to vehicle access. It also emphasizes the importance of providing space for pedestrians and cyclists. The text highlights that if one corridor cannot fully support all modes of transport, nearby corridors can complement the network functions for certain modes. This integrated approach ensures that different modes of transport work together in interconnected networks, providing efficient access to numerous destinations. The focus is on creating an inclusive and accessible urban environment for all users.

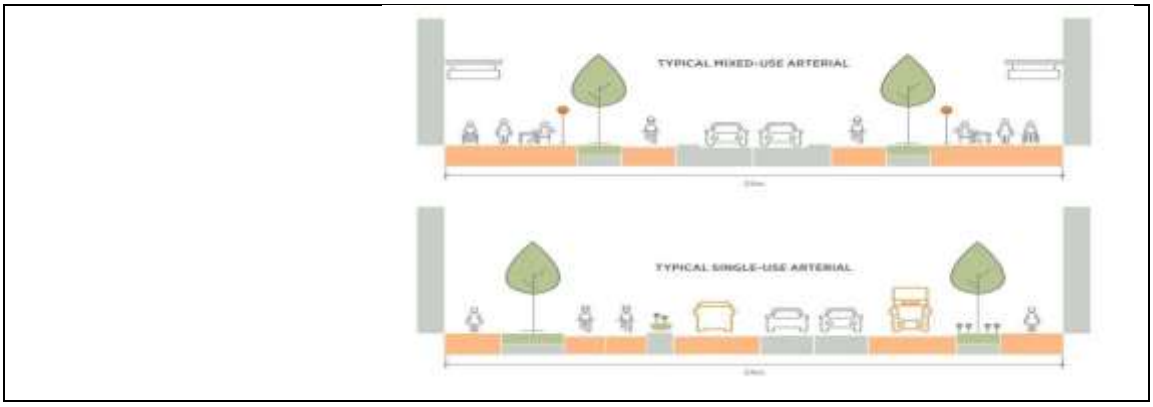


Figure 4: Illustrates the Concept of Multimedia

Reference : Urban Street and Road Design Guide, P.27, https://at.govt.nz/, p.56

Designing A Movement System Across Locations

Street design emphasizes the importance of considering the human system, rather than just focusing on places and vehicle restrictions. It emphasizes a comprehensive approach that takes into account how people use the space, their travel patterns, and the duration of their journeys. By imposing restrictions on vehicle movements based on people's behaviors and designing spaces that meet human needs. This approach aims to create more effective and human-centered urban spaces, which includes a set of considerations as outlined in (Table 2).

Table 2: Considerations of the Movement System

	user	Vehicles	Spaces
Actual considerations	Users differ according to their actions and depend on what they want to do and where they want to go. The design must take into account the full range of people and the behavior that can be expected.	Vehicles are chosen by people – train – bus, car, bicycle, scooter, wheelchair. Shoes are classified as vehicles for people who walk, as slips, trips, and surface water are important design considerations.	Places provide opportunities and constraints on what people might do and how they operate the car they chose.
Environmental considerations	The environment includes all other people, their vehicles, and the place they share. The way they perceive and understand the environment affects how they decide to act.		
Organizational considerations	The user has enough time to observe, make a decision, and then take the appropriate action.	The vehicles respond based on this action.	The place helps guide this action.

Users need to easily recognize every type of street and understand the appropriate behavior for each. This includes seeing the place they want to go to. Each type of street must be distinctive and consistent with streets of the same type, so that people choose similar, safe, and appropriate behaviors. (Self-explaining streets) is one way to describe that.

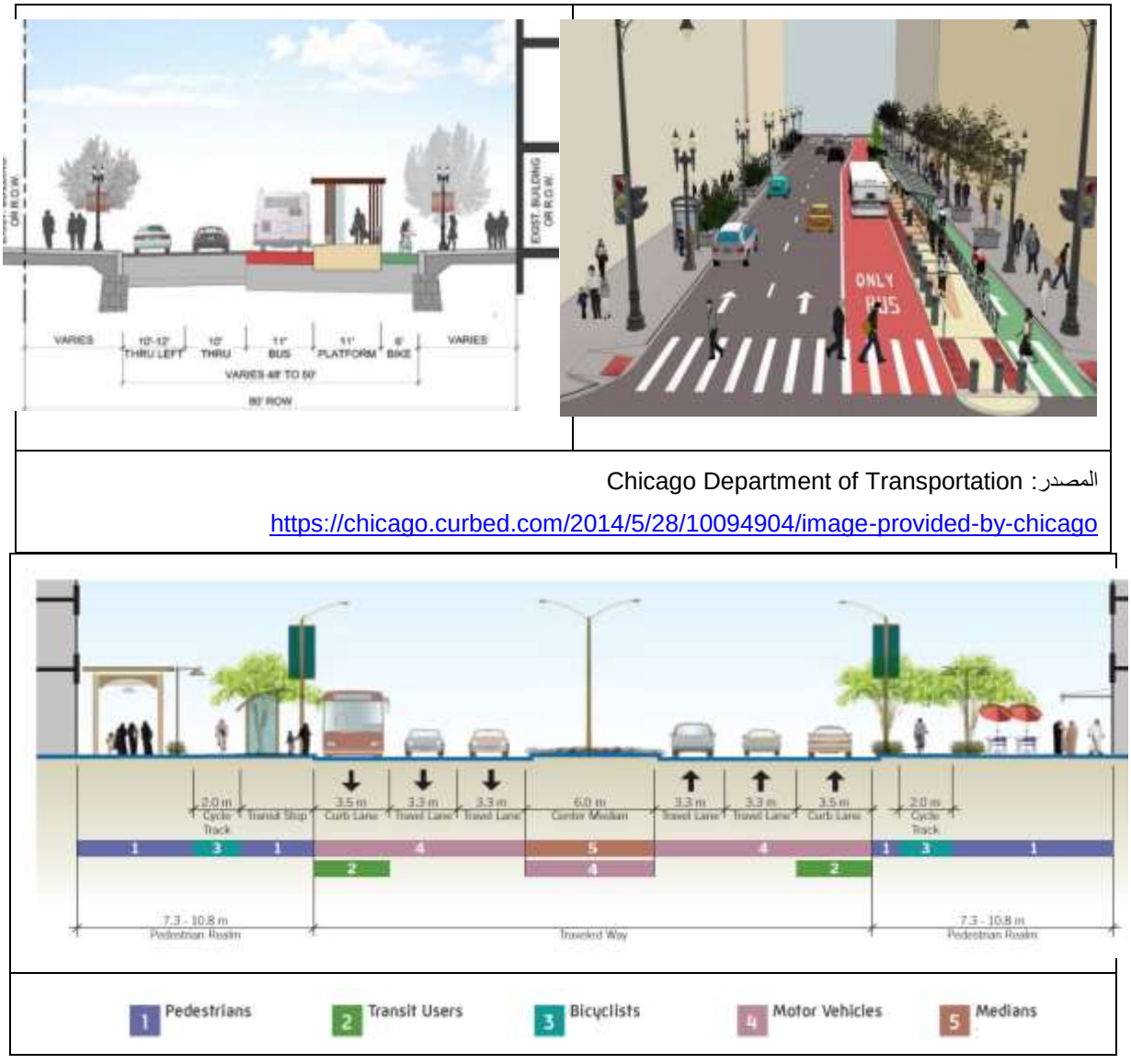
Users should also be given enough time to look around, determine where they should go, understand what others might do, decide what they should do, and then act. Where speed affects the distance people move while observing, and decision-making and action are key factors in designing a space for safe movement.

Elements Of Green Corridor Design

Street quality can be shaped through several elements, such as lines, textures, patterns, fences, separators, and some other street furniture. Street corridors can achieve visual unity through the shape, texture, color, and elements of street furniture to support the improvement of environmental quality. The spatial and visual quality of the street is important for shaping the street's quality, so it is essential to arrange, improve, and plan the existing elements in the street well and comprehensively. Each element of the integrated street design is responsible for creating a unique experience for anyone passing through it. These elements can be summarized as follows:

- **Vehicle Lanes**

Vehicle lanes are a very important part of every street. They should be designed taking into account the types of vehicles and traffic in a specific area. The size of each lane should be carefully determined according to its utility or function. Bike lanes and sidewalks will also add greater value to the street, as shown in the figure. (Urban Street and Road Design Guide, n.d.).



المصدر: Chicago Department of Transportation

https://chicago.curbed.com/2014/5/28/10094904/image-provided-by-chicago

Figure 5: Vehicle Lanes

Reference: Abu dhabi urban planning council- Abu Dhabi Urban Street Design Manual

- **Sidewalks and Pavements**

Street engineering must always consider pedestrians, their movement, and safety, as it enhances walking and connection to the place. A well-designed sidewalk can also enhance the space socially and economically.

Various activities such as sitting, accessing street vendors, reading newspapers, and so on can add life to the sidewalks. Each activity can also have designated areas exclusively, leaving clear space for movement.

The type of sidewalks adds a different dimension to the street. Walking on a regular gray sidewalk is a completely different experience from walking on a colored or textured sidewalk, as shown in the figure. (Nasima & Zahra, 2014).

(Figure 6) Sidewalks and Pavements

- المصدر: https://commercial.unilock.com/projects/streetscapes/

- **Curb Extensions**

Sidewalk extensions provide space for street furniture and also create room for designing bus stops. These extensions narrow the crossings for pedestrians while also helping to calm traffic. And they can also be used to provide parking spaces on the roadside, as shown in the figure. (GreenWorks PC, n.d.).

(Figure 7): Curb Extension

Reference: https://greenworkspc.com/ourwork/kenton-denver-avenue

- **Speed Control Elements, Emergency Equipment and Surveillance**

Speed control measures ensure safe and pedestrian-friendly streets. Elements such as speed bumps, speed tables, or speed cushions can be used to calm traffic and control speeds. Although these need to be placed carefully through a thorough analysis of their necessity. Excessive use of these things may frustrate drivers and can also lead to violence in extreme situations.

The street must be cleared quickly during an emergency, and safety alarms, firefighting equipment, and emergency call booths should be provided at intervals. It can be extremely difficult to continuously monitor the street, but electronic security measures such as (CCTV) can help create safe streets, as shown in the figure.(Journalist's Resource, n.d.).



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Figure 8: Speed Control Elements, Emergency Equipment and Surveillance

- **Stormwater Management**

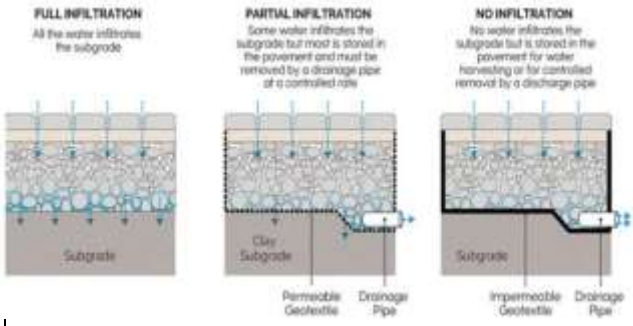
A good street should be designed taking into account the climate of the specific area. There must be effective systems for managing rainwater for the street design to be successful. And it is essential to drain a large amount of water in a very short period. Some of the methods used to achieve this are bioswales, flow-through planters, permeable pavers, pervious strips, and permeable pavers, as shown in the figure. (Dinić-Branković et al., n.d.).

flow-through planters permeable) , Reference: (pavers

https://water.phila.gov/gsi/tools/stormwater-planter/

(bioswalls), Reference

M. DINIĆ-BRANKOVIĆ ET AL.: BIOSWALES AS ELEMENTS OF GREEN INFRASTRUCTURE – FOREIGN PRACTICE AND POSSIBILITIES OF USE IN THE DISTRICT OF THE CITY OF NIŠ, SERBIA



(permeable pavers), Reference:

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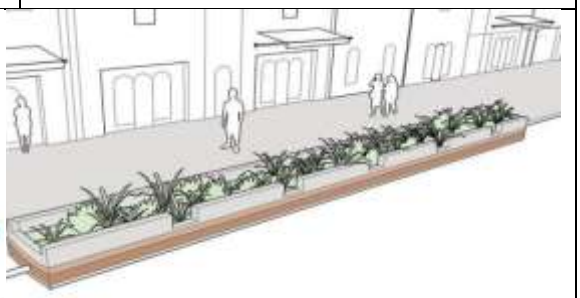

(pervious strips), Reference:

https://nacto.org/publication/urban-street-design-guide/street-design-elements/stormwater-management/pervious-strips/

Figure 9: Stormwater Management

- **Landscape Elements**

Landscaping can instantly improve the quality of any space. Represented by trees, flowers, and various plants, and although landscaping comes at a high cost and requires constant maintenance, it can add value to the place.

Trees contribute to creating a high-quality urban environment, benefiting all street users. As trees grow larger, the benefits they provide increase, which is why trees should be naturally integrated into street designs. Each new road should retain mature trees of value and size, plant new trees where appropriate, and provide green infrastructure.
The trees should be spaced regularly along the streets, as a continuous row of trees provides a regular rhythm to the street, as shown in the figure (Urban Street and Road Design Guide, n.d.). It also has a visual narrowing effect, which has been shown to reduce traffic speeds while calming driver behavior. And this provides continuous cover, offering shade and shelter.

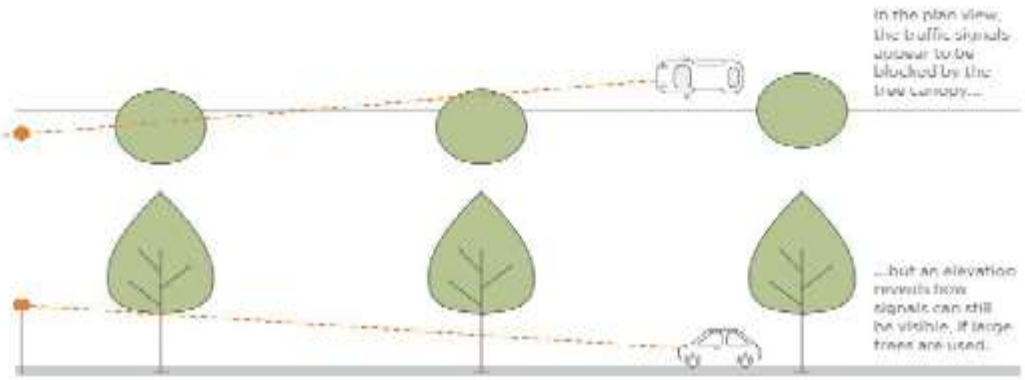

Figure 10: Trees in Street Design

Reference: Urban Street and Road Design Guide, P.56, https://at.govt.nz/

- **Street Furniture**

The street view is incomplete without the basic street furniture, as benches, lamp posts, phone booths, and signs form an important part of the street. However, this furniture is prone to theft or damage, and caution must be exercised during design and installation to make it vandal-proof. Street furniture creates places for rest, sitting, dining, and social gatherings with others. Such settings may be of great importance to the elderly, those with limited mobility, and adults with young children; but in addition to their functional aspect, furniture elements can also have social significance, as they provide these locations with a comfortable and attractive atmosphere, bringing people together and giving the city an iconic identity. The atmospheric effects should be taken into consideration in furniture design, and it should be made from safe, environmentally friendly materials, preferably from recycled materials, as shown in the figure. (Eco Renewable Energy, n.d.).

	Reference:
https://landscapeandamenity.com/sections/urban-environment/articles/2019-11-05/the-ultimate-in-modular-street-furniture-design	https://www.ecorenewableenergy.com.au/articles/building-smart-cities-with-smart-street-furniture/

Figure 11: Street Furniture

Lighting Elements

Lighting elements in green corridors serve as both aesthetic and security factors. And adequate lighting for the pathways will provide a clear view of the environment, while insufficient lighting will lead to a feeling of insecurity and make the pathway appear gloomy.

The streetlights used on road sidewalks vary according to the type of street or path and land use. In most contexts, standard heights in residential, commercial, and historical settings range between 8-

10 meters. The taller poles, between 10 m and 12 m, are suitable for wider roads in commercial or industrial areas.

The distance between two light poles should be about 2.5-3 times the height of the pole. Shorter light poles should be installed at closer intervals. The density, travel speed, and type of light source along the corridor will also determine the ideal height and spacing.

The light cone has a diameter approximately equal to the height of the light above the ground, and thus the height will determine the maximum suggested distance between two light poles to avoid dark areas, as shown in the figure. (Global Designing Cities Initiative, n.d.).

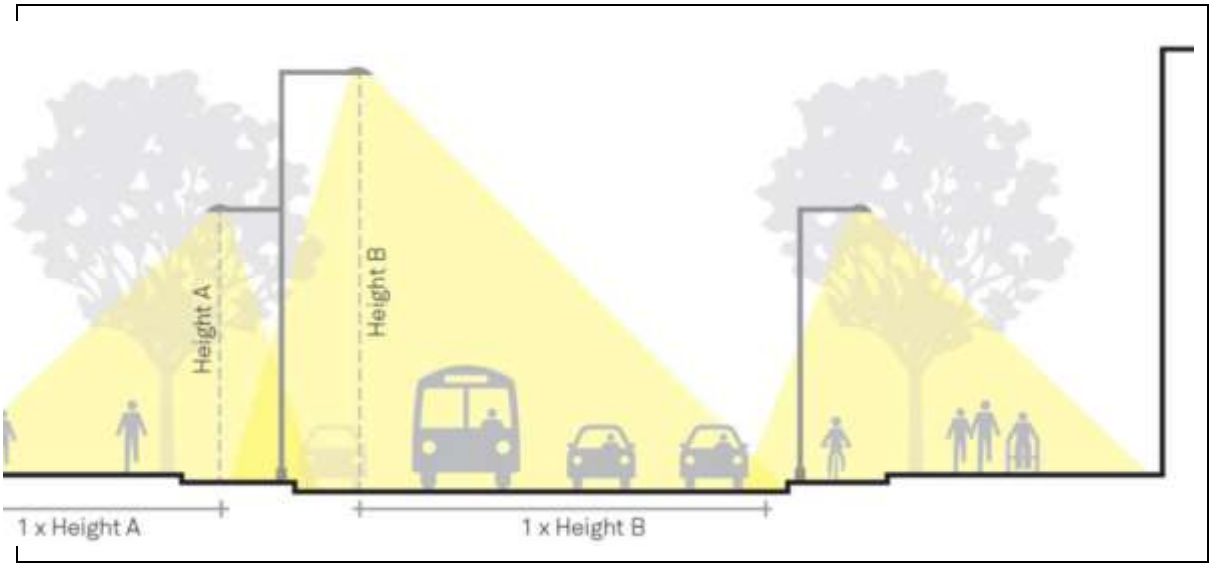

Figure 12: Lighting Elements

Reference: https://globaldesigningcities.org/publication/global-street-design-guide/utilities-and-infrastructure/lighting-and-technology/lighting-design-guidance/

The 2nd Indicator: The Art of Integrated Design

It is expected that renewable energy sources and eco-friendly materials will play an important role in the future of the transportation sector, as illustrated in the diagram. (Nasima & Zahra, 2014).

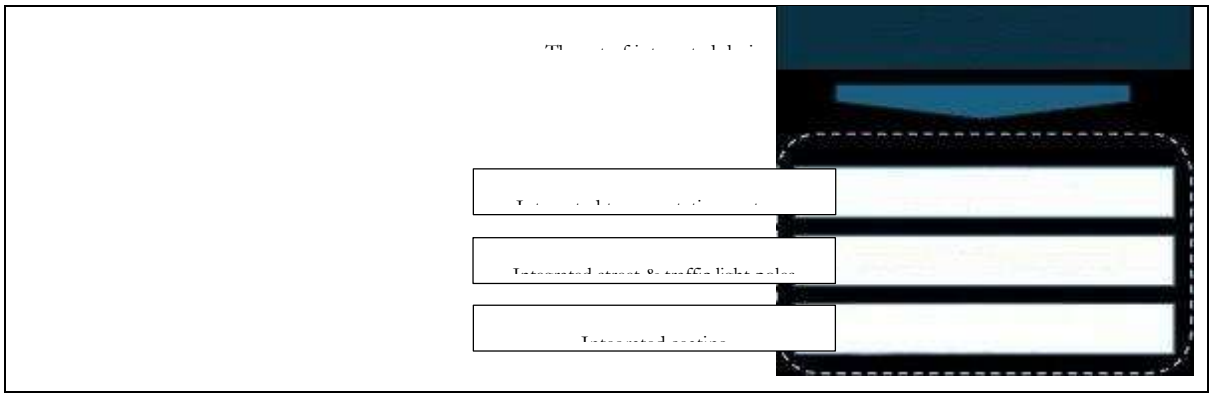

Diagram 6: Second Indicator: The Art of Integrated Design

Among the promising technologies currently is hydrogen fuel technology, which is used for energy storage and transport. It is usually used with solar energy, as well as with other renewable energy sources. Hydrogen is obtained through the electrolysis of water using renewable energy as a source of electrical energy, and then the hydrogen is stored. And electrical energy can be obtained from the hydrogen stock, as shown in the figure. (Nasima & Zahra, 2014).

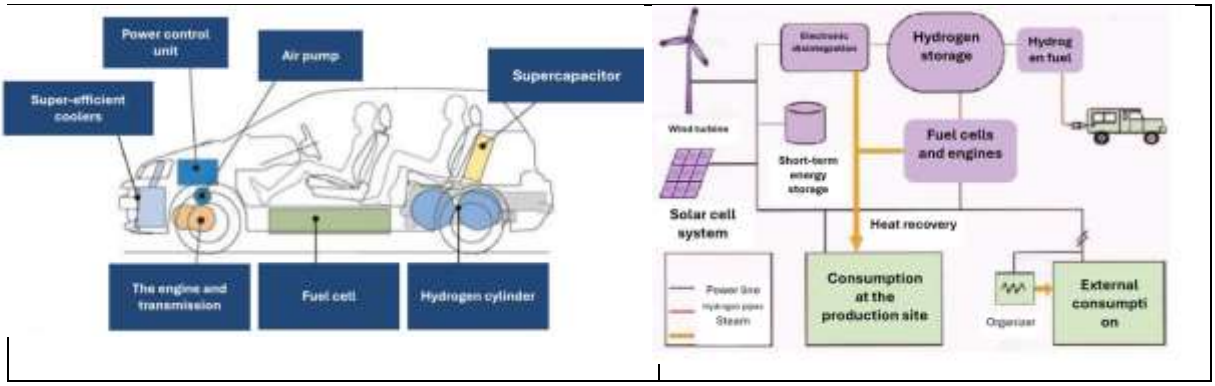

Figure 13: How To Obtain Hydrogen Fuel with an Illustrative Model of AaVehicle Equipped with Fuel Cells

Source: Nasima L. M., Nasima L. M., & Fatima Zahra M. (2014)

Renewable energy plays a significant role in the field of transportation concerning street furniture, where solar cells are integrated into streetlights, traffic signals, surveillance devices, as well as seating areas. This has a positive impact on encouraging energy conservation and reducing environmental impact, as shown in the figure. (Phoebus Light, n.d.).

https://phoebus-light.en.made-in-china.com/productimage/WdpaiYPrIftI-2f1j00lFAhRUtBANbI/China-Anti-Theft-Underground-Battery-80W-Solar-Street-Light-with-9-Meters-Light-Pole.html

Figure 14: The Use of Solar Cells in Streetlights, Traffic Signals and Branches

Reference: https://www.pinterest.com/pin/521362094345400402/

Recycled and eco-friendly materials are considered one of the most important trends towards sustainability. Many modern companies in different countries have developed plastic product waste to replace bitumen, and this material is made from 100% recycled waste and can contribute to reducing the amount of plastic waste. Additionally, this new material has a hypothetical lifespan ten times longer than that of regular asphalt and is 60% stronger than bitumen.It is also more resistant to cracks and potholes and less expensive than traditional paving materials.

A silicon-based eco-friendly asphalt technology has also been developed for paving paths, which possesses high efficiency and can be sprayed directly onto the surface of the path, allowing it to penetrate the asphalt structure layer. This technology restores the bright color of the asphalt, enhances its aesthetics, and improves its resistance to wear, effectively solving the problem of asphalt aging and extending the service life of the path.

The 3rd Indicator: Active Spaces

To make the corridor more vibrant and interesting, activities or spaces can be planned around it, such as cafes, shops, kiosks, or walkways, which can host various events like festivals and cultural activities, enhancing the social and economic aspects. Vehicles should be taken into consideration, and these activities should not interfere with pedestrian participation, as illustrated in the plan. (GreenWorks PC, n.d.).

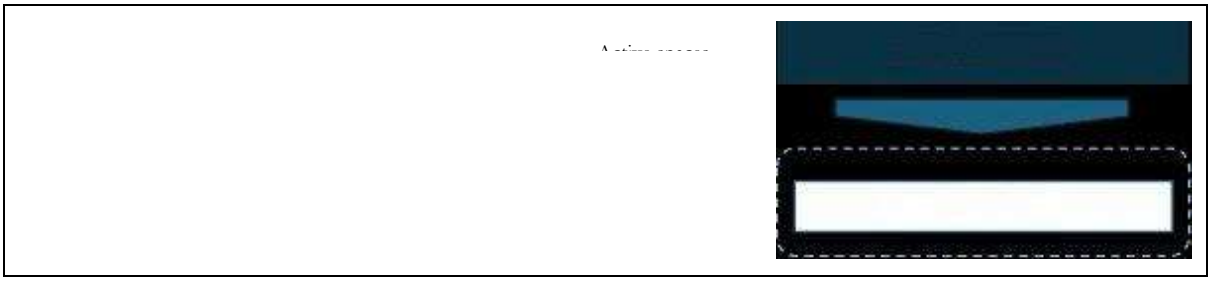

Diagram 7: The Third Indicator: Active Spaces, Source: (The Researchers)

Surrounding streets with buildings and trees helps define them as urban public spaces and promotes them as pedestrian-friendly areas. Designers should strive to enhance the sense of enclosure on the street, and this sense of enclosure can also have a calming effect on traffic, making the street appear narrower than it actually is, as shown in the figure. (AVN Archiurban, n.d.).

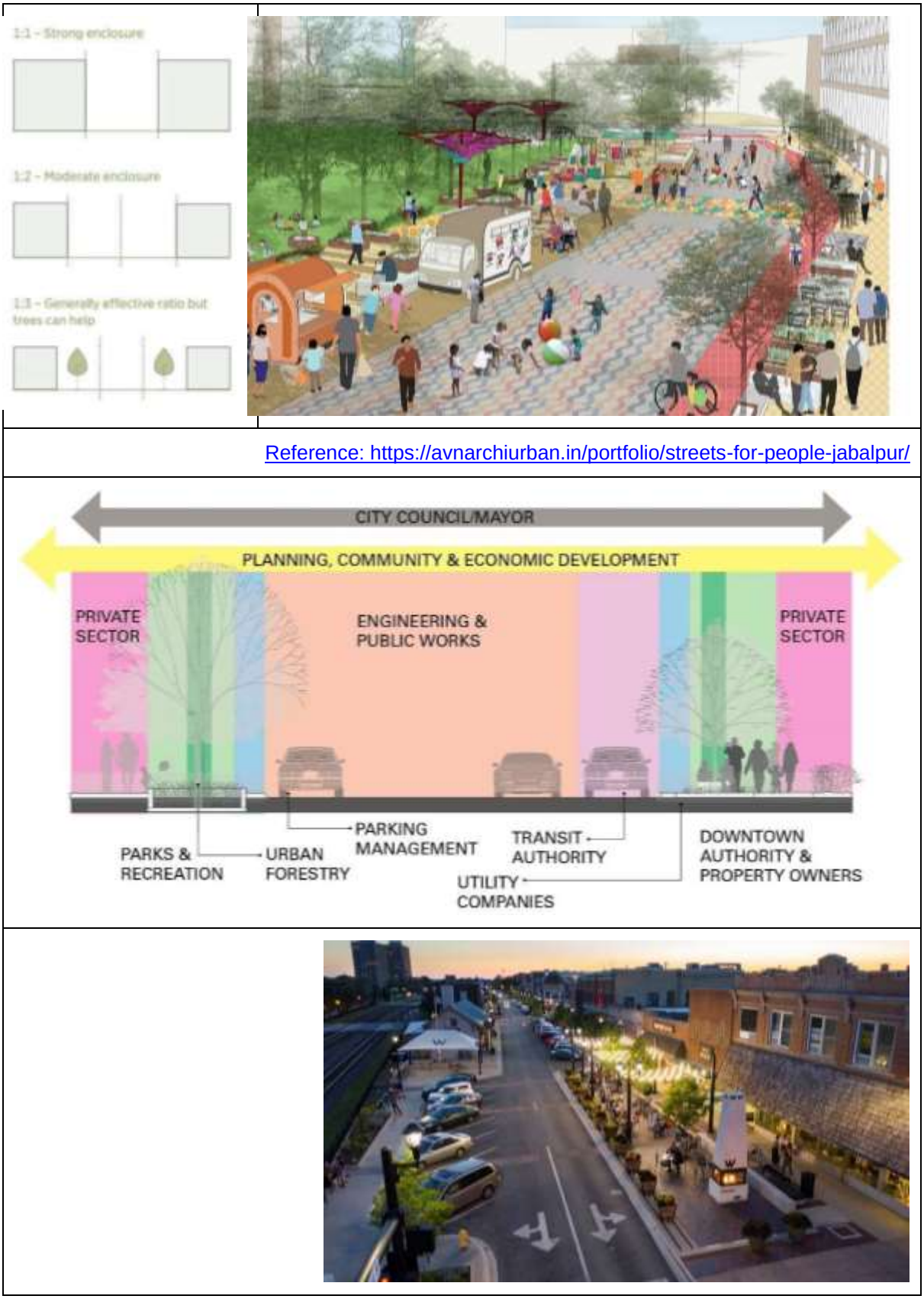

Figure 15: Active Space

Reference: https://land8.com/recreation-as-part-of-complete-streets-definition/

It is clear from the above that the benefit of moving towards designing green corridors can be summarized as follows:

- Improving safety
- Reducing human exposure to transport-related emissions
- Limiting injuries and fatalities associated with cars
- Limiting the contribution of transportation to air pollution
- Increase physical activity
- Managing chronic diseases
- Enhancing social, cultural, and economic activity.

Based on all the various aspects addressed in the studies and diverse practical experiments, the main indicators focused on the design of environmentally friendly green corridors were identified and represented in the table. (Al-sakli, I., 2021).

Table 3: Indicators for Designing Eco-Friendly Green Corridors

Key project indicators	Main paragraphs	Subsections	
The art of integrated design for green spaces	Multimedia	Working in interconnected networks	Single-use corridor
			Dual-use corridor
	Designing a movement system across locations	Practical considerations	User Vehicles The places
		Environmental considerations	
		Regulatory considerations	
	Elements of green corridor design	Vehicle lanes	Means of transportation
			Bicycle
			Pedestrians
	Sidewalk extensions	Design space for pedestrians	
		Design space for corridor elements	
		Design space for transportation vehicle parking	
	Speed controls, emergency equipment, and monitoring	Speed bumps	
		Alarm, safety, and fire-fighting devices	
		Speed bumps or lighting	
	Rainwater management	Biological walls	
		Flow farms	
		Previous tapes	
		Permeable pavement	
	Elements of landscapes	Trees	
		Plants and flowers	
	Corridor furniture	Seating arrangements	
		Streetlights	
		The kiosks	

		The signs
The art of integrated design	Integrated transport media	Hydrogen energy
	Integrated streetlights and traffic lights	Solar cells
	Integrated seating	
	Paving techniques	Recycled materials
		Adding reinforcing materials
Active spaces	Pedestrian activities	Pedestrian-friendly spaces
		The feeling of being embraced
		Enhancing the social, cultural, and economic aspects

Summary

In this section, a set of indicators for designing environmentally friendly green corridors has been developed, based on previous theoretical knowledge, which included three indicators as follows:

- The first indicator: The art of integrated design for green corridors.

- The second indicator: The art of integrated design.

- The third indicator: active spaces.

In the subsequent phase, a practical study will be conducted and these indicators will be applied in the redesign of a street within the selected study area to serve the project's objective.

Practical Study

Study Area

The study area is located in Al-Diwaniyah in Al-Qadisiyyah Governorate, which is one of the provinces in the Central Euphrates region. Which is encompassed by the alluvial plain of Mesopotamia, and the geographical location of the province is defined between the latitudes (31.17 and 32.24) North, and the longitudes (44.24 and 45.49) East. As for its administrative boundaries, it is bordered to the north by the provinces of Babil and Wasit, to the east by the provinces of Dhi Qar and Wasit, to the south by the province of Al-Muthanna, and to the west by the province of Najaf.

The University of Al-Qadisiyyah Street in the University District, extending between the Al-Jadriya Roundabout and the Al-Tahliya Road Roundabout, was chosen to implement a study on green, eco-friendly road corridors. It was selected because it is one of the most vital streets in the governorate and serves as its facade, being one of the main entrances to the governorate and the main road leading to the largest educational institution in the governorate (Al-Qadisiyyah University), in addition to its commercial and service-oriented character, as shown in the figure. (Google Maps, n.d.).

Figure 16: Study area (University Street - Diwaniya)

Reference: Google maps

Study Area Analysis

As a preliminary analysis of land uses in the study area, as shown in Figure (Researchers, n.d.), it indicates that the lands surrounding the study area have multiple uses, with a majority being residential and educational, in addition to the availability of commercial spaces. This qualifies the street to provide a comfortable, safe, interesting, and attractive experience for those who use the street on foot.

Figure 17: Land Uses in the Study Area (University Street - Diwaniyah)

Source: Researchers

Through the field survey of the study area, it became evident that the region lacks the most basic components of modern roads and is far from the concept of sustainable roads and environmentally friendly green corridors, as shown in the figure.(Researchers, n.d.). Where a number of problems were identified, the most prominent of which are as follows:

- The inefficiency of the rainwater drainage system.
- The poor condition of the paving.
- Traffic congestion and the lack of bus lanes.
- The absence of green spaces and the poor condition of the sidewalks.
- The lack of bicycle lanes and pedestrian paths.
- The irregular distribution of electrical wires.

● The exploitation of sidewalks by shop owners.

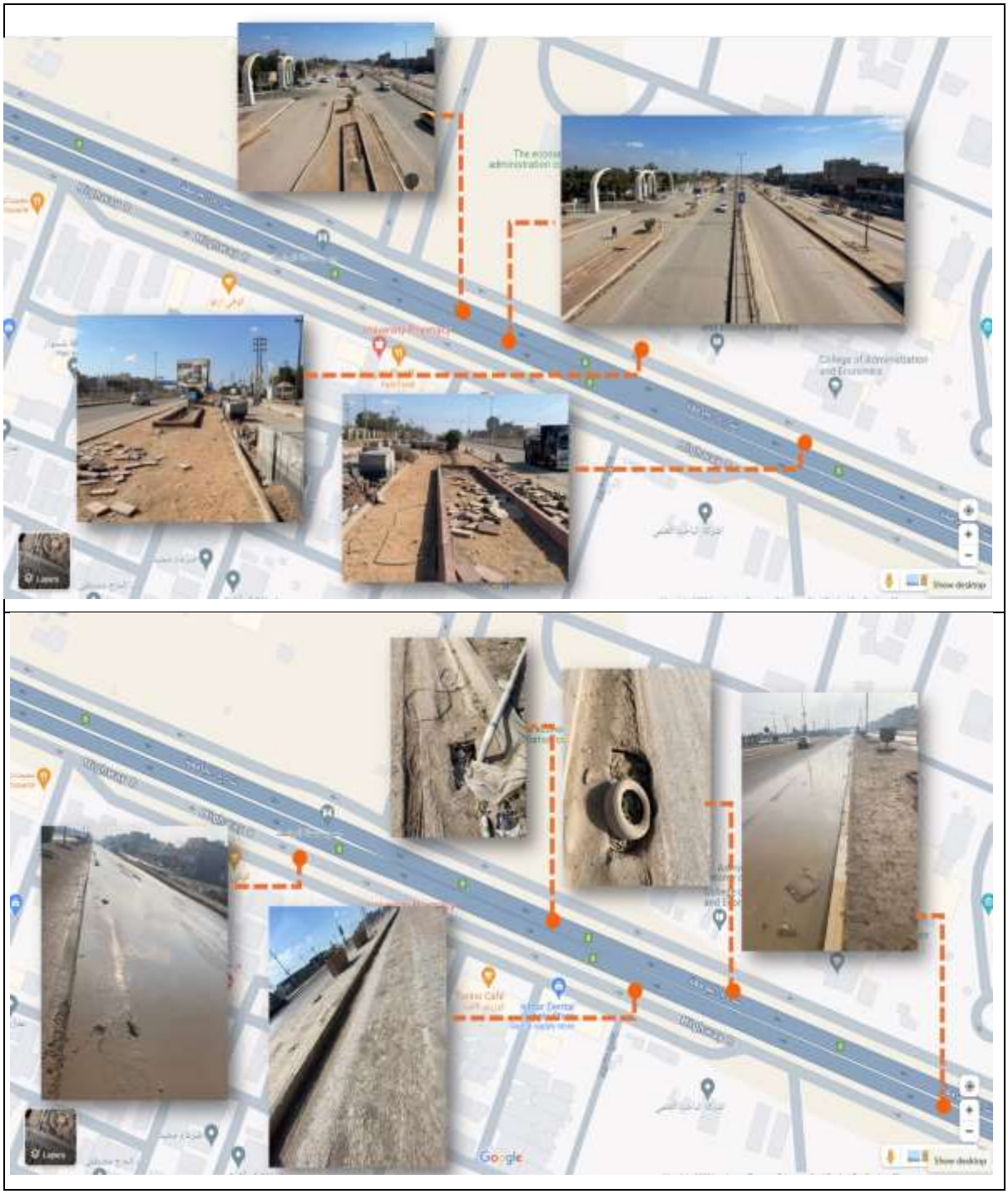

Figure 18: The Problems Identified in the Study Area (University Street – Diwaniya)

Source: Researchers

Identification and Redesign of the Selected Street

The street in the area located in front of the main entrance of Al-Qadisiyah University was selected, defined by the distance between the pedestrian bridge and the end of the third service road branch on the opposite side of the main university entrance, which is approximately (332.58m) long, as shown in the figure. (Researchers, n.d.)

Figure 19: The Specified Distance for the Redesign Area

Source: Google Maps

The street was redesigned using both the (AutoCAD) program and the program (3Ds Max & V-Ray).

The design indicators for environmentally friendly green corridors were relied upon, as shown in Table (Urban Street and Road Design Guide, n.d.), which were outlined in the previous chapter, as follows:

Table 5: Indicators for Designing Eco-Friendly Green Corridors

The first indicator: The art of integrated design for green spaces			
The street has been redesigned to be a corridor that operates with interconnected dual-use networks, which relies on a movement system through various modes of transport, including small and large vehicles, bicycles, and pedestrians.			
The street has been redesigned with elements of the green corridor consisting of lanes for vehicles, bicycles, and pedestrians.			
			
Bicycles	Curb extension	Sidewalks and pavement	Vehicles
Adding extensions to the road to create spaces for parking, pedestrians, and corridor elements.			
Adding speed control elements from speed bumps along with equipping the corridor with surveillance cameras.			
Managing rainwater by relying on previous strips, flow farms, and permeable paving.			

Designing natural landscape elements such as trees, flowers, and other plants to calm traffic, create a sense of enclosure, add aesthetic value to the corridor, and reduce environmental impact.

2nd Indicator: Art of integrated design

Equipping the corridor with road signs, kiosks, seating benches, and streetlights and traffic poles integrated with solar cells.

3rd indicator: active spaces

Preparing pedestrian-friendly spaces such as cafes, food trucks, and fountains, to create activities that foster a sense of inclusion and enhance social, cultural, and economic activity.

Results of the Practical Study Application

The design of eco-friendly green corridors in the selected area provides multiple benefits across various aspects of urban life and the environment, leading to the following results:

• Climate regulation: Trees and plants in green corridors can help mitigate the impact of urban heat islands and contribute to local cooling through transpiration.

• Improving air quality: The vegetation in green corridors can filter pollutants and particles, leading to cleaner air.

• Stormwater management: Green corridors can include natural drainage systems that reduce the impact of heavy rains and storms, alleviating flooding.

• Enhancing aesthetic value: Green corridors improve the visual appearance of urban areas, which can enhance residents' enjoyment and increase property values.

• Entertainment and wellness: They provide spaces for physical activity and relaxation, which can improve mental and physical health.

• Social cohesion: They serve as shared spaces that facilitate social interaction and community engagement.

• Sustainable transportation methods: as they include bike and walking paths, encouraging eco-friendly travel methods.

• Education and awareness: They can be used as living laboratories and educational resources to teach communities about the environment and sustainability.

• Economic benefits: By enhancing the area's attractiveness, it can stimulate local economies and tourism.
• Noise reduction: Vegetation can serve as a barrier against noise pollution in urban areas, creating quieter urban spaces.

Conclusions and Recommendations

Green corridors carry people and goods; the productivity of people's movement should be ensured. With the necessity of considering the length of the various journeys that any green corridor aims to undertake from start to finish. Conditions that support these outcomes should be enabled to ensure proper performance. The movement of land uses for shipping and services should be balanced with the pathways for people in the green corridors.

• Greenways can change; the designs of greenways must reflect these new conditions and priorities. Greenways can change through major interventions and capital improvement projects, and they can also change systematically through road renewals and ongoing maintenance. Greenway designs can also be implemented strategically through quick and low-cost interventions that can serve as temporary stages for long-term visions.

• Multimodal green corridors: The design of green corridors should support safe, comfortable, and attractive multimodal transportation for all users, including the elderly, children, and users with mobility impairments. Each mode should be integrated as appropriate across the transportation network. Any specific corridor may have a different mix of modes to achieve the goals of this network. Green corridors affect the quality of life, as they influence the ability to move, connect with broader transportation networks, and access the opportunities provided by the city. Where green corridors also shape the local environment and neighborhoods, enabling the expansion of activities and social interaction.

• The best green corridors are excellent for business, serving as a key platform for the economy, as improving access to a more welcoming green corridor environment attracts more people and more activity, thereby enhancing the communities, businesses, and society they serve.
• Green corridors are public spaces, where the design of green corridors should encourage recreation, social interaction, and commercial activity. The designs should increase the reserve space of the roads that will be used for social, economic, and environmental purposes. To create an attractive and comfortable pedestrian-sized environment with a range of amenities, including trees and other plants.

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