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Transport-Oriented Development as a Catalyst for Urban Sustainability: A Proposal for Relocating Helwan Metro Station

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Keywords Transit-Oriented Development, Multimodal Transportation, Sustainable Development, Helwan Metro Station, congestion mitigation Abstract: This study explores the transformation of Helwan Metro Station into a multifunctional transportation hub through the implementation of Transit-Oriented Development (TOD) principles. It proposes relocating the station to a nearby vacant, non-residential site approximately one kilometer from its current location to improve urban mobility, alleviate congestion, and promote sustainable development. Inspired by international case studies such as Shinjuku Station in Tokyo, Metro de Santiago in Chile, and the Hong Kong MTR, the research employs a methodology that includes a literature review, analysis of current conditions, and a flexible redevelopment vision. Findings indicate that relocation would ease congestion in residential zones, enhance connectivity to primary road networks, and encourage a modal shift from private vehicles to public transport. The proposed hub features integrated multimodal systems-including buses, taxis, and parking-alongside mixed-use commercial and hospitality developments. The practical implications involve stimulating local economic growth, fostering environmental sustainability through green infrastructure, and strengthening urban resilience. Socially, the project aims to improve quality of life by reducing pollution, encouraging public transport use, and creating accessible, vibrant urban environments. Overall, the study offers valuable insights into the localized application of TOD strategies, positioning the Helwan Metro Station as a strategic southern gateway to Cairo and providing a framework for future urban development.

1. Introduction

Transit-Oriented development is a new approach towards urban planning, which mixes land use with transit systems, creating environments with high accessibility while being able to reduce dependence on private vehicles. This concept transforms urban spaces into dynamic centers that enhance quality of life while simultaneously reducing environmental impact. [1]

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There are many examples of how the application of this concept has taken place: Shinjuku Station in Tokyo, The Metro de Santiago in Chile, and the Hong Kong MTR. The integration of the Shinjuku Station within a Commercial and investment area has helped in improving Transit efficiency and increasing economic growth.

Applying such findings to Helwan, a city dominated by residential areas, overpopulation, congestion of traffic, pollution, and insufficient public transportation [2]. This research recommends shifting Helwan Metro Station to a non-residential location one kilometer away from the station square. Located at the middle of an underdeveloped location, this proposal would offer good accessibility to primary roads for a regional Transit hub. Also, this would give Helwan a better location as the southern entrance to Cairo while developing urban sustainable transportation. The proposed redevelopment of Helwan Metro Station as a multimodal transportation hub-integrating local and regional buses, taxis, and parking facilities-aims to reduce dependence on private vehicles by promoting public transit use. This transformation is expected to stimulate economic growth, mitigate environmental impacts, and enhance urban sustainability. The inclusion of green public spaces will contribute to environmental resilience and improve the visual and recreational quality of the area for both residents and visitors. As a critical node in Cairo's transit network, the upgraded station addresses key urban challenges while aligning with broader objectives of sustainable development.

1.1. Research Objectives

The research presents a proposal for the development of moving Helwan Metro Station and rebuilding it as a multi-modal transportation hub based on the TOD principles. The proposal is aimed to address current urban mobility challenges, reduce traffic congestion, and create sustainable urban growth through relocating the station to an uninhabited, non-residential site approximately one kilometre from its current location. The study outlines a mixed-use redevelopment plan that integrates multimodal transportation terminals with commercial, hospitality, and green public spaces. The desired end product is to turn the Helwan Metro Station into an effective southern entrance to Cairo to assist the city in realizing its overall sustainable development plans.

1.2. Research Methodology

To effectively address the research *Objectives* and support the proposed transformation of Helwan Metro Station through Transit-Oriented Development (TOD), the methodological design of this study is presented within a structured framework, illustrated in Table 1 Building on this framework, the research methodology adopts a mixed research approach, integrating quantitative and qualitative methods to evaluate the redevelopment potential of Helwan Metro Station through TOD principles. The methodology was explicitly designed to address the following central research questions:

- What are the existing urban, transportation, and spatial challenges surrounding Helwan Metro Station?
- How can TOD principles be adapted to the local context to enhance mobility, sustainability, and economic activity?

- What development scenarios can effectively guide the relocation and transformation of the station into a multimodal hub?

Framework	Explanation					
Methodological	A mixed-methods approach combining qualitative and quantitative					
Approach	research. Structured in three phases: context analysis, site assessment, and					
Key Research	A comprehensive diagnosis of the station's challenges, supported by data					
Findings	and international comparisons, leading to a localized, strategic TOD					
Applied and Policy	Provides a replicable framework for implementing TOD in similar urban					
Implications	areas, offering actionable development strategies for policymakers and					
Effects and results	Promotes urban equity, improved access to mobility, and environmental					
of the application	stewardship, contributing to a more liveable and inclusive city model.					
Contribution and	Offers a scalable and sustainable urban transformation model grounded in					
Strategic Value	global best practices, tailored to Helwan's unique local context.					

 TABLE I: The Methodological Design Structured framework

The methodology is divided into three main phases. Each phase combines traditional research methods with modern analytical tools, drawing on insights from international case studies and data analysis to prepare the development proposal:

First. Phase One: Context Review and Analysis:

This phase focused on context review and analysis, aiming to ground the study in relevant literature and international best practices related to Transit-Oriented Development (TOD). Particular emphasis was placed on examining case studies of successful TOD implementations, particularly Shinjuku Station in Tokyo and The Metro de Santiago in Chile, and the Hong Kong MTR, all of which offer valuable lessons in integrating multimodal transportation systems in urban contexts. This comparative analysis was complemented by the collection of data from planning authorities, transportation departments, and statistical databases. This data helped establish a baseline understanding of the current urban and transportation conditions in Helwan, identifying existing gaps and areas requiring improvement for the proposed Transit-Oriented Development (TOD) intervention.

Second. Phase Two: Current Situation Assessment:

Focused on a detailed assessment of the current status of the Helwan Metro Station and its surrounding areas. This phase included a combination of site observations and field surveys to document key factors, including pedestrian and vehicle congestion, road accessibility, and the quality of public spaces. The assessment was also informed by previous field studies on passenger movement patterns and congestion issues within the station. Additionally, a GIS-based spatial analysis was conducted to assess the station's connectivity to multiple transit stops. This combination of qualitative and quantitative methods provided a comprehensive understanding of the station's transportation challenges and spatial constraints, facilitating the identification of possible solutions for subsequent phases of the study.

Third.Phase Three: Vision Formulation and Proposal Development:

This phase included vision formulation and proposal development. A comparative analysis of the Transport-Oriented Development (TOD) strategies identified in the first phase was used to adapt successful elements to Helwan's unique urban, social, and structural context. Insights from international case studies were used to ensure the relevance and feasibility of the proposed interventions. A flexible vision was then developed for relocating the Helwan Metro Station and transforming it into a multimodal, multi-use transportation hub. This proposal aligns with the principles of Transport-Oriented Development (TOD), focusing on improving transportation efficiency, enhancing environmental sustainability, and enhancing economic viability. The resulting strategic plan ensures that the proposed transformation is achieved in a sustainable and effective manner.

The study presents an adaptable, comprehensive development framework that addresses the Helwan region's transport demands effectively, while also stimulating environmental sustainability and economic growth. Furthermore, it offers a replicable model for TOD implementation in other areas of comparable urban environments. The study positions TOD as a strategic tool for achieving long-term sustainability, resilience, and enhanced livability in rapidly urbanizing environments

2. Literature Review on (TOD): Insights from Global Case Studies

Transit-Oriented Development (TOD) has emerged as a powerful framework for transforming urban spaces by integrating transportation systems with surrounding land use. This approach aims to reduce dependency on private vehicles, promote public transport, and enhance economic and environmental sustainability. Several international case studies demonstrate the effectiveness of TOD principles, offering valuable lessons for implementing similar strategies in cities like Cairo, particularly for the Helwan Metro Station redevelopment. The following case studies highlight successful TOD implementations and the strategies that contributed to their success.

2.1. Global Case Studies

2.1.1. Shinjuku Station and TOD in Tokyo, Japan

Shinjuku Station in Tokyo stands as one of the most complex and successful examples of TOD. As one of the busiest transport hubs globally, it integrates multiple transportation modes, including trains, buses, and subways, all within a dense urban environment. Shinjuku Station is located in the heart of Tokyo's business district, where multimodal transport facilitates ease of access to commercial, residential, and recreational spaces [3] [4].

2.1.2. The Metro de Santiago TOD Study in Chile

The Metro de Santiago, a rapid transit system serving Chile's capital, Santiago, is another notable example of TOD. The development of metro stations as central hubs for urban development has reshaped the city's transit landscape, focusing on improving accessibility, reducing traffic congestion, and enhancing public transport usage. Implementing similar

strategies could help align urban growth with public transport, reducing traffic congestion and increasing public transit use. The success of Santiago's TOD is largely attributed to the alignment of urban growth and public transportation, which has alleviated traffic congestion and improved accessibility [5].

2.1.3. The Hong Kong MTR and TOD Integration

Hong Kong is a global leader in TOD, with its Mass Transit Railway (MTR) system serving as a prime example of how public transport can be seamlessly integrated into urban development. The MTR system links transport with commercial, residential, and recreational areas, creating a cohesive urban environment. Hong Kong MTR's TOD model has proven highly successful in reducing congestion and increasing accessibility, providing a strong case for integrated transit-oriented development [6].

2.2. Lessons Learned from Global TOD Case Studies

The case studies reviewed highlight key strategies for transforming Helwan Metro Station, emphasizing the integration of metro stations into mixed-use developments, as seen in Shinjuku and Hong Kong, to create vibrant, sustainable urban spaces. Aligning urban growth with public transportation, as demonstrated in Santiago, supports economic development and environmental sustainability, while the use of multimodal transport systems, exemplified by Tokyo's Shinjuku Station, ensures seamless connectivity and reduces reliance on private vehicles. These global examples underscore the importance of a phased, comprehensive approach to Transit-Oriented Development (TOD) that incorporates urban, social, and infrastructural factors, providing valuable lessons for developing a sustainable, accessible, and economically vibrant Helwan Metro Station.

3. Research scope of study documentation

3.1. Documenting the study sample: Potential and Challenges

Helwan is a highly urbanized area located along the southern part of Greater Cairo, approximately 25 kilometres from downtown Cairo. Fig. ¹. [7]. It has developed into a densely populated area characterized by a mix of residential, industrial, and commercial functions. Helwan enjoys a strategic location; it serves as the southern entrance to Cairo. Fig. 2. It is an important node in the movement of people and goods from Upper Egypt to the capital, the Canal cities, the Delta, and even the North Coast. It is also located in close proximity to various industrial and economic transmission links with different parts of Cairo. The Helwan area exhibits a diverse urban fabric, reflecting a mix of planned and informal developments. The planned areas are characterized by regular street grids and organized layouts, often resulting from formal urban planning initiatives aimed at optimizing land use, infrastructure, and connectivity. Fig. 3. In contrast, the informal or "random" areas, with Irregular Street patterns without regulation Fig. 4. Typically driven by rapid urbanization, population growth, and socio-economic pressures. [8].



Fig. 1. Location of Helwan city in relation to Greater Cairo. [7]



Fig. 3. Regular urban fabric - in the main urban Fig. 4. Random urban fabric - in the urban block block of Helwan city [16]



Fig. 2. Administrative boundaries of Helwan city. [7]



on the outskirts of Helwan city [16]

- **3.2.** Helwan has some essential nodes and axes for transportation that give it greater accessibility: [9]
- The Autostrada Road connects Helwan directly to the core of Cairo to make transportation easier for passengers and goods with less cost regarding time and prices. Fig. 5.
- Ring Road: The ring road circles Greater Cairo and connects Helwan with the other suburbs to minimize travel time and enhance regional accessibility. Fig. 5.
- Middle Ring Road: another road to enhance connection with outer areas and decreases the pressure off the older roads. Fig. 5.
- Regional Ring Road: As a significant development, the Regional Ring Road project links Helwan with other governorates, making trade easier and increasing its potential in the national Transit network. Fig. 5.
- Assiut Desert Road: As a significant north-south transport corridor, the Assiut Desert Road bisects Helwan and connects Upper Egypt with the Nile Delta and the Mediterranean Sea, supporting regional mobility and economic integration. Fig. 5.



Fig. 5. Current and Proposed Road Network. [7]

Urban Challenges and Redevelopment Opportunities

Despite its strategic location, Helwan faces critical urban challenges, such as serious traffic congestion. Fig. 6. Environmental degradation, and an inadequate public transportation system. These challenges are aggravated by the lack of comprehensive urban planning that inhibits the potential of the district for sustainable development. [8]. That the provision of essential services is inherently tied to demand and environmental suitability. When a service is needed and the environment is conducive, it is imperative to organize its provision to ensure order and sustainability. Researches highlight that informal economic activities, such as street vending. Fig. ^V. Often emerge spontaneously in response to unmet demands in urban areas. This phenomenon is particularly evident near high-traffic transit hubs, such as metro stations or microbus stops, where the flow of passenger traffic creates a market for daily and urgent needs [10].



Fig. 6. Traffic congestion of cars and light transport vehicles in front of Helwan Metro Station [21]



Fig. 7. Street vendors and passengers crowd in front of Helwan Metro Station [18]

These challenges are particularly evident in the Helwan Metro Station area, the terminus of Cairo Metro Line 1. The station serves as a vital node connecting existing and future metro lines that interlink most neighbourhoods and suburbs of Greater Cairo. Fig. 8, Fig. 9. making

it a crucial transit hub for Helwan residents and surrounding areas such as 15th of May City, Tabin, El-Saff, Arab Ghoneim, and Arab Rashed [2].

The station's strategic role has led to overcrowding, exacerbated by the emergence of informal microbus stops operating without regulation. Additionally, the high volume of passengers has attracted street vendors who cater to commuters' needs through unregulated and illegal activities. This has intensified pedestrian congestion, worsened traffic flow, and contributed to elevated levels of air pollution and noise. In the absence of effective planning and regulation, such activities tend to occur in a disorganized manner, driven by the pressures of necessity. This can lead to challenges including congestion, safety hazards, and environmental degradation. Urban sustainability prioritizes minimizing pollution, managing traffic congestion, and enhancing urban liveability. Achieving these goals requires the development of efficient public transportation systems, strategically designed Transit hubs, and infrastructure that reduces environmental impacts. Research indicates that relocating Transit hubs from densely populated residential areas can significantly improve air quality, lower noise pollution, and enhance pedestrian safety [11]. Such interventions align with broader sustainability principles, promoting healthier urban environments and fostering more accessible mobility solutions.



Fig. 8. Existing Subway lines for Greater Cairo Metro. [14]



Fig. 9. Existing, Ongoing and Proposed Subway lines for Greater Cairo Metro. [7]

4. Concept and Objectives of Transit-Oriented Development (TOD)

4.1. Concept of Transit-Oriented Development (TOD)

Transit-Oriented Development (TOD) is a strategic urban planning framework that integrates transportation infrastructure with land use to create compact, and mixed-use urban environments. TOD focuses on developing areas around transit hubs such as metro stations, bus terminals, or railway stations, enabling efficient access to public transportation and reducing dependency on private vehicles. The concept seeks to balance the need for economic growth, environmental sustainability, and social inclusion while improving urban liveability.

4.1.1. Objectives of Transit-Oriented Development (TOD)

- Efficient use of public transport systems, supported by TOD principles, alleviates road congestion by encouraging a modal shift from private vehicles to public transit. [12]
- TOD stimulates economic activity by creating high-value, mixed-use developments around transit hubs. These areas attract businesses, investors, and residents, boosting local and regional economies. [12]
- Compact, walkable communities supported by TOD enhance quality of life by providing access to essential services, green spaces, and recreational opportunities within a short distance. [12]

4.1.2. Methodology for Selecting Relevant Global Case Studies

To identify the most relevant case studies for the transformation of Helwan Metro Station, it is essential to establish selection criteria that reflect both the unique challenges and opportunities presented by Helwan's urban environment. Given the context of Helwan's existing transportation infrastructure, population density, and the need for sustainable urban growth, the case studies that offer applicable lessons must align with the following criteria:

- Integration of Multimodal Transport: The selected case studies should demonstrate effective integration of different transportation modes (e.g., metro, bus, taxi, and pedestrian networks), which is crucial for improving connectivity and reducing reliance on private vehicles. Shinjuku Station in Tokyo and the Hong Kong MTR system provide exemplary models of multimodal integration, where seamless access between various transport options promotes efficiency and convenience for users [6] [3] [4].
- Mixed-Use Urban Development: The case studies illustrate the successful integration of metro stations into mixed-use developments, where transportation hubs are not only places for commuting but also foster vibrant commercial, residential, and recreational spaces. Shinjuku and Hong Kong are prime examples, where urban growth around transit stations has created dynamic, self-sustaining environments that attract both residents and businesses [6] [3] [4].
- Alignment with Sustainable Urban Growth: The selected case studies should provide evidence of urban development that aligns with sustainable growth principles, particularly in relation to environmental sustainability, economic vitality, and reduced traffic congestion. Santiago's Metro de Santiago project is an example of a successful TOD that have contributed to the reduction of congestion and the promotion of sustainable urban expansion [5].
- Feasibility in a Developing Context: The case studies should offer insights into the adaptability of TOD strategies in cities with varying levels of urban development, especially in contexts where rapid population growth and urban sprawl may pose challenges. The Metro de Santiago project provides valuable lessons for adapting TOD principles to developing or evolving urban contexts, where integrated transport systems can play a transformative role in shaping the city's growth [5].

4.2. Justification for Selected Case Studies

Based on the established criteria, the most relevant case studies for Helwan's metro station transformation are Shinjuku Station and Metro de Santiago. These case studies were chosen due to their direct applicability to Helwan's context, particularly in terms of multimodal

transport integration, alignment with sustainable urban growth, and the creation of mixed-use environments.

4.2.1. Study of Two Models for Helwan Metro Station Transformation

The primary objective of this study is to explore two case studies of successful Transit-Oriented Development (TOD) models-Shinjuku Station in Tokyo, Japan, and the Metro de Santiago in Chile. These models are analyzed in relation to their development methodology, economic and social returns, integration of multimodal transport, and contributions to sustainable urban revitalization. Insights from these case studies are then used to inform the proposed transformation of Helwan Metro Station in Cairo, Egypt, to create a sustainable and integrated urban space.

First. Shinjuku Station, Tokyo: A Global TOD Benchmark

The development objective of Shinjuku Station was to address the rapid urbanization and population growth in Tokyo, which required an efficient, multimodal transport hub that could reduce congestion, increase economic activity, and improve accessibility to the city center and surrounding areas. Shinjuku's TOD focuses on integrating transport infrastructure with mixed-use urban development to support both commercial and residential needs [3] [4].

- Development Areas: Shinjuku Station is located in one of Tokyo's busiest commercial districts. The station serves as a hub for multiple transport modes: railway, subway, bus, and pedestrian pathways. The integration of these systems with mixed-use development, including office spaces, retail areas, and residential buildings, has created a dynamic urban environment. The surrounding area has become a key economic center, contributing significantly to Tokyo's economy [3] [4]. Fig. 10.
- Economic and Social Returns: Shinjuku's TOD has led to substantial economic growth. The area surrounding the station has become a commercial and business center, attracting international and local businesses. This, in turn, has generated employment, boosted retail sales, and increased tax revenues for the city. Socially, Shinjuku provides a lively environment with easy access to essential services, leisure, and housing, which contributes to improved quality of life for residents and commuters. The development also supports a balanced, inclusive urban community by offering diverse residential and commercial spaces that cater to different income groups [3] [4].
- Transportation Solutions: Shinjuku Station's success lies in its seamless integration of different transport modes, reducing dependency on private vehicles. The station connects suburban areas to the city center efficiently, thus enhancing regional accessibility. The development of a pedestrian-friendly environment, with safe walkways and easy access to buses, trains, and subways, encourages non-motorized transport and alleviates traffic congestion [3] [4].
- Sustainable Development: Shinjuku's TOD approach aligns with sustainable urban growth by promoting public transport over private vehicle use, thereby reducing carbon emissions and air pollution. The integration of green spaces and energy-efficient buildings further supports environmental sustainability. Fig. 10. The focus on mixed-use development also minimizes urban sprawl and ensures efficient land use [3] [4].



Fig. 10. The development of a multimodal transport hub improved regional accessibility and transformed the surrounding area into a key economic centre. [19]

Second. Metro de Santiago, Chile: Aligning Urban Growth with Public Transport

The development objective of Metro de Santiago was to create a public transportation system that would improve urban mobility, reduce traffic congestion, and promote sustainable urban development. The city aimed to align urban growth with the expansion of the metro system to create interconnected, accessible neighborhoods [5].

- Development Areas: Metro de Santiago operates a comprehensive rapid transit system that connects various districts across Santiago. The development around metro stations focuses on mixed-use spaces, combining residential, commercial, and recreational facilities. This approach has led to the emergence of transit-oriented districts that are well-integrated into the wider urban fabric [5].
- Economic and Social Returns: The expansion of Metro de Santiago has led to a substantial reduction in traffic congestion and a significant increase in metro ridership. The area around metro stations has seen a rise in property values, attracting investment and promoting local economic activity. Socially, the metro system has improved accessibility, especially for lower-income populations, by providing affordable, reliable transport. The system has contributed to more equitable urban development, offering improved connectivity to underserved areas [5].
- Transportation Solutions: The metro stations in Santiago are strategically located in key urban areas, ensuring that they serve as hubs for various transport modes. The integration of the metro system with bus and pedestrian networks facilitates smooth, multi-modal transit options that are both efficient and sustainable. Additionally, the design of the stations and surrounding areas promotes walkability, reducing the need for private car usage and contributing to lower traffic volumes [5]. Fig. 11.
- Sustainable Development: The Metro de Santiago is a prime example of TOD contributing to sustainable urban growth. The metro system promotes public transport, reduces car dependency, and helps mitigate air pollution. The development around the stations is

planned to minimize urban sprawl and maximize land use, supporting the city's long-term sustainability goals. The inclusion of green spaces and the emphasis on walkability further enhance the environmental sustainability of the metro system [5].



Fig. 11. Integrating the metro network and surface stations with buses enhances walkability, green infrastructure, reduces private vehicle dependence, and promotes environmental sustainability. [20]

4.2.2. Applicability to Helwan Metro Station Relocation

Both Shinjuku Station and Metro de Santiago provide valuable lessons for the transformation of Helwan Metro Station. Shinjuku's success in integrating multimodal transport with mixeduse development offers a comprehensive model for creating a vibrant, sustainable urban space in Helwan. The development around Shinjuku Station has been a key factor in reducing congestion and enhancing economic activity, providing a roadmap for how Helwan can integrate various transport options to improve connectivity and accessibility.

Similarly, the Metro de Santiago's approach to aligning urban growth with public transport provides a solid foundation for transforming Helwan's surrounding areas into transit-oriented districts. By fostering a balance between public transport infrastructure and urban development, Helwan can reduce congestion, stimulate economic growth, and sustainable urban growth.

5. Application to Helwan Metro Station in Cairo

Helwan Metro Station presents a pivotal opportunity for the application of Transit-Oriented Development (TOD) principles. Currently situated within a residential area it faces significant

challenges, including overcrowding, traffic congestion, environmental degradation, and limited integration with the surrounding economic landscape. Redesigning and relocating the station in alignment with TOD principles could transform Helwan into a multifunctional, sustainable transit hub that advances Cairo's broader urban development goals.

5.1. Strategic Relocation

Relocating Helwan Metro Station strategically can address several urban challenges:

- Relocating the station can alleviate traffic congestion, noise, and air pollution in nearby residential areas, enhancing urban livability by minimizing disruptions.
- The new location should prioritize accessibility to commercial hubs and public services.
- Site selection criteria should include proximity to major roads, the availability of suitable land, and the potential for urban growth, fostering a dynamic business and community hub.
- The relocation and redevelopment can catalyze local economic growth by attracting businesses, creating jobs, and promoting investment, particularly in underserved areas.

5.2. Urban Mobility Challenges: A Case Study of Helwan Metro Station

Helwan Metro Station in Greater Cairo highlights the challenges faced by many transit hubs due to insufficient infrastructure and weak regulatory frameworks, resulting in congestion and unsafe conditions. This study examines the disparity between rising transportation and commercial demands and the area's limited infrastructure. By analyzing field survey data, it identifies passenger travel patterns and primary destinations, underscoring the necessity for comprehensive urban planning to optimize transportation, support economic activities, and improve the overall urban environment. The Helwan metro station area experiences persistent congestion and disorder due to insufficient urban planning to regulate minibus parking and traffic. Minibuses, the primary form of private mass transit, and light transport vehicles, such as tuk-tuks, contribute to unstructured traffic flows. Efforts to mitigate these problems, such as establishing a central parking lot (Tochka) 500 meters from the station, have had limited success, as unlicensed parking spaces are still found randomly and in scattered areas, as shown in Fig. 10. In addition, the poor infrastructure for commercial activities has led to the spread of street vendors who occupy traffic lanes, which has intensified congestion and created dangerous conditions for road users.



Fig. 12. Crowding rate in front of Helwan Metro Station in 2020 [15]



Fig. 13. Increase in congestion rate in front of Helwan Metro Station in 2023 [16]

This scenario underscores a systemic issue characterized by a misalignment between the growing demand for transportation and commercial services and the inadequacy of supporting infrastructure. The persistence and escalation of this problem, despite containment efforts, are evident in, Fig. 12. Which illustrates the congestion around the station in 2020, and its significant intensification by 2023, as shown in Fig. 13. Addressing these challenges necessitates comprehensive urban planning strategies to optimize transportation systems and seamlessly integrate commercial activities into the urban fabric. The integration of commercial functions into the urban fabric must be approached in a manner that complements and supports existing transportation systems. An analysis of the transportation network surrounding Helwan Metro Station reveals a broad and complex system of minibus routes that serve a wide range of destinations. These include the station's immediate residential surroundings, various suburban districts within Helwan City, newly developing urban zones, and more distant areas spanning several Egyptian governorates. Table 2 outlines these destinations in detail, reflecting the extensive reach and importance of this node in the regional transport system.

This diversity of destinations highlights the urgent need to establish a multimodal transportation centre at Helwan. Such a hub would integrate the metro with the surrounding minibus network and other public transit systems to enable seamless, efficient passenger transitions. Enhanced connectivity of this kind is essential to improving system performance and user experience, as well as to supporting urban development objectives.

Analysis of passenger distribution patterns reveals significant trends in commuter behavior. The 15th of May City accounts for the highest percentage of minibus passengers (29%), suggesting a strong residential base and a high volume of daily commuting. El-Saff follows with 17%, reflecting its regional connectivity and the role it plays in serving rural and periurban populations. Tabin represents 15%, likely due to the presence of industrial employment centers. The American Project, a smaller residential enclave, accounts for 5% of users. Notably, 11% of passengers are local Helwan residents, confirming the station's dual function

	Hub of Destinations on the path of metro lines	Governorate Hub	New Cities Hub	Suburban Hub	internal Hub
Destinations from Helwan	Helwan University	Beni Suef City	6th of October City	Tebbin, Steel	Atlas Arab Ghoneim ArabRashed
	Ma'asara.Tora	Fayoum City	New Cairo City Madinaty Rehab	ElSaff Atfih	
	Maadi, Dar El Salam	Minya City	15th of May City		
	Old Cairo	Assiut City	Badr City		
	Old and New El Marg.	Suez City	El Obour City		
	Ain Shams and Materia	Ismailia City	Cairo International Airport		
	Attab	Hurghada City			
	Abbassia	City Zaafarana			
	ElMonib.				
	Haram and Faisal Street				

 TABLE 2: Multiple destinations for independent bus passengers from Helwan. [13]

as both a regional hub and a local access point.

This diverse range of destinations underscores the necessity of developing a multimodal transportation center to enhance connectivity and operational efficiency. Such a center would integrate various modes of transportation, including metro services, minibuses, and other transit systems, ensuring seamless transitions for passengers.

6. Relocate Helwan Metro Approach for Sustainable Urban Integration

The proposed relocation and comprehensive redevelopment of Helwan Metro Station present a pivotal opportunity to implement the core principles of Transit-Oriented Development (TOD) within Cairo's evolving urban context. Drawing on the international best practices exemplified by Shinjuku Station in Tokyo and Metro de Santiago in Chile, this initiative seeks to address site-specific challenges such as traffic congestion, pollution, and urban overcrowding, while simultaneously advancing broader objectives of sustainable mobility, economic revitalization, and enhanced urban livability. By integrating proven strategies for creating a multimodal, sustainable, and economically dynamic transit hub, the project aspires to transform Helwan into a catalyst for local and regional development.

6.1. Relocation as a Strategic Response to Urban Congestion and Land Use Conflicts

Relocating Helwan Metro Station from a congested residential zone to an underutilized site near the Autostrada and Middle Ring Roads establishes the foundation for a multimodal urban center aligned with the principles of Transit-Oriented Development (TOD). Fig 14. This strategic move mirrors the placement of Shinjuku Station within a dynamic commercial district, reflecting a shared objective of alleviating urban congestion, preserving residential livability, and redistributing development intensity toward transit-accessible zones. The proposed location enhances connectivity with regional transportation corridors and enables the integration of multiple transit modes-including metro, bus, and microbus, and informal light transport-into a cohesive, high-capacity network. This approach not only promotes efficient, convenient intermodal transfers and reduces dependency on private vehicles but also replicates the success of global TOD benchmarks such as Shinjuku Station in Tokyo and the Hong Kong MTR in creating accessible, sustainable, and economically vibrant urban environments.

6.2. Multimodal Integration for Efficient and Inclusive Urban Mobility

The reimagined Helwan Station will function as a centralized hub incorporating key elements of sustainable urban mobility. These include:

- Regional bus stations to connect Helwan with remote governorates,
- Microbus terminals for underserved inner-city areas,
- Light transport modes (e.g., tuk-tuks) to provide last-mile solutions,
- Park-and-ride facilities to attract suburban users,
- Pedestrian pathways and dedicated bicycle lanes to support non-motorized mobility.

These components support TOD objectives by enabling sustainable, inclusive access to public transport, reducing greenhouse gas emissions, and encouraging modal shifts away from car

dependency. Furthermore, the proposed tunneling of the metro line between Ain Helwan and the new site ensures minimal surface disruption, facilitating seamless land use planning and uninterrupted connectivity across the urban fabric. This approach is consistent with TOD's goal of efficient land utilization and maintaining urban continuity. Fig 15. These elements directly reflect the multi-tiered connectivity achieved by both Shinjuku and Santiago, where successful TOD hinges on reducing dependency on private vehicles through diverse transport offerings and intuitive transfers. The inclusion of park-and-ride facilities further supports the behavioral shift toward public transit usage, mirroring the strategies adopted in Santiago to extend metro access to suburban and underserved populations.



Fig. 14. The proposed relocation of Helwan Metro Station to the development axis of the Multi-Modal Transport Centre (Downtown) and the commercial-investment zone. [16]

6.3. Mixed-Use Development and Urban Revitalization

Beyond its transportation function, the station's redevelopment includes the establishment of a mixed-use district incorporating residential, commercial, and cultural facilities. This reflects TOD's commitment to compact, walkable communities that offer essential services within a short distance, thus fostering a vibrant, pedestrian-friendly environment. Locating the station away from densely populated residential zones also mitigates congestion, noise, and air pollution, enhancing the quality of life and urban livability in line with global TOD strategies.

6.4. Economic Development and Regional Integration

The project is poised to catalyze regional economic growth by integrating Helwan into a broader metropolitan transit network. The station's proximity to major roadways-including the Assiut Desert Road, Cairo-Alexandria Desert Road, and Middle Ring Road-positions it as a regional transit hub, improving inter-governorate connectivity and facilitating smoother travel for populations in Upper Egypt, the Canal region, and the Delta. This regional integration not only enhances access to employment and services but also supports equitable urban development, another fundamental TOD objective.

Simultaneously, the surrounding area is envisioned to attract private investment in commercial retail, street vending, healthcare, and administrative services, generating employment in construction, transit, retail, and ancillary sectors. These developments

contribute to the economic stimulation outlined in TOD principles, positioning the station as a transformative anchor for regional urban regeneration. Fig 15.

The relocation and transformation of Helwan Metro Station serve as a replicable model for implementing TOD in Cairo and other rapidly urbanizing contexts. By linking land use with multimodal transport infrastructure and embedding sustainability into urban design, the proposal aligns with key TOD objectives-including congestion reduction, environmental improvement, economic stimulation, and enhanced regional connectivity. Ultimately, the project promises not only localized benefits for Helwan but also broader metropolitan impacts, contributing to Cairo's strategic vision of a more resilient, livable, and inclusive urban future.



Fig. 15. (Phase 1) Proposed schematic development axis for the multimodal transport hub and commercial-investment area. [16], [17]

6.5. Phased Development of the Helwan Metro Station for Sustainable Urban Growth

The transformation of Helwan into a regional mobility hub closely mirrors Santiago's approach, where metro expansion serves as a catalyst for peripheral urban development and enhanced accessibility to the city core. By connecting Helwan to major transportation corridors-such as the Assiut Desert Road, Cairo-Alexandria Desert Road, Autostrada Road, and Middle Ring Road-the project strategically extends the metropolitan transit network to previously underserved regions, thereby promoting spatial equity in access to employment, services, and urban opportunities. Similar to the outcomes observed in Metro de Santiago, the project is expected to stimulate increases in property values, commercial activity, and transit-oriented investment, generating long-term economic benefits and improving the quality of life for diverse population groups.

Importantly, the urban development associated with the relocation of Helwan Metro Station is structured to unfold in progressive, open-ended stages, allowing for multi-directional expansion into the extensive areas adjacent to the Autostrada and Middle Ring Roads. These vast zones offer considerable opportunities for diversified land uses, as outlined in the staged development framework shown in Fig. 16. Phase 2 envisions investment, recreational, and green spaces surrounding the core transit area, while Phase 3 focuses on industrial and commercial development along the Autostrada corridor. In Phase 4, a residential-service axis

is proposed to extend toward the Middle Ring Road, supporting balanced urban growth and functional integration.

The Helwan Metro Station redevelopment thus presents a comprehensive Transit-Oriented Development (TOD) model, anchored in multimodal connectivity, mixed-use urbanization, and sustainable economic and environmental practices. Beyond addressing current inefficiencies in Cairo's transportation system, this initiative positions Helwan as a strategic urban and regional hub. The adaptable, phased development plan not only enhances local livability and regional integration but also serves as a replicable pilot for TOD implementation across Greater Cairo and other rapidly urbanizing areas in Egypt.



Fig. 16. Proposed schematic development axis for the multimodal transport hub and commercialinvestment area. [16], [17]

7. Constraints and Considerations for Implementation

While the proposed relocation and redevelopment of Helwan Metro Station present a strategic opportunity to advance Transit-Oriented Development (TOD) in Cairo, several critical constraints must be acknowledged to ensure a comprehensive and realistic understanding of the project's feasibility. These limitations span financial, social, environmental, and legislative domains, each of which requires further specialized study and coordinated planning among stakeholders.

• Financial Constraints: The proposed relocation and infrastructure development require substantial investment, including tunneling operations, multimodal hub construction, land acquisition, and utility realignment. While long-term economic benefits are anticipated, the initial financial burden may exceed public funding capacity, necessitating private-sector engagement, public-private partnerships (PPPs), or international development financing. A detailed financial feasibility study is essential to assess cost implications and identify viable funding mechanisms.

- Social Constraints The relocation strategy aims to alleviate pressure on densely populated areas; however, shifting the station location may disrupt existing user patterns and informal transport economies. Potential displacement of local activities and community adjustments during construction phases necessitate inclusive planning, public consultation, and transitional support to mitigate social impacts and promote equitable outcomes.
- Environmental Constraints: Although the project supports reduced car dependency and improved air quality, construction phases-especially tunneling-pose temporary environmental risks such as soil disturbance, noise, and emissions. A comprehensive Environmental Impact Assessment (EIA) is essential to evaluate these risks, recommend mitigation strategies, and ensure environmental compliance.
- Legislative and Institutional Constraints Effective implementation depends on alignment with urban planning regulations, transportation policies, and land use laws. Legislative issues related to land ownership, zoning, and inter-agency coordination could delay execution. Collaboration among government ministries, municipal authorities, and transport agencies is crucial for overcoming these barriers and ensuring coordinated governance.

While this research does not extend to specialized infrastructure studies-such as soil analysis or detailed facility mapping-it recognizes their importance in evaluating the project's feasibility. Comparable precedents in more complex and densely populated areas, such as Faisal and Shubra, are noted. The proposed relocation route, which passes beneath a main road rather than residential zones, is expected to minimize potential risks and facilitate future technical assessments by the appropriate authorities.

8. Conclusions

The relocation and phased redevelopment of Helwan Metro Station represent a transformative opportunity to embed Transit-Oriented Development (TOD) principles within Cairo's evolving urban framework. By shifting the station to an underutilized site near the Autostrada and Middle Ring Roads, the project initiates a strategically phased urban development process that extends beyond transportation infrastructure into integrated land use planning, economic revitalization, and spatial equity. In alignment with the multidimensional outcomes outlined in the proposal, the anticipated results include:

- Urban Decongestion and Livability: Relocating the station away from dense residential zones mitigates localized congestion, air pollution, and noise, thereby enhancing environmental quality and neighborhood livability.
- Multimodal Accessibility and Reduced Car Dependency: Seamless integration of metro, regional bus, microbus, light transport, and non-motorized mobility networks promotes convenient and equitable access while reducing reliance on private vehicles-key TOD objectives mirrored in international models such as Shinjuku and Santiago.
- Economic and Spatial Integration: The station's proximity to major transportation corridors supports regional connectivity and inclusive access to jobs and services. Surrounding development, staged across multiple phases, introduces a balanced mix of

functions-including green and recreational zones (Phase 2), industrial-commercial corridors (Phase 3), and residential-service expansions (Phase 4)-ensuring flexible, multidirectional urban growth.

- Replicability and Policy Alignment: As a replicable TOD model, the Helwan project aligns with Egypt's broader urban sustainability goals, contributing to national climate objectives and offering a scalable strategy for equitable urban transformation.
- The Helwan Metro Station redevelopment advances a holistic vision of sustainable urban growth, anchored in connectivity, inclusivity, and resilience, while offering a dynamic pilot for TOD-led planning in Greater Cairo and beyond.

Although this study does not include technical infrastructure analyses such as geotechnical or utility mapping, it recognizes their critical role in future feasibility assessments. Lessons from dense urban areas like Faisal and Shubra underscore the need for integrated planning. The selected route, beneath a main road rather than residential zones, is expected to minimize risks and ease future evaluations. Successful implementation of the Helwan TOD proposal depends on addressing its complex constraints through targeted studies, stakeholder coordination, and robust financial planning, with specialized assessments essential to ensuring technical feasibility and maximizing socio-economic and environmental benefits.

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