

Reducing Carbon Emissions in the Municipality of Alexandria through Intelligent and Sustainable urban Mobility Infrastructure

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Abstract

The paper presents the integrated smart-mobility project implemented by the Municipality of Alexandria under the South-Muntenia Regional Programme 2021–2027, aimed at reducing carbon emissions through the development of intelligent and sustainable urban mobility infrastructure. The research addresses the increasing need for medium-sized cities to adapt to European climate-neutrality objectives by integrating ecological transport systems, digital traffic management technologies and resilient urban infrastructure into local development strategies. The study builds on recent approaches regarding smart-city governance, sustainable urban mobility planning and intelligent transport systems, emphasizing the role of digital technologies in improving urban resilience, public-service efficiency and environmental sustainability. The paper uses a case-study approach based on the implementation of a complex urban mobility investment project financed through European funds, combining infrastructural interventions with intelligent urban-management systems. The project includes approximately 14.6 km of bicycle lanes, a public bike-sharing system with 300 bicycles and 22 automated stations, modernization of 32 public transport stations, implementation of an intelligent traffic-management and video-surveillance system using 96 cameras and 15 prioritized signalized intersections, construction of a modern bus depot, a Park&Ride facility with 200 parking spaces and modernization of pedestrian infrastructure. The results highlight the contribution of integrated mobility solutions and real-time urban monitoring technologies to reducing traffic congestion, improving mobility flows, increasing public-transport accessibility and supporting data-driven administrative decision-making processes. The study also underlines the challenges related to interoperability between intelligent systems, institutional coordination and the integration of local urban policies into broader European sustainability objectives. The paper contributes to the current academic and professional debate on sustainable urban development by presenting a practical model for implementing smart and low-carbon mobility infrastructure in medium-sized municipalities, demonstrating the role of digital urban technologies in supporting resilient and environmentally responsible cities.

Keywords: sustainable urban mobility, smart city, intelligent infrastructure, traffic management, carbon emission reduction, bike-sharing, ITS systems, urban resilience, ecological public transport, digital urban monitoring.

1. Introduction

European cities are increasingly required to adopt sustainable and climate-resilient urban development strategies in response to the environmental challenges generated by traffic congestion, fossil fuel dependency and urban pollution. Within this context, medium-sized municipalities face the challenge of modernizing mobility infrastructure while simultaneously improving accessibility, reducing greenhouse gas emissions and integrating digital technologies into urban management processes.

The Municipality of Alexandria has initiated a large-scale integrated mobility project financed through the South-Muntenia Regional Programme 2021–2027. The project

represents a strategic intervention designed to transform the local transport system into a more sustainable, intelligent and citizen-oriented urban mobility network.

The project combines investments in pedestrian infrastructure, cycling infrastructure, intelligent traffic management systems and modern public transport facilities. The integration of these components supports the transition toward a low-carbon urban model aligned with European Green Deal objectives and Sustainable Urban Mobility Plan principles.

2. General Objectives of the Project

The project aims to improve urban mobility conditions and increase the quality of life by promoting sustainable and environmentally friendly transport solutions. The main objectives include:

- reducing greenhouse gas emissions generated by urban traffic;
- encouraging active mobility through cycling and pedestrian accessibility;
- improving public transport efficiency and attractiveness;
- implementing intelligent traffic-management systems;
- increasing urban safety through digital monitoring technologies;
- supporting behavioral change toward sustainable mobility practices;

The implementation period of the project is between 27 August 2024 and 31 December 2025, with a total investment value of €15,309,301.94, financed through European Union funds, national budget allocations and local government contributions.

3. Development of Pedestrian Infrastructure

3.1. Urban Accessibility and Walkability

One of the central components of the project is the modernization of pedestrian infrastructure in order to improve urban accessibility, safety and walkability. Contemporary urban planning policies increasingly recognize pedestrian mobility as a key factor in sustainable city development, contributing to reduced car dependency, healthier lifestyles and improved urban environmental quality[1].

Within the project, approximately 28,132 square meters of pedestrian areas are being modernized, particularly along Libertății Street, one of the city's major urban corridors. The intervention includes:

- rehabilitation of sidewalks and pedestrian pathways;
- installation of accessible pedestrian crossings;
- modernization of urban public spaces;
- improvement of street lighting and urban furniture;
- adaptation of pedestrian infrastructure for persons with reduced mobility;

These interventions contribute to the creation of a more inclusive, safe and environmentally sustainable urban environment, while also enhancing the overall attractiveness and functional connectivity of the city.



Fig. 1. (a) before rehabilitation; (b) the project
Source: archive of the Alexandria city hall



Fig. 2. after rehabilitation;
Source: archive of the Alexandria city hall

3.2. Social and Environmental Impact

The modernization of pedestrian infrastructure contributes to reducing urban fragmentation and increasing accessibility to public services, educational institutions and commercial areas. Improved pedestrian conditions encourage walking as an alternative mode of transport, reducing short-distance vehicle use and associated carbon emissions.

From an environmental perspective, pedestrian-oriented urban design supports the reduction of noise pollution and improves urban air quality. At the same time, the creation of attractive pedestrian spaces contributes to urban regeneration and increased social interaction within the city. [2]

4. Development of Cycling Infrastructure

4.1. Sustainable Cycling Network

The cycling infrastructure component represents one of the most significant investments within the project. The Municipality of Alexandria aims to transform cycling into a viable and attractive alternative to private car usage by developing an integrated and safe bicycle network.

The project includes the construction of 14,625 meters of dedicated bicycle lanes strategically connected to residential areas, educational facilities, public institutions and transport hubs. The cycling lanes are designed according to European standards regarding urban cycling safety and accessibility.

4.2. Public Bike-Sharing System

In addition to the cycling lanes, the project introduces a modern bike-sharing system consisting of:

- 300 public bicycles;
- 22 automated bike-sharing stations;
- 15 stations with 20 docking places;
- 7 stations with 40 docking places;

The bike-sharing system is digitally managed and integrated into the city's smart mobility infrastructure, enabling real-time monitoring of bicycle availability and usage patterns.



Fig. 3. Public bike-Sharing System;
Source: archive of the Alexandria city hall

4.3. Environmental and Behavioral Benefits

The promotion of cycling contributes directly to the project objective of reducing greenhouse gas emissions by approximately 5.2%. By encouraging active mobility, the municipality supports healthier lifestyles, lower fuel consumption and decreased urban congestion.

Cycling infrastructure also improves urban connectivity and offers affordable mobility solutions for different social categories, including students, commuters and tourists. The project therefore contributes not only to environmental sustainability but also to social inclusion and economic accessibility.



Fig. 4. Cycling infrastructure;
Source: archive of the Alexandria city hall

5. Development of Public Transport Infrastructure and the Bus Depot

5.1. Modernization of Public Transport Facilities

An important dimension of the project involves strengthening the city’s public transport infrastructure. Public transport systems are essential for sustainable urban mobility because they reduce private car dependency and optimize urban traffic flows.

The project includes the construction or modernization of 32 public transport stations equipped with modern passenger-information systems, improved accessibility conditions and enhanced passenger comfort [3].



Fig. 5. The purchase of new buses;
Source: archive of the Alexandria city hall

5.2. Construction of the New Bus Depot

A major infrastructural investment within the project is the construction of a new modern bus depot with a total area of 2,333 square meters. The facility includes:

- a 940-square-meter administrative building;
- a 613-square-meter maintenance and washing facility;
- 16 parking spaces for buses covering 780 square meters;

The bus depot is designed to improve operational efficiency, vehicle maintenance capacity and service reliability for the municipal public transport operator.



Fig. 6. The design phase;
Source: archive of the Alexandria city hall

5.3. Park & Ride Facility

The project also includes the development of a Park & Ride facility with:

- a total area of 5,560 square meters;
- 200 parking spaces;

The Park & Ride system encourages commuters entering the city to transition from private vehicles to public transport, thereby reducing traffic congestion in central urban areas.



Fig. 7. The design phase;
Source: archive of the Alexandria city hall



Fig. 8. During execution;
Source: archive of the Alexandria city hall



Fig. 9. During execution;
Source: archive of the Alexandria city hall

5.4. Smart Traffic Management and ITS Systems

To support efficient public transport operations, the project integrates Intelligent Transport Systems (ITS), including:

- traffic prioritization systems in 15 signalized intersections;
- installation of 96 video-surveillance cameras;
- real-time traffic monitoring technologies;
- digital traffic-flow management systems;

The intelligent traffic-management system enables better synchronization of traffic flows, reduced travel times and improved road safety conditions. Additionally, the collected urban mobility data supports evidence-based administrative decision-making and long-term urban planning strategies.

6. Public Awareness and Behavioral Change

Beyond physical infrastructure investments, the project includes public-awareness campaigns aimed at promoting sustainable mobility and environmentally responsible behavior. The educational component focuses on:

- increasing public awareness regarding the environmental impact of fossil fuel consumption;
- promoting cycling and active mobility;
- encouraging the use of public transport;
- supporting healthier and more sustainable urban lifestyles;

Behavioral change is considered essential for the long-term success of sustainable urban mobility policies. Infrastructure investments alone cannot generate significant environmental improvements without corresponding social adaptation and citizen participation.

7. Conclusions

The integrated mobility project implemented by the Municipality of Alexandria represents a practical example of sustainable urban transformation in medium-sized European cities. By combining pedestrian modernization, cycling infrastructure, intelligent traffic systems and modern public transport facilities, the municipality advances toward a low-carbon and digitally integrated urban model.

Table 1. Main Components of the Integrated Smart Mobility Project in Alexandria

Project Component	Main Interventions	Technical Indicators
Pedestrian Infrastructure	Modernization of sidewalks and pedestrian areas	28,132 m ² of rehabilitated pedestrian infrastructure
Cycling Infrastructure	Construction of bicycle lanes	14,625 meters of dedicated bicycle lanes
	Installation of automated bicycle-sharing stations	300 bicycles and 22 automated stations
Public Transport Infrastructure	Modernization and construction of bus stations	32 modernized public transport stations
Bus Depot Development	Construction of a modern operational bus depot	2,333 m ² total area, including administrative and maintenance facilities
Park & Ride Facility	Development of intermodal parking infrastructure	5,560 m ² area with 200 parking spaces
Smart Traffic Management	Intelligent traffic monitoring and prioritization systems	15 signalized intersections with traffic prioritization
Urban Video Surveillance	Real-time traffic and safety monitoring	96 video surveillance cameras installed
Environmental Objectives	Reduction of greenhouse gas emissions	Estimated reduction of 5.2% in CO ₂ emissions
Public Awareness Campaigns	Promotion of sustainable mobility behavior	Educational and environmental awareness activities

Source: Municipality of Alexandria, Integrated Sustainable Urban Mobility Project financed under the South-Muntenia Regional Programme 2021–2027

The project demonstrates how European funding mechanisms can support local climate action and urban resilience objectives through integrated infrastructure investments and smart-city technologies. At the same time, the case study highlights the importance of institutional coordination, interoperability between digital systems and citizen engagement in achieving sustainable mobility goals.

Through the implementation of intelligent urban-management solutions and environmentally friendly transport infrastructure, Alexandria is positioning itself as a greener, smarter and more accessible city aligned with European sustainability and climate-neutrality strategies.

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