

## **Innovative impact of sustainable transportation systems on sustainable urban design and planning for the city of Hilla**

**Elaf Saleam**

Master, Architecture, University of Babylon, Iraq, eng434.elaf.saleem@uobabylon.edu.iq

**Baydaa Abdul-Hussein Bedewy\***

PhD, Urban & Regional Planning, University of Babylon, Iraq,

\*eng226.badia.alhussien@uobabylon.edu.iq

**Zainab Riad Zainal**

Master, Urban & Regional Planning, University of Babylon, Iraq,

eng438.zainab.riadh@uobabylon.edu.iq

**Zaidoon N. M. Al-Mamouri**

PhD, Architecture, University of Babylon, Iraq, eng.zaidoon.najah@uobabylon.edu.iq

**Khalid Kadhem**

PhD, Architecture, University of Mustaqbal, Iraq, khalid.kadhem.hasan@uomus.edu.iq

**Ahmed Mohammed Al-Shamari**

Iraqi Ministry of Planning, Iraq, a07813795031d@gmail.com

### **Abstract**

Developing a planning vision for establishing a sustainable transport system in Al-Hilla City represents one of the most significant factors contributing to the vitality and dynamism of the urban framework. Such a system provides comfort and quality for urban residents and serves as an effective tool for intervention and influence within the city. Given its importance, sustainable transport has become a key instrument of sustainability worldwide, aiming primarily at urban regeneration, enhancing the city's modern image, preserving its environment, and acting as the backbone that connects its neighborhoods. Accordingly, this project falls within the framework of the urban development strategy and the Sustainable Transport Plan of Babil Governorate. Al-Hilla City is considered a central area and an important transportation node, characterized by continuous urban and population growth, which has negatively affected traffic movement and the development of the transport network. This situation prompted to study the impact of the tramway system on achieving a sustainable urban environment in Al-Hilla and to incorporate the tramway project within the governorate's strategic plans. The study examined the role of the tramway in urban regeneration based on

several field studies and analytical outputs, concluding that certain areas should be prioritized for tramway corridors while ensuring integration among them. The research findings indicate that the lack of comfortable public transport modes and the inadequate provision of stations and bus services have led to road networks being unable to accommodate private vehicles, particularly in university districts and along major arterial streets. Furthermore, insufficient accessibility within neighborhoods has resulted in difficulties in reaching many urban areas. Based on these findings, the tramway was proposed as an effective solution to improve the urban environment and revitalize the urban dynamism of Al-Hilla City. This was achieved through proposing three alternative tramway network routes and selecting the optimal option with the least conflicts while serving the largest proportion of the city's population.

**Keywords:** Tramway, Urban Regeneration, Urban Environment, Sustainable Transport, Sustainable Development, Urban Mobility, Urban Transport; Restructuring and Rehabilitation.

## Introduction

Human Movement Corridors Throughout city areas which became diverse decades ago. As this space has expanded, the population and human requirements have multiplied in diversity with ever growing means of individual and collective conveyance for passage from one point to another. Urban and regional development is one of the topical issues and major axis of transport policy due to the fact that most advanced Economy in any country is located within a city where there exist an efficient road and transport network. In the present time, transportation is advanced and more focused to urbanization. An integral part of the ecological balance are the sustainable public transport systems, that have become a requirement. Thus, economic developments themselves are related to the enhancement and facility of transit systems constructed in cities. The sustainable considerations of public transport are commonly a part of the urban development foundation, that contributes step by step during long term evolution, from infra-structure to architectural space and education supporting urban sustainability and economy with environment balance.

## General Research Problem

Al-Hilla City suffers from severe traffic congestion, resulting in a range of environmental, economic, and social problems. These challenges are primarily attributed to the lack of efficient and reliable public transportation systems capable of accommodating increasing urban mobility demands.

## Specific Research Problem

There is a pressing need to address traffic congestion in university districts and major arterial roads in Al-Hilla City, as these areas experience high traffic volumes that exacerbate environmental degradation, economic inefficiencies, and social impacts. This necessitates the exploration of sustainable transportation solutions capable of mitigating congestion while enhancing urban environmental quality and overall urban performance.

## Research Hypothesis

The study assumes that implementing a tramway system as a sustainable transportation mode, integrated within architectural design and urban planning frameworks, will contribute to alleviating traffic congestion and have a positive impact on achieving a sustainable urban environment in Al-Hilla City.

## Research Aims

- To analyze the current transportation conditions in Al-Hilla City and assess their impacts on architectural composition and urban form.
- To identify planning alternatives for selecting tramway network routes and to determine the optimal alternative.
- To examine the feasibility of implementing public transportation lines using a tramway system for the selected alternative.

## The Important of Research

- To propose planning solutions to address traffic congestion in Al-Hilla City.
- To contribute to the achievement of Sustainable Development Goal 11 (SDG 11), “Making cities and human settlements inclusive, safe, resilient, and

sustainable,” particularly by ensuring universal access to safe, affordable, accessible, and sustainable transportation systems.

### **Temporal and Spatial Boundaries of the Study**

- **Temporal Boundaries:** The study is limited to the period during which it was conducted, namely the year 2028.
- **Spatial Boundaries:** The spatial boundaries of the study are defined by the geographical limits of the urban center of Al-Hilla City, the capital of Babil Governorate.

### **Theoretical Framework**

#### **The Concept of Transportation:**

Transportation is considered one of the most significant economic and urban activities due to its essential role in economic, social, and cultural development. It represents a fundamental pillar for reconstruction and urban development. Transportation is defined as an integrated system for the movement of people and goods, connecting centers of production and consumption. It contributes to economic growth, market expansion, and the facilitation of interaction among residents. Transportation is viewed not merely as an end in itself but as an intermediary service and a means to achieve developmental objectives. It plays a pivotal role in urban progress and in ensuring the smooth flow of individuals and goods throughout the city.

Economist Thomassin defines transportation as primarily an intermediary service and a means to achieve a goal without being an objective in itself, where the intended objective is contextually expressed, whether concerning individuals or goods. (Bouskar, R.2002–2003, p.9). General Classification of Transportation: Transportation can be classified according to several criteria: operational domain, route, propulsion type, service type, service level, and the nature of the transportation mode—distinguishing between public and private transport. This classification is of particular interest to specialists in urban transportation planning, as both public and private transportation modes are considered highly influential elements in the overall transportation process. They play a critical role

in urban mobility, specifically in facilitating the movement of people and goods within city environments. (Bouskar, R.2002–2003).

### **Urban Stations:**

An urban station is a designated area for receiving passengers from different neighborhoods and districts. It serves as a convergence point for various transportation modes arriving from multiple areas, where urban lines intersect, facilitating passengers' transfers between destinations. The station typically includes designated spaces for vehicles, waiting areas, and rest zones for passengers. (Sahbi, K. 2020, p20).

### **Urban Renewal:**

Urban renewal is defined as a deep intervention in the existing urban fabric, which may involve the demolition of old buildings and their replacement with new structures that either serve the same function or are assigned a new function. The process of urban renewal requires the preparation of new designs that are compatible with the developmental changes occurring in the studied area. (Louati, A., & Kerkoud, N. 2016. p. 8)

### **Rehabilitation:**

Rehabilitation refers to processes aimed at improving the condition of a residential area, both internally and externally. This includes organizing roofs, enhancing building façades, paving streets, installing lighting, and improving the surrounding open spaces. (Sahbi, K.2020, p20).

### **Sustainable Development:**

The concept of sustainable development was formalized in 1987, defined as meeting the needs of the present without compromising the ability of future generations to meet their own needs, through the rational use of resources and the achievement of a balance among economic, social, and environmental dimensions. Cities play a pivotal role in achieving sustainable development goals, particularly Goal 11, which focuses on making cities inclusive, safe, resilient, and sustainable, by providing safe and sustainable transportation systems and promoting active

mobility, such as walking and cycling. In this context, a sustainable transportation plan for Babil Governorate was prepared up to 2030, in collaboration with the Local Area Development Program, the European Union, and the Ministry of Planning. The plan included several recommendations that resulted in six main objectives aimed at enhancing mobility through a contemporary planning approach, integrated within Iraq's national transportation framework, (Mobility and Transport, 2020–2021).

### **The Concept of Urban Development:**

The concept of urban development is closely linked to the processes of growth and transformation experienced by urban areas. The definition of these areas varies from one country to another, depending on multiple criteria such as population size or administrative standards. In Iraq, for example, municipalities serve as a key criterion for classifying cities. Urban development is defined as a comprehensive process that mobilizes resources and capabilities, relying on strategic and technical planning while promoting community participation. Its primary goal is to achieve social and economic change that contributes to improving the standard of living and enhancing the overall quality of urban life. (Local Area Development Program European Union (2018)

### **Objectives of Urban Development:**

- To improve and coordinate the economic and social living standards of residents.
- To create new environments that enable people to carry out their activities effectively.
- To expand industrial and production activities.
- To promote development across all sectors, including social, economic, and health domains. (Mahmoud, M. T. (2001) p. 70)
- To implement changes in the living environment to enhance urban quality of life.
- To empower individuals with skills and values that enable them to address challenges and actively contribute to societal change. (Mahmoud, M. T. (2001) p. 72)

### Urban Transportation:

Urban transportation refers to the set of infrastructures and means designed to organize mobility under suitable conditions, including safety, comfort, speed, and cost-efficiency. It relies on technical, economic, and social studies to ensure effective functioning. Urban transportation comprises urban entities concentrated on road networks and the movement systems operating within them, as well as various components of the urban network across smaller or larger areas, interconnected through an organized system of diverse transportation routes. (Mobility and Transport, 2020–2021).

- a. Importance of Urban Transportation: The importance of urban transportation can be summarized according to two main criteria:
  - Functional Criterion: Cities cannot develop or function efficiently without transportation and land. Commercial, industrial, and residential activities would face significant challenges in performing their roles without adequate transport systems.
  - Quantitative Criterion: Transportation occupies a large portion of urban land. In modern cities, it ranks second after residential areas, and its share may exceed one-third of the built-up area, increasing further when including parking spaces.
- b. Factors Affecting Urban Transportation :Several factors influence urban transportation systems, including:
  - Land Uses: Commercial areas, residential neighborhoods, industrial zones, and educational, recreational, and healthcare service areas.
  - Economic Factors: The availability of financial resources and the economic capacity of the city and its residents.
  - Technological Advancement: Adoption of modern transportation technologies and innovations.
  - Infrastructure: Basic structures such as tunnels, bridges, transit stations, parking facilities, and supporting service installations. (Mobility and Transport, 2020–2021)

### Sustainable Modern Urban Transportation:

Modern sustainable urban transportation constitutes one of the fundamental prerequisites for achieving sustainable development, given the direct and indirect impacts of the transportation sector on the urban environment. Conventional urban transport systems generate various forms of environmental pollution and waste, which adversely affect air quality, public health, and the overall urban ecosystem. Therefore, there is an urgent need to develop sustainable urban transport systems that rely on energy efficiency and the reduction of emissions. Such development contributes positively to environmental protection, enhances the quality of urban life, and supports environmentally sustainable development pathways within cities. (United Nations. p. 43)

### Fundamental Principles of Sustainable Transportation:

These principles include: ensuring accessibility, achieving social equity, integrated transportation planning, health and safety, environmental quality, and economic feasibility.

### Factors Influencing Urban Transport:

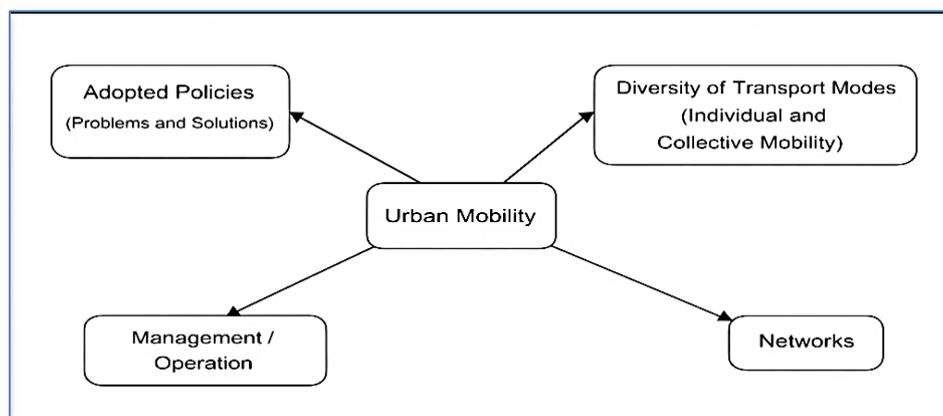


Figure (1): Key determinants of urban transportation systems. Source: Prepared by the authors, 2025

### Sustainable Urban Transportation Planning for the City:

Transportation planning relies on collecting data on current transport services and anticipated future services, as well as on population density and its spatial distribution, with the aim of developing and expanding transportation networks and

preparing appropriate modes. Decision-makers in the transportation planning process bear the responsibility for designing sustainable and integrated systems and solutions, rather than implementing partial or temporary measures, while considering the following:

- a. Coordination between public and private sectors and stakeholders in planning and operating transportation, ensuring that transport decisions are integrated with environmental, health, energy, and urban land-use considerations.
- b. Making proactive decisions to address potential negative impacts of transportation, thereby avoiding long-term and costly infrastructure expenditures.
- c. Ensuring that transportation decisions are transparent and inclusive, keeping the public informed about options and impacts, and encouraging participation to meet community needs. (Lwati & Karkoud, 2016, p. 19)
- d. Prioritizing environmental considerations in planning to reduce pollution, protect biodiversity, and minimize the environmental impact of transportation.
- e. The significance of urban transportation planning lies in its role as an integral component of comprehensive urban planning. It contributes to organizing land uses and meeting the needs of the population. Urban planning is characterized by a systematic and organized approach to selecting sustainable land-use patterns, addressing negative challenges, and preparing for future urban growth. Modern urban transportation also aims to enhance the urban environment, improve the quality of public spaces, and present the city with a modern and sustainable image. (Lwati & Karkoud, 2016, p. 19)

The Role of National and Local Development Plans in Advancing the Transportation Sector: National and local development plans have emphasized the critical role of transportation in sustainable urban development. The Five-Year National Development Plan (2018–2022) highlighted passenger mobility, setting strategic objectives based on a thorough assessment of sector challenges. These include enhancing transport efficiency through governance and private-sector management, promoting private investment in competitive intra- and intercity services, and modernizing public transport fleets to provide safe, comfortable, and environmentally compliant mobility. (National Development Plan, 2018–2022,

p.165). Similarly, the Sustainable Transport Plan for Babil Governorate, prepared in coordination with UN-Habitat, focuses on accessible, resilient, equitable, safe, environmentally sustainable, and financially viable transport systems. Together, these frameworks demonstrate the importance of integrated transport planning in improving service quality, supporting social inclusion, and fostering sustainable urban growth. (European Union. 2018, p. 28)

### **Sustainable Urban Transport Modes:**

- A. Electric Bus (Trolleybus):** The electric bus operates using electricity supplied through an overhead network, combining the environmental advantages of urban rail with lower infrastructure costs compared to train lines. It is characterized by zero emissions and minimal noise but is less flexible and more expensive than conventional buses, requiring significant street space. It can transport approximately 20% more passengers than traditional buses, as shown in Figure 2.
- B. Bus Rapid Transit (BRT):** BRT is a mass transit system that uses dedicated lanes and modern stations, offering superior service compared to conventional buses at a lower cost than metro or train projects. It does not require expensive infrastructure or long implementation periods and was first introduced in Curitiba, Brazil, in 1974, as illustrated in Figure 3.
- C. Metro (Subway):** The metro is an electric mass transit system operating in underground tunnels and on surface sections. It is highly efficient for large cities over distances exceeding 10 km, with speeds exceeding 500 km/h. Despite its high cost, it is considered ideal for cities with populations over one million, as shown in Figure 4.
- D. Urban Tramway (Tram):** The tramway is an electric urban transport mode running at ground level, suitable for distances between 2 and 10 km, with speeds up to 54 km/h. It is economical and environmentally friendly, combining the advantages of metro and bus systems. However, it is costly to construct, inflexible on narrow streets, and can generate noise, as shown in Figure 5. (Salem, 1985, p. 216)
- E. Tram-Train:** The tram-train is a hybrid transport mode that combines the advantages of trams and metro systems. It operates within urban areas like a tram at low speeds and in suburban areas like a train at higher speeds,

seamlessly connecting the city with its outskirts. Running on dedicated tracks, it is well -suited for high-density residential and commercial zones over short distances and typically does not require supplementary transport modes. Its passenger capacity ranges from 3,000 to 9,000 per hour, with vehicle lengths varying between 30 and 60 meters.

The selection of a public transport mode depends on several factors, including: the number of passengers to be transported per hour per lane or direction; the capacity of existing primary and secondary road networks and the feasibility of dedicating lanes for bus operations; the projected growth rate of passengers and private vehicle ownership; the nature of land use in the area (residential, commercial, industrial, etc.); and the available financial and material resources. (Salem, 1985, p. 216).

			
<b>Figure5.Urban Tramway</b> (Source: URL4,accessed October 4, 2024)	<b>Figure4.Metro (Subway)system</b> (Source:URL3, accessed November 15, 2024)	<b>Figure 3. Bus Rapid Transit (BRT) with dedicated lanes</b> (Source: URL2, accessed March 10, 2024).	<b>Figure 2. Electric Bus</b> (Source:URL1, accessed February 2, 2024)

**The following table summarizes the key characteristics of urban public transport modes:**

Table (1): Key Features of Urban Public Transport Modes (Source: (Salwa & Omar, 2000, p. 41))

Transport Mode	Capacity (Passengers)	Average Speed (km/h)	Maximum Speed (km/h)
Conventional Urban Bus	50–100	15–20	40–50
Electric Bus (Trolleybus)	60–120	15	40–50
Urban Rail (Tramway)	120–180	15	30–40
Metro (Subway)	600–800	30–40	80–100

In summary, the diversity of urban public transport modes plays a crucial role in enhancing mobility efficiency within cities. Although tramway construction costs

are higher compared to other public transport options, trams offer high passenger capacity, reduced travel time, and improved accessibility. Additionally, they contribute to lowering environmental pollution and noise levels, as well as reducing energy consumption, making them a sustainable urban transport option compared to fossil-fuel-based modes.

### **Definition of Tramway:**

The tramway is a rail-based public transport mode, typically running alongside urban roads and sometimes on independent tracks separated from vehicular traffic. It operates on electric power and is widely used in many countries, historically referred to as the electric railway. Tramways primarily serve passenger transport within cities and their surrounding areas, but they can also connect cities, rural zones, and nearby regions, and can be utilized for light freight transport. Modern tram systems are characterized by operational efficiency and reliance on clean energy. (Sarra & Misran, 2020, p. 7).

### **Advantages of Tramway:**

Tramways offer high operational performance due to their dedicated tracks, separated from regular traffic, which enhances reliability and efficiency. They encourage the use of public transport, reducing dependency on private cars and mitigating traffic congestion. Moreover, tramways play a key role in urban regeneration by improving connectivity between residential areas and transport networks, enhancing daily urban life quality. Being electrically powered, tramways are environmentally friendly, producing no air pollutants, and they provide a quieter mode of transport compared to conventional fuel-based vehicles, thereby reducing noise pollution (Sarra & Misran, 2020, p. 7).

### **Impact of Tramway on Urban Development:**

The implementation of tramways is typically accompanied by urban development through: Renewal of public spaces by relieving streets from excessive car traffic, Development of open and landscaped areas, Allocation of parking in front of buildings to prevent illegal sidewalk parking, Facilitation of traffic flow, Redevelopment of urban areas with continuity across tram routes, Reduction of

travel times and alleviation of congestion, Enhancement of urban aesthetics, Reducing car dependency and promoting pedestrian accessibility. (Lwati & Karkoud, 2016. p. 27)



**Figure 8. Urban tram-train shared with vehicular traffic** (Source: URL10, accessed May 28, 2024.



**Figure 7. Intersection of traffic flow with the tramway route** (Source: URL9, accessed May 28, 2024.



**Figure 6. Dual urban train.** (Source: URL8, accessed May 28, 2024.

## Previous Studies (General and Specific)

1. Abbas, S. & Omran, Y. (2016), “Sustainable Transportation and Urban Form” Using the city of Baghdad, Iraq as a case study area, this research explores the association between sustainable transportation and urban form with an objective to bridge literature gap that concerns how sustainable modes of transport influence urban form. The study sought to develop a theoretical perspective from which such a relationship could be uncovered. It was shown that sustainable transportation actually affects urban forms, conservation of cultural and urban heritage, human needs satisfaction in the mean and long term. Methodology: The research adopted a descriptive-analytic approach, and investigated some Arab and international cases Selected on the basis of differences in sustainable transportation systems. It was found that sustainable transport cities have a strong level of local cohesion and polycentricity. Walk also helps those living in historic areas ‘preserve and maintain’, satisfy basic safety (and) freedom and pleasurable travel needs (Townsend, 1999).
2. Anouz, A. (2017), “Strategies for Sustainable Urban Transportation in Iraqi Cities: The Karbala Metro Project as a Model” This research emphasised that urban transportation is one of the most important strategic elements for achieving urban sustainability with relatively high preference in Karbala, which has spatial, economic, tourism and social value. The research

demonstrated that the existing urban transportation structure was insufficient and unreasonable, which caused a series of traffic problems. The objective was to plan a strategy for the future of sustainable transportation with the creation of a metro network project to tackle these problems in respect to the natural and human environment. It was decided to develop strategy as a solution for transportation problems. Effect of urban public transport and lack of specialized studies (which result in Traffic congestion accidents, environmental pollution and ... the traffic conditions. The results highlighted that the metro project is a vital approach for sustainable urban transportation and to develop economy, tourism, society, and environment at the time of goods occasioned phases (religious gathering) especially.

3. Latifa, Q. (2021), “Sustainable Transportation as an Indicator of Urban Sustainability: The Case of Masdar City, Abu Dhabi” The study aimed to clarify the role of sustainable transportation as an indicator of urban sustainability and to demonstrate mechanisms for translating it from theory into practical implementation. A descriptive–analytical approach was employed along with a case study, analyzing the experience of Masdar City in Abu Dhabi. The results indicated that Masdar City represents the first sustainable urban experiment in the Middle East, relying on a zero-carbon transportation strategy. This approach contributed to achieving a sustainable urban future, protecting the environment, and supporting sustainable development.

## Materials and Methods

This study adopts a descriptive–analytical approach, supported by an applied methodology, to achieve its objectives and test its hypothesis. The research is carried out through the following stages:

- **Descriptive Approach:**

This stage focuses on presenting the theoretical framework of sustainable transportation concepts, the tramway as an urban mobility mode, and sustainable urban environments. It also examines the relationship between transportation systems and architectural design, relying on previous studies, literature, and planning and architectural standards.

- **Analytical Approach:**

The current state of the transportation system and traffic movement in Al-Hilla City is analyzed to identify the causes of traffic congestion and its impacts on the urban and architectural environment. Lessons are drawn from selected global tramway experiences to extract design indicators that are applicable to the local context.

- **Applied Approach (Case Study):**

Al-Hilla City is used as a case study to determine the tramway routes within the urban fabric and to examine their compatibility with architectural composition and urban spaces. The study then evaluates the potential impact of the tramway system on reducing congestion and improving urban environmental quality.

### **Location of Al-Hilla City:**

The geographic location of Al-Hilla plays a crucial role in its economic activity due to its link to human settlement patterns. The city is situated on both sides of the Hilla Canal, at the intersection of longitude 44° 66' E and latitude 32° 29' N, covering an area of 161 km<sup>2</sup>, representing 18.3% of Al-Hilla District and 3.1% of Babil Governorate. Al-Hilla serves as the administrative center of Babil Governorate, lying at the heart of its administrative units and adjacent to several important neighboring governorates. Its strategic location and connectivity to a network of transport routes linking it with nearby cities enhance its role as a regional hub, positively influencing its economic potential, as shown in Map 1.

### **Population Studies of Al-Hilla City:**

Al-Hilla City is one of the oldest Iraqi cities and is considered an attractive urban center due to its significant historical and cultural importance. It serves as the administrative center of Babil Governorate and occupies a central position among its administrative units. The city is characterized by a high population density of approximately 3,176 inhabitants/km<sup>2</sup> within the urban area. In 2020, the population of Al-Hilla's urban area reached 508,185 inhabitants, representing 22.6% of the total population of Babil Governorate. Al-Hilla City covers an area

of 5,681 hectares and comprises 98 residential neighborhoods (2016). The Municipality of Al-Hilla adopted a sectoral classification of the city, dividing it into four main sectors: Al-Firdous Sector, Al-Fayhaa Sector, Al-Salam Sector, and Al-Furat and Al-Zuhour Sector, as illustrated in Map (2). (Al-Asadi & Al-Tufaili, 2018)

### **Population Distribution:**

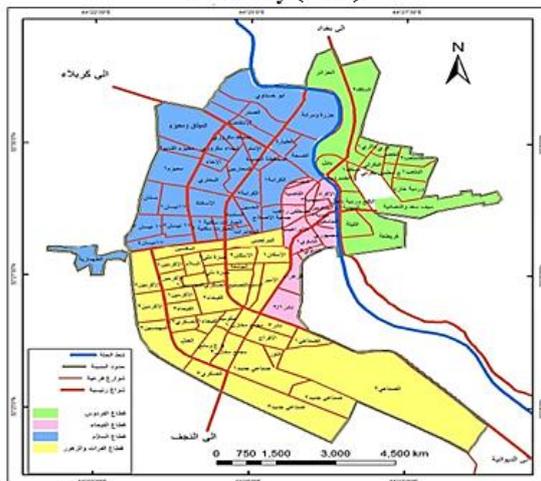
Population distribution within the city varies across its neighborhoods and areas. Studying this distribution and identifying spatial relationships helps determine the factors influencing it. As shown in the population distribution map, the residents of Al-Hilla City are distributed across four main sectors as follows:

- a. Al-Firdous Sector: Located on the eastern side of the city, this sector has a population of 60,538 inhabitants distributed across 17 residential neighborhoods, accounting for 14% of the city's total population. It is locally known as Al-Sub Al-Sagheer and ranks fourth in terms of population size.
- b. Al-Fayhaa Sector: Situated on the western side of the city, this sector represents the old area or the commercial core of Al-Hilla. Despite the diversity and multiplicity of land uses within this sector, it exhibits a noticeable population concentration due to its distinctive characteristics. It ranks third in population size, comprising 24 neighborhoods with a population of 73,518 inhabitants, representing 16% of the city's population. (Al-Asadi, 2018, p. 342)
- c. Al-Salam Sector: Also located on the western side, this sector extends over the northeastern part of the western bank of the city up to Al-Tahmazia Street, which separates it from the Al-Furat and Al-Zuhour Sector to the south. It has a population of 160,093 inhabitants, accounting for 36% of the city's total population, ranking first in terms of population size. This is largely attributed to extensive spatial expansion and the sale of agricultural land plots, particularly following approvals by the Ministry of Agriculture and the Ministry of Construction and Housing, which led to the emergence of informal and unplanned residential neighborhoods. (Al-Asadi & Al-Tufaili, 2018)
- d. Al-Furat and Al-Zuhour Sector: This sector extends from Al-Salam Sector northward from Al-Tahmazia Street toward the southwestern part of the city on the western bank, along the Al-Hilla–Diwaniyah highway. It has a

population of 154,226 inhabitants, representing 34% of the city's population, ranking second in population size. (Al-Asadi, 2018, p. 342)

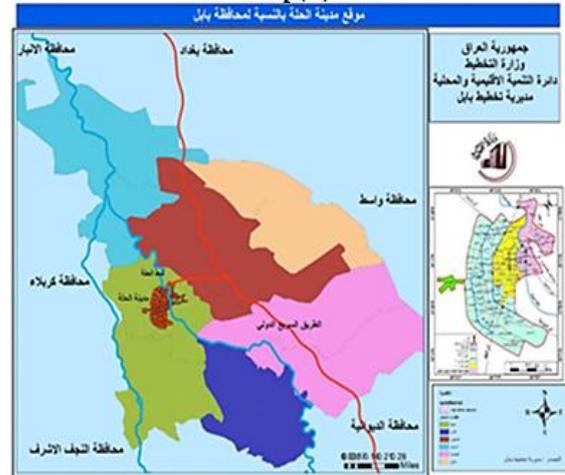
Overall, the population of Al-Hilla City is distributed on both sides of the Hilla Canal, with the right bank accommodating the largest population and the highest density, as illustrated in Map (3).

Map 2. Spatial sectors and residential neighborhoods of Al-Hilla City (2016).



Source: (Al-Asadi & Al-Tufaili, 2018)

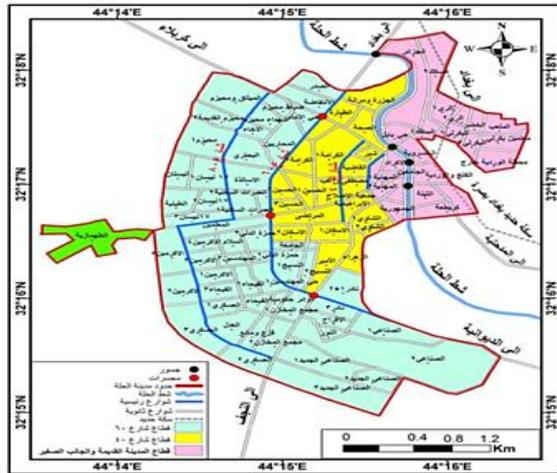
Map( 1)



Source: Prepared by the authors based on Geographic Information Systems (GIS), 2025

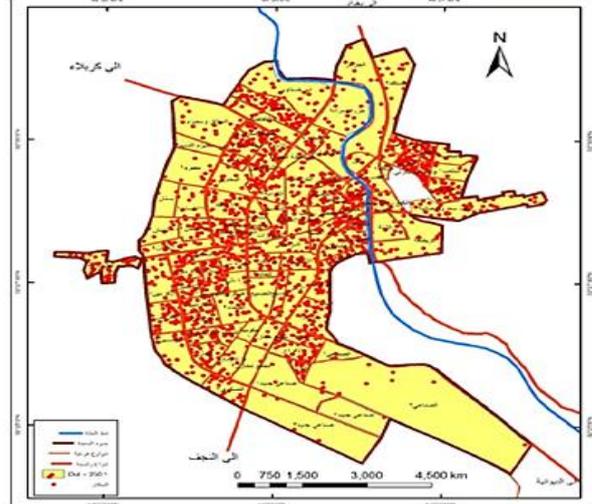
Road Network of Al-Hilla City: Urban road networks play a fundamental role in economic and regional development, as they significantly influence the location and growth of urban and economic projects. Al-Hilla City comprises several categories of transport roads. This study analyzes street lengths across residential neighborhoods based on the city's master plan, as illustrated in Map (4).

Map 4. Road network of Al-Hilla City.



Source: (Mousa, Z.A., 2018).

Map (3): Population Distribution of Al-Hilla City.



Source: (Al-Asadi, Ali, & Al-Tufaili, 2018, p. 343).

Table (2): Traffic in Hillah City (Source: Prepared by the researchers based on the referenced sources) Al-Hilli, NABD News, & IASJ, 2020))

Road Type	Location / Street	Traffic Density	Peak Hours	Notes
External	Northern Entrance (from Baghdad)	Heavy	06:00–09:00 AM / 03:00–07:00 PM	Connects the city with neighboring governorates, continuous congestion
External	Western Entrance (Anana)	Heavy	06:00–09:00 AM / 03:00–07:00 PM	Main road connecting Hillah to Karbala Governorate
Internal	Street 40	Moderate to Heavy	06:00–09:00 AM / 03:00–07:00 PM	Maintenance works affect traffic flow
Internal	Street 80 / Street 100	Light to Moderate	All day	Stable traffic, less congested than main streets
Internal	Al-Um Bridge & Major Intersections	Moderate	06:00–09:00 AM / 03:00–07:00 PM	Traffic signals installed to reduce congestion
Connector / Neighborhood Roads	Connecting roads between neighborhoods	Moderate to Heavy	06:00–09:00 AM / 03:00–07:00 PM	Help distribute traffic and reduce pressure on main streets

### Road Network Problems in Al-Hilla City:

The street network in Al-Hilla City faces several challenges, which can be summarized as follows:

A. Relationship between Street Network Design and Land Use: The planning of the city's street network and its land uses are closely interrelated and cannot be

considered independently. Many of the resulting problems stem from the fact that Al-Hilla's original master plan and street network were designed when the city had a small population and a correspondingly low number of vehicles. These streets were sufficient to accommodate the limited traffic at that time.

B. Increasing Traffic Congestion: Traffic congestion in Al-Hilla's streets has been exacerbated by several factors:

- Delays in implementing infrastructure projects, such as the sewage network, which forced traffic to be redirected to alternative routes in an unplanned manner.
- Encroachments by shop owners who place goods or stalls (basat) outside their stores, forcing pedestrians onto the street.
- Insufficient parking facilities relative to the area's capacity, compelling vehicle owners to park near sidewalks, thereby reducing street space and causing congestion.
- The presence of concrete blocks in front of many government offices, which obstruct portions of adjacent streets.

C. Lack of Regular Street Maintenance: The Al-Hilla Municipality does not provide continuous maintenance, resulting in roads with potholes, uneven surfaces, and damage caused by heavy vehicles on streets unable to bear such loads. Table 3 illustrates the load-bearing capacity of soil for certain streets in Al-Hilla.

Table (3): Soil Load-Bearing Capacity for Selected Streets in Al-Hilla (Source: (Aloush, 2012, p. 154))

Location	Street 40	Al-Dubbat Neighborhood	Al-Bakrli Neighborhood	Al-Nader Neighborhood	City Center Commercial Area
Soil Load Capacity (ton/m <sup>2</sup> )	4	7	8	5	5
Soil Texture	Medium Clay	Medium Clay	Medium Clay	Medium Clay	Medium Clay

### Tramway Planning Scenarios:

The tramway project in Al-Hilla City is one of the most significant urban development initiatives, as it helps reduce pressure on the city center and facilitates transportation for residents and suburban areas. Implementing this sustainable project requires urban modifications along its route, representing a

form of urban renewal. Three tramway route scenarios were developed based on key planning indicators, including population density, high-traffic areas, priority zones, and locational suitability to achieve sustainable urban transport. The proposed alternatives are as follows:

### Alternative 1:

This route was proposed to serve the areas with the highest population density and to alleviate traffic congestion. The tramway extends from the old city and central commercial district (Central Market) along *Street 40* southwards through Al-Nader Neighborhood to the university area. The line includes two tram tracks spanning 13 km with eight stations: Central Market, Bab Al-Hussein, Street 40, Al-Umm Intersection, Street 80 Intersection, Hilla Exhibitions, Residential Complex Station, and University Station. This route is illustrated in Figure 9. The tramway route design was based on technical standards and the available width of Street 40, which is 40 meters. As illustrated in the following figure, the design includes three lanes in each direction, with sidewalks and pedestrian pathways to encourage foot traffic, as well as a dedicated lane for bicycle movement. Figure 10.

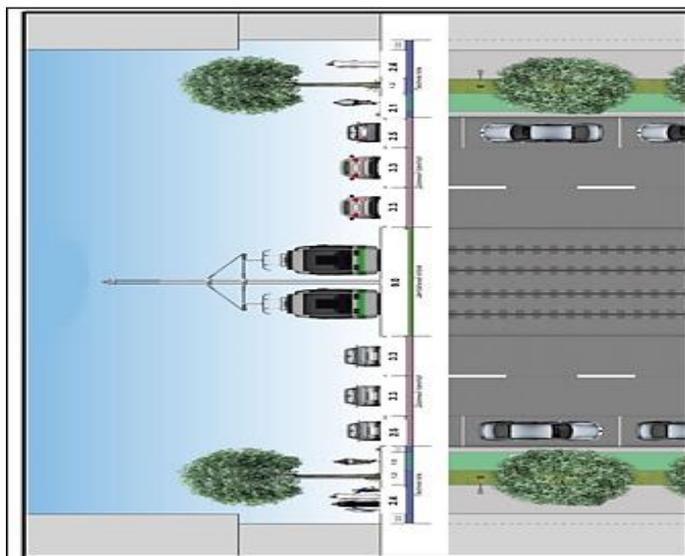


Figure 10. Proposed redesign of Street 40 in Al-Hilla City (Source: Authors' work, 2025).

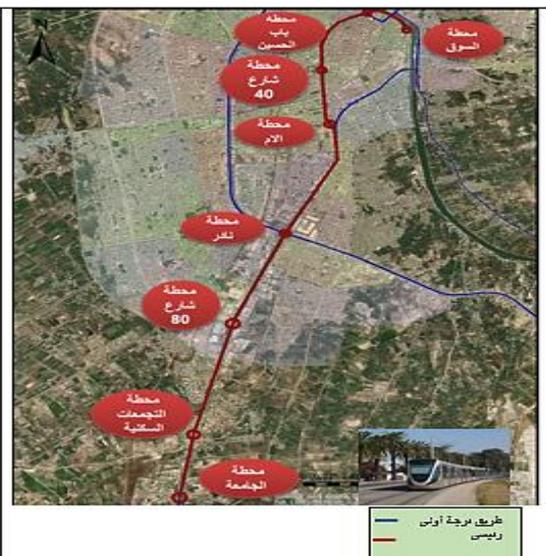


Figure 9. Alternative 1 of the tramway route and stations in Al-Hilla City (Source: Prepared by the authors based on satellite imagery using GIS, 2025).

### Alternative 2:

This alternative was proposed based on the high population density of the city, aiming to serve the largest number of residents and to alleviate traffic congestion, as illustrated in Figure 11. The route is designed to connect the Greater and Lesser Al-Hilla districts, starting from Marjan City, then passing through Babil Neighborhood, the old city represented by the commercial district (Central Market), and Street 60, which suffers from heavy traffic due to through-traffic coming to and from neighboring governorates. The route then continues southward through Al-Nader Neighborhood to the university area, with two tram tracks spanning a total length of 17.5 km and including twelve stations: Marjan City, Al-Bakrli, Central Market, Bab Al-Hussein, Al-Thawra, Street 60, Al-Tahmazia, Unified Garage Station, Al-Nader, Street 80 Intersection (Hilla Exhibitions), Residential Complex Station, and University Station.

The tramway was proposed along both sides of Street 60, taking advantage of the available road width, as shown in Figure 11. In the Bab Al-Hussein area, the tramway track was designed to run alongside vehicular lanes according to international road standards, creating a more dynamic roadway accommodating different modes of transport, as illustrated in Figure 12.

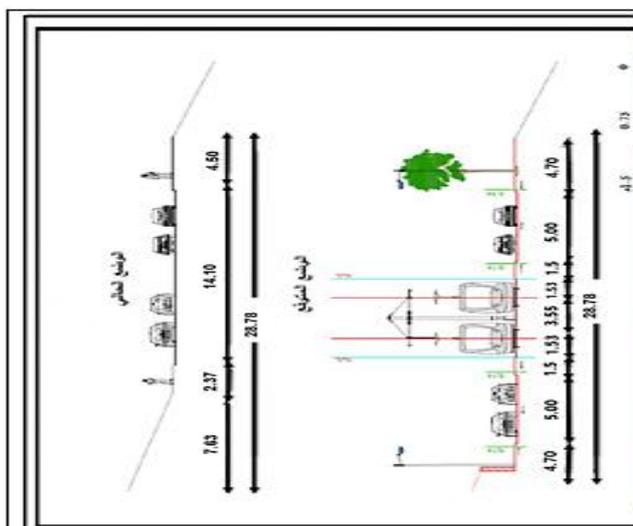


Figure 12. Proposed schematic design of Bab Al-Hussein Street in Al-Hilla City (Source: Authors' work, 2025).

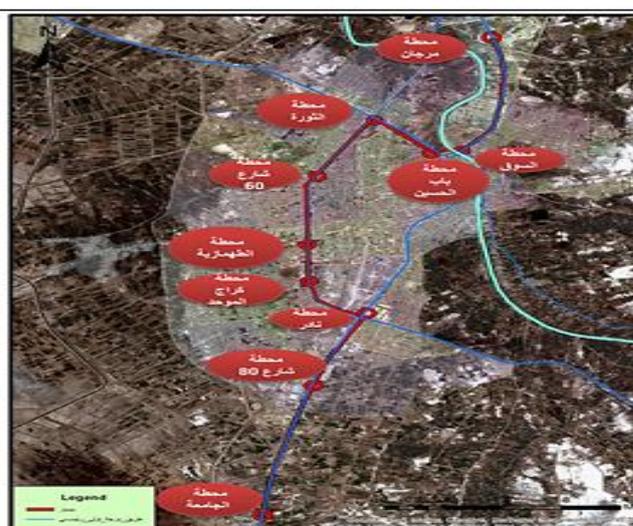


Figure 11. Alternative 2 of the tramway route and stations in Al-Hilla City (Source: Prepared by the authors based on satellite imagery using GIS, 2025).

### Alternative 3:

This alternative was proposed based on the high population density of the city, aiming to serve the largest number of residents, reduce traffic congestion, and connect the Greater and Lesser Al-Hilla districts across both sides of the Hilla River, as illustrated in the figure below. The route extends from Marjan Medical City, then passes through the old city and the central commercial district (Central Market), including Street 40, southward through Al-Nader Neighborhood to the university area, with two tram tracks spanning a total length of 15 km and including ten stations: Marjan City, Al-Bakrli, Central Market, Bab Al-Hussein, Street 40, Al-Umm Intersection, Street 80 Intersection (Hilla Exhibitions), Residential Complex Station, and University Station. Figure 13. This alternative occupies a strategic location, linking the Greater and Lesser Al-Hilla districts across the Hilla River and passing through areas with high traffic density, including Marjan Medical City and the northern neighborhoods of Al-Hilla City.



Figure 14. Urban view of the tramway (Source: URL11)



Figure 15. Tramway stations (Source: URL12)



Figure 13. Alternative 3 of the tramway route in Al-Hilla City (Source: Prepared by the authors based on satellite imagery using GIS, 2025).

## Results

**Selection of the Optimal Alternative:** After a detailed study and analysis of the three alternatives, using planning principles aimed at achieving sustainable development, including comfort, congestion mitigation, accessibility, ease of

planning and implementation, economic development, access to public services, connectivity, serving the largest number of people through public transport, respecting cultural privacy and traditional heritage, and creating new urban development through reconstruction of facades and buildings along roads according to modern planning standards, these criteria were adopted to compare the alternatives and select the optimal one, as shown in the following table:

Table (4): Selection of the Optimal Alternative among the Three Tramway Routes (Source: Prepared by the authors based on a sensitivity analysis to determine alternative weights and select the optimal route)

Criteria (Objectives)	Weight	Alternative 1	Score	Alternative 2	Score	Alternative 3	Score
Accessibility	10	8	80	10	100	10	100
Number of Beneficiaries	10	6	60	10	100	8	80
Economic Importance of the Project	8	6	48	6	48	8	64
Social Importance	5	4	20	4	20	5	25
Spatial Suitability	15	12	180	15	225	15	225
Potential for Urban Renewal	15	15	225	10	150	15	225
Comfort and Safety	8	6	48	6	48	8	64
Cost	15	15	225	10	150	12	180
<b>Total</b>			886		841		963

It is evident from the table above that **Alternative 3** is the most suitable for the city's future development. Therefore, it is essential to prepare a medium- and long-term urban development plan and designs that align with international best practices, while allocating sufficient financial resources, due to the significant impact on urban development.

Figure 16. Comparison of tramway alternatives based on key planning criteria, highlighting Alternative 3 as the optimal choice. Source: Prepared by the authors.

## Discussion /Results: Benefits of the Tramway Project for Al-Hilla City

- a. Impact on the Urban Transport System: The tramway is expected to serve more than 1,900,000 passengers annually, encouraging people to shift to public transport due to its comfort, safety, and accessibility. This will positively affect the city's overall transport network by reducing pressure and congestion.

Additionally, streets will be redesigned to accommodate the project requirements, creating a more adaptable urban environment, especially by providing pedestrian pathways within urban centers.

- b. **Environmental Benefits:** The proposed tramway will reduce environmental pollution, traffic congestion, and visual pollution, thereby improving the city's overall environment. It will also enhance road safety by providing dedicated pedestrian pathways, promoting non-motorized mobility, and contributing to a more livable urban environment from both environmental and social perspectives.
- c. **Economic Value:** The tram project will provide over 10,800 trips annually, with approximately 30 trips per day on two lines. Economically, this translates to an estimated annual saving of 9.5 billion Iraqi dinars. In addition, it will create employment opportunities and stimulate multiple urban and service projects along the tramway corridor.
- d. **Supportive Policies for Project Implementation:** Key factors for project success include reducing traffic congestion in the city center, especially the old city and commercial hubs. Supportive policies and measures highlighted include:
  - Coordinating new urban development projects with tramway routes and stations, prioritizing large projects such as commercial or residential complexes.
  - Increasing density along the route, particularly near tram stations.
  - Encouraging walking by diversifying land uses and providing pedestrian pathways that consider local climate conditions, especially in summer.
  - Designing dedicated parking spaces near tram stations to promote "Park and Ride" systems.
  - Redesigning streets according to the new tramway standards, with sidewalks and pedestrian pathways to encourage public transport use.
  - Revitalizing commercial centers, retail, and real estate activities along the tramway corridor, particularly at stations, thereby stimulating the local economy.

## Conclusion

1. Traffic congestion in Al-Hilla city is the prevailing feature of the urban landscape of Babil Governorate and has a significant negative impact on urban development due to decades of accumulated weaknesses in infrastructure and service provision. This study opens serious avenues for dialogue and discussion with local government and relevant authorities to develop urban transport and prioritize it within Al-Hilla's urban planning framework.
2. Linking the planning process aimed at resolving traffic congestion with economic, social, and environmental standards is essential to meet the fundamental needs of the city's residents.
3. The main reasons behind the decline in transportation services and deteriorating traffic conditions in Al-Hilla are twofold: a substantial increase in population on one hand, and the inability of the original city design to accommodate this growth on the other. This situation has been exacerbated by successive migrations from rural areas and neighboring governorates to Al-Hilla, along with the spread of informal settlements, which now constitute approximately 80% of the city's total area.
4. Based on desk and field analyses of Al-Hilla's topography and demographics, three alternative tramway routes were identified, with the optimal route selected to serve the highest number of residents while minimizing conflicts.
5. The implementation of the sustainable tramway transport system is accompanied by improvements along its route, which can be described as urban regeneration, contributing to urban development in the areas traversed by the tramway.

## Recommendations

1. The local government places significant emphasis on enhancing urban planning in Al-Hilla by adopting sustainable urban transport policies.
2. Design and implement tramway routes according to international standards to meet current and future population needs while ensuring safety.
3. Promote urban regeneration by improving building facades and public spaces during project implementation.
4. Maintain existing roads regularly to prevent long-term deterioration.
5. Enhance traffic legislation, improve the efficiency of traffic personnel, and equip them with modern tools and devices.

6. Raise public awareness and encourage the use of public transport to reduce congestion and pollution.
7. Construct multi-level parking facilities to accommodate more vehicles without consuming excessive land.
8. Remove encroachments on sidewalks and streets caused by informal vendors and kiosks.
9. Develop bypass roads and external routes to divert intercity traffic and reduce inner-city congestion, e.g., the 100th Street ring road.

## References

1. Ministry of Planning. (2018–2022). National development plan. Iraq.
2. European Union, Local Area Development Program. (2018–2022). Transport plan for Babil Governorate. Iraq.
3. Suwaileh, O., & Martini, O. (2000). Urban planning theories. University of Aleppo, Faculty of Architecture, Aleppo, Syria, p.41.
4. Salem, M. T. (1985). Transport and traffic engineering. Dar Al-Rateb University, p.216.
5. Al-Asadi, A. M., & Al-Tufaili, H. M. (2018). Population growth and its impact on urban sprawl in Al-Hilla city. Babel Center for Humanities Studies Journal, 8(3).
6. Mousa, Z. A. (2018). Status of the urban transport system in Al-Hilla city (2011). Babel Center for Humanities Studies Journal, 8(1).
7. Aloush, Q. M. (2012). Analysis of transport and traffic in Al-Hilla city. University of Babylon, College of Education for Humanities, Department of Physics, 2(1), p.154.
8. Sara, M. (2020). Tramway station design (Master's thesis). Faculty of Arabic Literature and Arts, University of Abdelhamid Ibn Badis, Mostaganem, p.7.
9. Abbas, S., & Omran, Y. (2016). Sustainable transport and urban form. Iraqi Journal of Architectural Engineering, 15(1), 187–206.
10. Anouz, A. (2017). Strategies for sustainable urban transport in Iraqi cities: Karbala metro project as a case study. Paper presented at the 3rd Scientific Conference, College of Urban Planning, University of Kufa.
11. Latifa, Q. (2021). Sustainable transport as an indicator of urban sustainability: Case study of Masdar City, Abu Dhabi. Economics of North Africa Journal, 17(26).

12. Babil Governorate. (2018–2022). Urban development strategy for Babil Governorate.
13. Bouscar, R. (2002–2003). Quantitative and qualitative assessment: Case study of Biskra city (Master's thesis). University of Batna, p.9.
14. United Nations. (n.d.). General political guidelines for sustainable urban planning, p.43.
15. Hussein, M. (2014). Dimensions of sustainable development and their relationship with urban development. University of Kasdi Merbah, Algeria, p.9.
16. Qiyadi, M. I. (n.d.). Urban sociology and challenges of construction and urban development, p.21.
17. Louati, A., & Kerkoud, N. (2016). Impact of tramway on urban regeneration: Constantine city. University of Larbi Ben M'ehdi, College of Earth, Universe, and Architectural Engineering, Department of Geography, p.8.
18. Mahmoud, M. T. (2001). Development and society. Modern University Press, p.70.
19. Adler, H. (1970). Planning, transport sectors, and projects (A. Qadir, Trans.). Ministry of Planning, Baghdad, p.50.
20. Sahbi, K. (n.d.). Urban renewal: Creation of a new city center of OEB, p.20.
21. Iraqi Academic Scientific Journals (IASJ). (2020). Urban road network and traffic flow study in Hillah. Retrieved from <https://iasj.rdd.edu.iq/journals/uploads/2025/05/07/9ee28237ece6ae2fd9851ec34e03897e.pdf>.
22. Al-Hilli, M. (2020). Traffic analysis and urban road performance in Hillah City. Journal of Planning and Development, University of Baghdad. Retrieved from <https://jpd.uobaghdad.edu.iq/index.php/jpd/article/view/560>.
23. Media. (2020). Traffic signals and bridge improvements in Hillah City. Retrieved from <https://964media.com/256780>.
24. NABD News. (2020). Street 40 rehabilitation project in Hillah. Retrieved from <https://nabd.com/s/139340763-42118f>.  
URL1: <https://attaqa.net/2023/>  
URL2: <https://agadir24.info/media>  
URL3: <https://akhbarelyom.com/news/newdetails/>  
URL4: <https://radiozm.com>  
URL5: <http://www.Linternaute.com/savoir/grands-chantiers/06/dossier/tramway-paris/rappelhistoire>

- URL6: <https://www.bing.com/images/blob?bcid=RKOVtv0ffeoBvA>  
URL7: <https://radiozm.com>  
URL8: <https://www.envisionsl.com/ar/blog/the-significance-of-enterprise-asset-management-eam-in-metro-rails-and-its-contribution-to-industry-value>  
URL9: <https://www.alarabiya.net/aswaq/2014/11/11/%D8%A7%D9%84%D9%8A%D9%88%D9%85-%D8%A7%D9%86%D8%B7%D9%84%D8%A7%D9%82-%D8%AA%D8%B1%D8%A7%D9%85-%D8%AF%D8%A8%D9%8A-%D8%A8%D8%AA%D9%83%D9%84%D9%81%D8%A9-4-%D9%85%D9%84%D9%8A%D8%A7%D8%B1-%D8%AF%D8%B1%D9%87%D9%85->  
URL10: <http://ahdath.info/content/uploads/2016/06/Tramway-Rabat.jpg>  
URL11: <http://www.mapexpress.ma/ar/wp-content/uploads/2017/10/Bouregreg-504x300.jpg>  
URL12: <https://cdn.al-ain.com/lg/images/2018/11/12/133-025232-passenger-transport-tram-2.jpeg>