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The Role of the Sustainability of Land Transport Passenger Stations in Sustainable Development

Omaima Fayed Abdelmageed¹, Amir Saleh Ahmed², Mohamed Said Meselhy³

Researcher in the Department of Architectural Engineering, Faculty of Engineering, Fayoum University, Egypt¹

Assistant Professor, Department of Architectural Engineering, Faculty of Engineering, Fayoum University, Egypt²

Assistant Professor, Department of Architectural Engineering, Faculty of Engineering, Fayoum University, Egypt³

ABSTRACT Passenger transport stations are the central nucleus for achieving development in society, through their ability to link different modes of transportation in one place, and meet all the requirements for encouraging passengers to use public transport. Therefore, most countries in the world have witnessed an increasing interest in passenger transport stations in general and their design requirements in particular. This is evident in contemporary sustainable transportation trends, which call for the application of sustainability aspects in the transportation system in general, and in passenger transport stations in particular. The aim of the research is to provide a clear and comprehensive theoretical framework for the design requirements of sustainable land passenger transport stations, And the extent to which aspects of sustainability can be applied in passenger transport stations.

KEYWORDS: sustainable development, sustainable transportation, Sustainable stations for land transport passengers.

I. INTRODUCTION

The world has seen in recent decades a significant increase in construction projects, from new cities and urban communities to residential groups and others. This is in order to provide urban services and fill the accumulated deficit of housing units in particular. And with the increasing pressures of these projects on the environment, urbanization has not had a sustainable urban structure commensurate with the requirements and needs of citizens. Since the demand for mobility has become a necessity that is constantly increasing and affecting the economic, social and cultural aspects of citizens all over the world. Many countries of the world have sought to adopt a sustainable transportation system that includes patterns and mechanisms with a low impact on the environment, including non-mechanical modes of transport such as walking and cycling, including collective and environmentally friendly mechanical modes of transport, green vehicles, adherence to its principles and the application of these principles to the transport system in general and in Passenger stations in particular.[1]

Local land passenger transport stations suffer from many problems related to providing easy access and achieving a safe transport environment that encourages passengers to use public transport, and the absence of design requirements for establishing passenger transport stations that take into account the social and economic needs of passengers and operators, which negatively affected the efficiency of public transport. The need to develop these stations has also emerged due to the diversity and complexity of the current transport needs, which led to the emergence of the importance of research in finding a comprehensive vision of how to establish sustainable passenger transport stations and determine their design requirements.

II. RELATED WORK

1-the general knowledge framework for the concept of sustainable stations for land transport passengers

1-1 sustainable development

The concept of sustainable development has been formulated as development that meets the needs of the present without affecting the satisfactory fulfillment of needs by future generations. Here, the focus was on preserving natural resources and achieving the richness and quality of life for human societies, present and in the future. [2]

And developed the concept of sustainability and it has been described as a strategy that combines the three dimensions of social, economic and environmental (The social dimension is guaranteeing the human right to live in a clean environment through which he practices all activities without reducing the opportunities for future generations. The economic dimension stems from the environment and is an integrated economic entity as a base for development and Any pollution to it and depletion of its resources causes a weakening of its future development opportunities. The environmental dimension It is concerned with the management of natural resources, which is the backbone of sustainable development) with the application of this at all levels of national and local administration.

Long-term solutions were put in place to integrate environmental goals and development goals, hence the term "sustainable development" was used and defined as: this type of development that provides a real improvement in the quality of human life, and at the same time preserves the vitality and diversity of the earth, and the goal is to achieve development provided it is sustainable.

The United Nations Conference for the Achievement of Sustainable Development for the year 2030 came, and declared the sustainable development goals 17 goals as integrated and indivisible, and the conference emphasized moving towards sustainable development to achieve global development and Some of the sustainable development goals are directly related to sustainable transportation. [3]

1-2 sustainable transportation

Sustainable transportation is an aspect of urban sustainability, which deals with meeting the current needs of road and transport users without compromising the needs of future generations. Transport is said to be “sustainable transportation” on the amount of its impact on the environment and society, and it can also be a way to help achieve sustainability in other aspects. of humanitarian activities. The concept of sustainable transport is defined as: "the ability to meet the needs of society to move freely and smoothly, and to provide easy access, interaction and mutual relations between individuals, and its price is appropriate, and it works efficiently, and provides freedom in choosing the means of transport, and reduces emissions and waste so that they do not exceed The absorptive capacity of the environment, reduces the consumption of non-renewable resources, reuses and recycles its components, and reduces the use and exploitation of land and noise pollution. [4]

Sustainable transport aims to achieve some factors, including the use of non-motorized means of transport such as walking and cycling, the use of public transport instead of a private car, thus saving huge economic costs (saving time, consuming less energy and less pollution), and the use of means of transport with future technologies that It includes the use of fuel from renewable energy sources such as hydrogen produced from solar energy, intelligent transportation systems, automated highways, and smart railways, and significantly reducing the harmful environmental impacts on human health. [5]

Sustainable means of transportation can enhance economic growth, increase ease of movement, take into account the environment, improve social justice, health, and the ability to connect cities. Transport stations play an important role in achieving the goals of sustainable transportation, as they are considered a meeting point for different means of transportation and provide public transport services and mobility. Efficient and sustainable inside and outside cities, transport stations help promote the use of public transportation and clean and sustainable means of transportation, improve transportation infrastructure, reduce air pollution and improve the quality of life. and Transportation stations can play a critical role in achieving the global goals of sustainable development. [6]



Figure.1 sustainable transportation goals Source: SLOCAT

1-3 Sustainable land transportation passenger terminals

Sustainable stations are defined as facilitating multi-modal transport, and their first role is the efficiency of communication between different types of transport (such as public and private), represented in time and place with coordination of schedules and emphasis on clarity of directions and lighting and the combination of internal and external space, and is defined as “the building or space.” Which provides the appropriate conditions to achieve continuity and communication in performance and operation. [7]

We can develop a general concept for sustainable passenger transport stations, which are defined as "stations in which environmental, social and economic aspects of sustainability are integrated, and which apply the principles of sustainable transport by defining the design requirements for providing a safe and equal transport environment for all users."



In general, sustainable transport stations can be explained as stations that have the following:

(A) - Social sustainability requirements

The station must have good transport that fulfills the requirements of the user, creates social interaction between users in the leisure and service spaces of the station, provides easy access, and secures security and safety requirements.

(B) Economic sustainability requirements

Economic sustainability is achieved by providing investment opportunities, renting shops, creating commercial activities and economic exchange within the station, in addition to providing jobs and job opportunities within the station and eliminating unemployment.

(C) environmental sustainability requirements

Represented by taking into account the environmental aspect in the design of the station, and taking into account the efficiency in energy use, to reduce the operational cost. [8]

Land transport passenger stations are the central nucleus through which sustainable transport can be achieved through the ability to link multiple types of transport in one place, and to fulfill all the requirements for encouraging passengers to use public transport, and this has appeared within the contemporary trends of transport called sustainable transport. Which called for the application of aspects of sustainability in the transport system in general and in passenger transport stations in particular, and to create a state of interaction between the movement of users and the spaces of the station that must be attractive and cohesive. [9]

1-4 Requirements for the sustainable design of road transport stations

The most important requirements, major and minor, can be drawn from the sustainable design of land transport passenger terminals.

Table 1. sustainable design requirements Source: Author

sustainable design requirements	Major requirements	Minor requirements
Urban requirements	Efficient communication and ease of access	Providing the necessary services to connect the various modes of transport to the station, such as waiting areas. Proximity to amenities and main streets Separation between different modes of transport in the horizontal or vertical plane
	Safety for circulating traffic and pedestrians	Proximity to major destinations Providing signs and guiding signs Provide pedestrian paths that reach the means, taking into account that they are direct and avoid sharp corners Place pedestrian bridges near the center of the platforms not far from the entrance to the ticket offices Placing lighting poles to provide adequate lighting
Architectural requirements	Functional requirements	Functional sequence of spaces, communication and interdependence (physical - visual)
		Organizing spaces (isolating public and private spaces - linking internal and external spaces)
		Integrated approach (combining functional and aesthetic efficiency)
		Providing waiting areas, bathrooms, restaurants and shops
		Provision of information and ticket offices to be located near the entrances
		Providing clarity and attention to the needs of people with special needs
		The structure of the station expresses its function from a formal and structural point of view.
		Achieve aesthetic form, functional efficiency and respect for cultural heritage.
		Providing vertical means of transportation such as elevators, stairs and ramps.
		Clarify the entrances and locate the services
	Observing the absence of obstacles in the meeting areas	
Mobility requirements		Reducing the difference in levels as much as possible for the comfort of wheelchair users, and providing ramps and elevators
		Provide requirements for people with special needs
		Provide easy access and movement separation
		Avoid intersections and reduce walking distance
		Reducing the change in the direction of movement

		Centralized assembly of vertical transmissions
		Clarity of movement axes
Economic requirements	Investment requirements	Reduce information gathering costs
		Investing in renewable energy sources to reduce operating costs
		Providing investment and rental spaces
Social requirements	Security and safety requirements	Provide adequate lighting in spaces
		Controlling entrances and providing surveillance cameras
		Providing escape corridors and exits, and using warning signs
	Comfort requirements	Providing a safe environment for users and protection from weather conditions
		Availability and integration of information
		Providing service spaces
Sustainable environmental design requirements	Preserving the environment and reducing energy consumption	Use of advertising banners
		Benefit from natural lighting and natural ventilation
		Using solar energy for heating and cooling
		Use of local materials
		Exploitation of roofs to collect rain water
		Using glass facades to take advantage of natural lighting
		Use of wear-resistant and maintainable materials
		Caring for indoor gardens and green surfaces
		Optimal orientation of the building and exploitation of natural ventilation
		Provide good insulation and maintain the air-conditioned interior environment by automatically controlling the door openings and the outer cover

III.METHODOLOGY

The study is based on the analytical methodology for applying sustainable design thinking to land transport passenger stations.

IV.EXPERIMENTAL RESULTS

2- Analytical study of some international projects for passenger stations that apply the idea of sustainability

2-1 Transbay Bus and Railway Station - San Francisco - USA

2-1-1 About the project: The bus and rail station were built to facilitate travel across the Bay Bridge and connect San Francisco to the north, east and south. It is located in downtown San Francisco and was opened in 1939 on First and Mission Streets and was redeveloped in 2019, It is a regional land passenger transport station on an area of 22,680 m². It is a central station whose aim is to connect the urban communities of the city, The station is considered one of the distinctive features of the architecture of transport stations in the twenty-first century, and it is an exceptional project based on sustainable design approaches. it connects residential areas of 145 acres, and its length is about one million square feet. The new Transbay Transit station accommodates more than 100,000 passengers every day, and the project will reduce emissions by 28,200 tons annually. The station aims to reduce greenhouse emissions and energy consumption. sustainable.



Figure.2 Transbay Bus station after renovation

Source: <https://lens.google.com>

2-1-2 Architectural description of the station: The station consists of six floors and is divided into two parts: an underground part consisting of two floors, the first for the train track and the second for passenger traffic. An above-ground part consists of four floors: The ground floor contains a large lobby and is characterized by the presence of a heavenly courtyard that provides natural lighting for all floors of the station. It also contains the entrance, information offices, ticket sales areas, main stairs and elevator, The first floor contains commercial shops, and the second floor for bus services, whose location is directly below the roof floor. Buses reach it through special ramps and are integrated with the road network and the roof floor or what is called (Park City) covered with green spaces with an area of (21850 m²) and a length



Figure.3 Vertical section at the station

Source: <https://modulo.net/com>

of (427 meters), and the park includes many recreational activities, and it contains an open theater, quiet seating areas for reading and relaxation, children’s play areas, restaurants, cafes, and an amphitheater that can accommodate 1,000 people.

2-1-3 The urban side: Transforming the area surrounding the new station center into a vibrant new mixed-use neighborhood featuring high-density housing, commercial spaces, public gardens, plazas, and expanded sidewalks with trees it has improved accessibility and connectivity with public transportation.

2-1-4 The economic and social side: The terminal provided more than 125,000 construction jobs and 27,000 permanent jobs, generating economic revenues and providing the city and region's workforce with thousands of new jobs, and the infrastructure to support them. Almost 50% of these new jobs were filled by passengers, accommodating more than 48,000 new passengers to Transportation to and from San Francisco each business day. the project worked to provide 100% affordable new homes, such as low-income housing.

2-1-5 The environmental side : the station has improved air quality by reducing 260,000 miles by car per day, and the use of public transportation has reduced dependence on private cars, reducing traffic congestion, and reducing harmful emissions by more than 2.5 tons of carbon monoxide and half a ton of nitrogen oxides per day, agreen building system was used in the design of the building, including passive solar shading, high-performance geothermal cooling, wind energy, and an upscale public space filled with light and energy.



Figure 4. Parks on the roof of the station
Source: <https://lens.google.com>

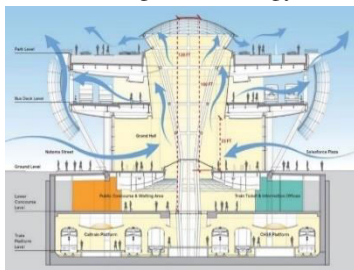


Figure 5. Natural ventilation in the station building



Figure 6. Conservation of energy at the station Source: Author

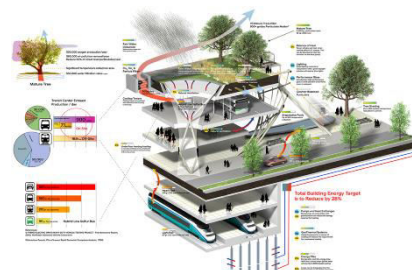


Figure 7. Station levels and environmental factors Source: Author

2-2 Nivy Bus Station - Bratislava- Slovakia

2-2-1 About the project: the station continued for 34 years without any reconstruction operations, which led to its deteriorating condition until it was completely closed and rehabilitated in 2017, It was opened in 2021. It worked to integrate suburban and long-distance bus transportation. It is a vital hub for urban transportation. And part of the smart city project on the right bank of the Danube. The goal was to build a building that is transparent from all sides, integrating multiple functions in one place, and creating a dynamic, high-quality public space both inside and outside the building, accessible from all sides. The latest digital technologies were used throughout the entire design and planning process with regard to environmental sustainability, and the building received the BREEAM certificate

2-2-2 Architectural description of the station: the building consists of five floors, three of them above ground and two underground. The ground and first floors include retail stores, the second floor is the market and the food court, and the third floor has a green roof that contains a garden, sports facility and gathering space. On the first underground floor there is an area of approximately 30,000 square meters from the station itself, which are bus platforms, and on the second-floor underground car park,

which can be entered from Mlinsky Neve Street, the only place where you can take a bus to all parts of Slovakia and abroad.



Figure 8. Nivy Bus Station
Source: Author



Figure 9. Multiple activities on the roof of the station Source: Author

2-2-3 The urban side: Nivy Station is located on Mlynske Nivy Street, in the Ružinov suburb of Bratislava, the capital of Slovakia. The location is in the middle of the business district about 15 minutes walk from Bratislava city centre. The station can be reached from almost all parts of the city, Exceptionally high quality bike infrastructure and quality sidewalks are built

2-2-4 The economic and social side: This lively public area attracted passengers and employees, which means high profits, and the station includes the largest market with an area of 5000 m², which increased its attractiveness and competitiveness. Nivy Station is an ideal location for the new social and business center of Bratislava. The green roof of Nivy Bus Station is a new platform for community life for the residents of the neighborhood. Area of 12,000 m².

2-2-5 The environmental side: it operates with an automatic control system for lighting, ventilation and heating, and this helps to save energy, Plants planted on top of buildings improve air quality in the city, improve thermal insulation, reduce energy consumption used for indoor heating by 25% and air conditioning by 75%, and act as an acoustic membrane for sound insulation in a building located in a noisy environment, and retain rainwater And using it in agriculture works to improve the urban environment. A solar energy system has been installed on the roof of the station, which generates the electric energy needed to operate part of the station.

2-3 Vilkaiviškis Bus Station - London _ England

2-3-1 About the project: the bus station is located in the center of the city of Vilkaiviškis in Lithuania. The station was built in 1905 AD and is considered one of the oldest stations in Lithuania. The station was designed in the style of classical architecture. The station was in a state of severe deterioration after decades of continuous use, and it was renovated in 2016 to preserve on the cultural and historical heritage of the city, and to improve the quality of services and facilities available to passengers and tourists, and it opened in 2020 AD. It was listed as the European Union award that integrates logistics requirements.

2-3-2 Architectural description of the station: the building consists of one floor and its area is 3300 square meters, and the old trees are integrated with the building, and the interior design is inseparable from the exterior despite the complexity of effective construction within the garden environment, and the ceiling is large concrete, and it is placed at a height of 7 meters above the ground and supported on steel columns and covers the station Stretching out over the park, the oversized windows dissolve the real separation between inside and outside and allow a connection with nature.

2-3-3 The urban side: the roads around the station provide bus, train and taxi services, making transportation in the area easy and convenient. The area has parking lots for cars and buses, which makes it convenient for travelers who want to use their own cars. The roads around the bus station in Vilkaiviškis are well-organized, easy to access, regular maintenance, good lighting, proper ventilation, clean and modern sanitary facilities, which makes it a good point of communication

2-3-4 The economic and social side:

It encourages the movement of people, promotes commercial activity, and works to provide local job opportunities and enhance the local economy

2-3-5 The environmental side:

The design relied on natural building materials and finishes, in addition to concrete, glass and painted aluminium, and the use of openings for the effect of light and shadow. The facades of the station are made of double glazed panels to insulate sound and allow vision and communication with the outside environment. Plants improve air quality and provide a more attractive and comfortable environment for travelers and residents.



Figure 10. Green spaces on the roof of the station Source: Author



Figure 11. Vilkaiviškis Bus Station Source: Author



Figure 12. Corrugated aluminium wall and steel columns Source: Author



Figure 13. Easy access to wide roads and good lighting around the station Source: Author



Figure 14. Green spaces inside the bus station Source: Author

2-5 the most important vocabulary extracted from the international projects of passenger stations that apply the thought of sustainability. See Table 2

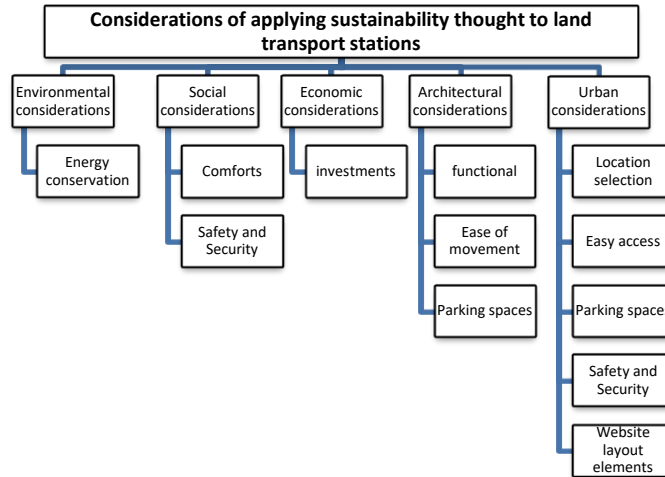
Table 2: vocabulary extracted from the international projects for sustainable land transport passenger terminals.

project name	Major requirements	Minor requirements
Transbay Bus and Railway Station San Francisco - USA	Attention to requirements that provide ease of movement and access	Providing clear entrances and providing elevators and escalators
		Allocate special ramps for buses to reach the departure platforms
		There is no conflict between the movement of passengers and vehicles
		Provide horizontal and vertical transportation axes such as corridors, stairs and elevators
	Relying on sustainable design principles	Using roof gardens and relying on natural ventilation
		Relying on natural lighting, taking advantage of solar energy
		Rainwater collection and recycling
		Recycle construction materials
	Increase social interaction and achieve economic efficiency	Respect the privacy of the site and the climatic conditions of the region
		Providing job opportunities, commercial areas, cafes and restaurants
Nivy Bus Station Bratislava- Slovakia	Providing movement and accessibility requirements	Achieving social interaction in the roof garden area
		Isolate pedestrian traffic from vehicles
		Provide pedestrian paths that reach the means, taking into account that they are direct and avoid sharp corners
		Functional sequence of spaces, communication and interdependence (physical - visual)
	Achieve economic efficiency	Clarify the entrances and locate the services
		Investing in renewable energy sources to reduce operating costs
		The presence of administrative offices and commercial companies that provide an opportunity for economic investment
	Achieving social interaction	Providing a safe environment for users and protection from weather conditions
		Providing clarity and attention to the needs of people with special needs
		Providing escape corridors and exits, and using warning signs
	Environmental design consideration	Provide good insulation and maintain the air-conditioned interior environment by automatically controlling the door openings and the outer cover
		use of durable, maintainable and replaceable aluminum panels
		Provide sound insulation and treat noise and vibration
Recycling and benefiting from previous waste and waste		
Vilkaviškis Bus Station - London _ England	Requirements that provide ease of movement and access	Coherence, spatial sequence and clarity
		Provide easy access and movement separation
		Functional sequence of spaces, communication and interdependence
	Economic investment	promotes commercial activity, and works to provide local job opportunities and enhance the local economy
	Achieving social interaction	Provide a safe environment, and provide services and information
		Exploitation of natural lighting and ventilation
	Achieve sustainable design	Use of local and recycled materials
		Preserving plants and reusing rainwater for irrigation

2-6 Conclusions drawn by analysing international projects for Land transportation passenger stations

Through what has been studied in the theoretical study and analytical models, urban, architectural and environmental considerations can be drawn during (the planning stage - the design stage - the implementation stage) that can be followed to apply the idea of sustainability to the land transport passenger stations.

Figure 15. Considerations of applying sustainability thought to land transport station



2-6-1 Urban Considerations

By choosing the location of the station and its relations with the neighboring buildings and placing the station in the center of the city or at its periphery, and it is clearly visible and studying the traffic density near the station and placing the station near the facilities and main streets, and ease of access through non-conflict with different means of transportation and achieving security, safety and comfort for users, Designing long, safe and completely isolated pedestrian paths from surface transport, planning a walking distance to the station not exceeding 400 meters, providing signs and signals, placing pedestrian bridges near the center of the platforms, placing lighting poles, placing umbrellas to protect from sunlight, providing green elements on the site, and providing Sufficient parking space.

2-6-2 Architectural considerations

Functional by organizing the internal spaces to facilitate the movement of passengers and achieving physical and visual interdependence between the station’s spaces and expressing the station’s structure for its function in terms of form and construction and providing service spaces and taking into account people with special needs and reducing the different levels for the comfort of wheelchair users and providing ramps and elevators and separating passenger movement from means of transportation and designing entrances The exits are near the road and clearly visible

2-6-3 Economic considerations

Achieving investments by providing shops and entertainment venues

2-6-4 Social considerations

Achieving comfort by providing waiting areas, seating areas, and various activities inside the station, achieving security and safety by reducing travel time and cost, achieving control over entrances, providing surveillance cameras, providing escape corridors and exits, using warning signs, and providing appropriate lighting in spaces.

2-6-5 Environmental considerations

Energy is rationalized by relying on natural lighting and reducing the use of mechanical ventilation, relying on natural ventilation through openings and doors, placing umbrellas to protect from sunlight and using solar breakers, relying on natural elements inside the station, using environmental roofs and vertical farming, and rationalizing water use such as disinfection Unclean water and reuse and waste recycling, and the use and recycling of local materials.

V. CONCLUSION

-The emergence of sustainable passenger transport stations is a response to the social, technological and environmental changes of the current era, and an achievement of the principle of sustainable transport as a result of the expansion of cities and the increase in the number of users, in addition to the technological development that the world has witnessed in the field of modern means of transport, and an urgent need has emerged to redefine the design requirements in passenger transport stations. land to meet the psychological, economic and environmental needs of users and operators.

-To achieve sustainable land passenger terminals, sustainable design requirements must be taken into account in the urban, architectural, economic, social and environmental aspects, through: The necessity of paying attention to sustainable environmental design through the use of local materials that are resistant to weather conditions and recyclable, collecting and reusing rainwater, reducing the operational cost of the station, conserving energy, increasing green spaces inside and around the station, cultivating the roofs of buildings, and respecting the privacy of the site. It is necessary to encourage users to increase the turnout of the station, and to improve the psyche of passengers by allocating recreational areas such as sitting and resting areas, and paying attention to providing play spaces for children.

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