



**NORO GREEN CITIES**  
Smart Future

# Mapping Smart City Solutions Report

**NORO GREEN CITIES Project**  
**NORwegian - ROManian GREEN Cooperation Initiatives Towards**  
**Innovation and Environmental Sustainability**

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<https://oceanopolis.no/noro/>

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## 1. Executive Summary

This document aims to map existing and in-progress smart city solutions in Romania, specifically those contributing to sustainability and addressing key urban challenges.

By identifying and analysing these solutions, the document will provide insights into the current digital landscape within Romanian urban areas, highlighting areas where smart city initiatives are already making an impact, as well as opportunities for future development. The information gathered will serve as a foundation for informed decision-making, collaboration, and innovation in the NORO Green Cities project.

### Objectives of Mapping Smart City Solutions in Romania

- To **identify and categorize** current smart city solutions across Romania, focusing on enhancing sustainability and addressing urban issues such as waste management, energy efficiency, mobility, and citizen engagement.
- To **assess the progress and effectiveness** of these solutions in contributing to green and smart city objectives within local government and public administration.
- To **highlight gaps and areas of opportunity** for implementing new digital solutions or enhancing existing ones, facilitating the alignment of efforts with NORO Green Cities' strategic goals.
- To **create a knowledge base** that will enable public and private stakeholders to leverage best practices and foster innovation through potential collaborations.

### Expected Outcomes and Impact on the NORO Project and Participating Regions

- **Enhanced Strategic Planning:** The findings will enable participating regions to better understand the smart city ecosystem, informing strategies that align with sustainability goals and local needs.
- **Strengthened Public-Private Partnerships:** By mapping current solutions and identifying key players, the document will encourage collaboration between municipalities, technology providers, and business partners to co-develop solutions.
- **Knowledge Sharing and Capacity Building:** Insights from successful projects will be shared among stakeholders, encouraging the adoption of proven practices across municipalities.
- **Accelerated Digital Transformation:** The map of digital solutions will serve as a blueprint for regions looking to adopt or scale up smart city technologies, directly contributing to the NORO Green Cities project's mission of promoting green, sustainable urban development.

This document will thus be a key resource, fostering a collaborative, innovative approach to sustainable urban planning and digital integration in Romania.

## 2. Introduction

The **NORO Green Cities** project is a collaborative initiative aimed at advancing green, sustainable urban development across participating regions in Romania. The project fosters partnerships between public authorities, technology providers, and environmental organizations to design and implement solutions that enhance urban resilience and sustainability. By aligning with EU green transition goals, NORO Green Cities is dedicated to creating smarter, more sustainable urban spaces, where digital innovation meets environmental responsibility to improve the quality of life for residents.

### **Importance of Smart City Solutions in Addressing Urban Challenges and Improving Sustainability**

Smart city solutions play a vital role in addressing today's urban challenges, such as resource management, pollution, mobility, and citizen engagement. These digital solutions provide municipalities with real-time data, predictive capabilities, and enhanced connectivity, empowering them to make informed, sustainable decisions. For instance, smart waste management systems reduce environmental impact, while intelligent transportation networks decrease congestion and emissions. By implementing these solutions, cities can achieve higher levels of efficiency, reduce their carbon footprint, and foster a healthier, more sustainable urban environment that meets the needs of modern citizens.

### **Brief on Methodology for Mapping Existing and In-Progress Digital Solutions**

The mapping of smart city solutions within this document follows a systematic methodology designed to capture a comprehensive picture of the current digital landscape in Romania. This process includes:

- **Data Collection:** Information is gathered through a combination of surveys, interviews with key stakeholders, and review of available public and private reports.
- **Categorization:** Solutions are categorized by their functional areas (e.g., mobility, energy, waste management) and assessed for their alignment with sustainability and smart city objectives.
- **Analysis of Solution Effectiveness:** Solutions are analysed based on their scalability, effectiveness, and potential for replication across other municipalities.
- **Identification of Key Players and Partnerships:** The methodology involves mapping the main stakeholders, including technology providers, local governments, and NGOs, to understand the collaborative landscape supporting these solutions.

This approach ensures that the resulting map provides a well-rounded view of Romania's smart city initiatives, pinpointing both achievements and opportunities for growth in sustainable urban innovation.

## 3. Methodology

### Data Collection Process

The data collection process for mapping smart city solutions includes three main approaches to ensure a comprehensive understanding of both implemented and in-progress projects:

1. **Surveys and workshops:** three structured surveys are distributed to local public authorities (LPAs), technology providers, and relevant NGOs. The surveys gather quantitative and qualitative data on existing and planned digital solutions, including information on implementation stages, functionality, cost, and perceived impact on sustainability.
2. **Secondary Research:** Public reports, case studies, and academic articles are reviewed to supplement primary data and provide context on trends in smart city solutions. This research helps in benchmarking local initiatives against best practices and innovations seen globally, particularly within the EU.

By combining these methods, the data collection process yields a robust and multifaceted view of the smart city solutions landscape in Romania.

### Criteria for Selecting Smart City Solutions

To ensure that the mapped solutions align with the goals of the NORO Green Cities project, the following selection criteria are applied:

1. **Scalability:** Solutions must have the potential to scale, either within the municipality where they were first implemented or to other regions, thereby increasing their impact across a broader area.
2. **Impact on Sustainability:** Only solutions with measurable or projected impacts on sustainability will be included. This encompasses initiatives that reduce emissions, increase energy efficiency, improve waste management, or otherwise contribute to environmental resilience.
3. **Integration with LPA Operations:** Solutions that can be integrated into existing local public authority workflows or enhance LPA capacity are prioritized. These include solutions that streamline public services, improve governance, or facilitate real-time data sharing and analysis.
4. **Innovation and Technological Advancement:** Projects that incorporate advanced technologies (e.g., IoT, AI, renewable energy systems) and represent innovative approaches to urban challenges will be highlighted.
5. **Community and Stakeholder Engagement:** Solutions that actively involve citizens or engage multiple stakeholders, such as public-private partnerships, are given preference, as they contribute to a more participative urban environment.

## Definition and Categorization of Smart City Solutions

To organize and analyse the smart city solutions systematically, they are defined and categorized based on the following dimensions:

1. **Sustainability Goals:** Solutions are grouped according to their primary sustainability objectives, such as emissions reduction, waste reduction, or energy efficiency. This categorization helps link each solution with the specific environmental benefits it aims to achieve.
2. **Technology Used:** Solutions are also classified based on the technologies they employ, such as Internet of Things (IoT) for data collection, artificial intelligence (AI) for predictive analytics, renewable energy sources, or blockchain for secure data management. Categorizing by technology highlights the technological landscape and helps identify gaps or areas for further innovation.
3. **Functional Areas:** Solutions are organized into functional areas commonly addressed in smart city planning, including:
  - **Mobility and Transport:** Covers systems like smart traffic lights, public transit optimization, EV infrastructure, and bike-sharing.
  - **Energy and Utilities:** Includes smart grids, energy-efficient building solutions, and renewable energy systems.
  - **Waste and Water Management:** Focuses on digital systems for waste collection, recycling, and water quality monitoring.
  - **Citizen Engagement and Governance:** Solutions that enhance citizen participation, public services, and governance efficiency.
  - **Public Safety and Security:** Encompasses urban surveillance, emergency response systems, and other safety-enhancing technologies.
  - **Environment and Health Monitoring:** Solutions for monitoring air quality, water quality, noise pollution, and public health metrics.

## 4. Mapping of Existing Digital Solutions in Romania

### 4.1 Socio-Economic Context of Romania

To better understand the implementation of digital solutions in Romania, it is essential to analyze the country's socio-economic context. This section provides an overview of key economic and demographic indicators, highlighting the opportunities and challenges for Smart City development.

## *Economic indicators*

### **Gross Domestic Product (GDP):** <sup>1</sup>

- **Total GDP:** In the third quarter of 2024, Romania's GDP amounted to 446.176 billion lei at current prices, based on seasonally adjusted data.
- **GDP per capita:** During the same period, GDP per capita was approximately 4,705 USD.

### **Economic Growth Rate:** <sup>2</sup>

- In the third quarter of 2024, Romania's GDP stagnated compared to the previous quarter and recorded a 0.1% decrease compared to the same period in 2023.
- In the first nine months of 2024, GDP grew by 0.8% compared to the same period in 2023, both in gross and seasonally adjusted terms.

These figures reflect Romania's moderate economic performance in 2024, highlighting a period of stabilization amid external and internal challenges, with opportunities for growth supported by targeted investments and reforms.

## *Demography and Urbanization*

### **Percentage of the population living in urban areas:**

As of January 1, 2024, Romania's resident population was 19,064,409 people, of which 9,898,000 (approximately 51.9%) lived in urban areas<sup>3</sup>.

### **Relevant demographic changes:**

- **Population aging:** <sup>4</sup>

The share of individuals over 65 years increased from 19.7% in 2023 to 20% in 2024, while the proportion of children under 14 years remained steady at 16.2%.

- **Demographic dependency ratio:** <sup>5</sup>

This indicator, which reflects the number of young and elderly individuals per 100 working-age adults, rose from 56.0 in 2023 to 56.8 in 2024, indicating increased pressure on the active population to support the inactive.

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<sup>1</sup> <https://www.agerpres.ro/economic-intern/2024/08/30/ins-populatia-rezidenta-a-romaniei-a-crescut-cu-9-900-de-persoane-la-1-ianuarie-2024--1347516?utm>

<sup>2</sup> <https://www.mediafax.ro/economic/pib-ul-romaniei-a-scazut-cu-0-1-in-trimestrul-iii-2024-fata-de-trimestrul-precedent-22595196?utm>

<sup>3</sup> <https://www.agerpres.ro/economic-intern/2024/08/30/ins-populatia-rezidenta-a-romaniei-a-crescut-cu-9-900-de-persoane-la-1-ianuarie-2024--1347516?utm>

<sup>4</sup> <https://adevarul.ro/stiri-interne/societate/cati-oameni-traiesc-in-romania-populatia-a-2385062.html?utm>

<sup>5</sup> <https://adevarul.ro/stiri-interne/societate/cati-oameni-traiesc-in-romania-populatia-a-2385062.html?utm>



- **International migration:** <sup>1</sup>

The net migration balance for long-term temporary international migration was positive, with 81,988 people in 2024, contributing to a slight increase in the resident population.

These figures highlight current demographic trends in Romania, emphasizing challenges related to population aging and maintaining a balance between the active and dependent population.

### *Mobility and Infrastructure*

#### **Increase in car ownership:**

- **New cars:** <sup>2</sup>

In 2024, 151,105 new cars were registered in Romania, representing a 4.49% increase compared to 2023.

- **Second-hand cars:** <sup>3</sup>

328,834 second-hand cars were registered, marking a 4% increase compared to the previous year.

- **Hybrid cars:** <sup>4</sup>

Registrations of hybrid vehicles grew by 35% in 2024, indicating a rising interest in sustainable mobility.

#### **Other transport infrastructure data:**

- **High-speed roads:** <sup>5</sup>

197 km of high-speed roads were opened to traffic in 2024, including 100 km as part of the A7 Motorway.

- **Highways and expressways:** <sup>6</sup>

A record 200 km of highways and expressways were completed in 2024, surpassing the previous record from 2013 of 118 km.

<sup>1</sup> <https://www.agerpres.ro/economic-intern/2024/08/30/ins-populatia-rezidenta-a-romaniei-a-crescut-cu-9-900-de-persoane-la-1-ianuarie-2024--1347516?utm>

<sup>2</sup> [https://economedia.ro/inmatricularile-de-autoturisme-noi-in-romania-au-crescut-cu-45-in-2024-fata-de-2023-topul-celor-mai-populare-marci.html?utm\\_source=chatgpt.com&uord=kV4eJrFwhWRhTm5GRVhkLSVS9wkunfJTkdY0lchuUuivsWNfI6CPPF2KSDtQXv2VpItVsm2uk4i3MtJxpkROQVKPRV0IMy7R9Y1ulvRWxjyZkpyeHue9gGUpTneUQ\\_swZS1%3DQY4z](https://economedia.ro/inmatricularile-de-autoturisme-noi-in-romania-au-crescut-cu-45-in-2024-fata-de-2023-topul-celor-mai-populare-marci.html?utm_source=chatgpt.com&uord=kV4eJrFwhWRhTm5GRVhkLSVS9wkunfJTkdY0lchuUuivsWNfI6CPPF2KSDtQXv2VpItVsm2uk4i3MtJxpkROQVKPRV0IMy7R9Y1ulvRWxjyZkpyeHue9gGUpTneUQ_swZS1%3DQY4z)

<sup>3</sup> <https://ziare.com/masini-second-hand/romanii-cumparat-noi-marci-preferate-1915427?utm>

<sup>4</sup> <https://economedia.ro/inmatricularile-de-autoturisme-noi-in-romania-au-crescut-cu-45-in-2024-fata-de-2023-topul-celor-mai-populare-marci.html>

<sup>5</sup> <https://www.mediafax.ro/politic/sorin-grindeanu-2024-un-an-cu-rezultate-fara-precedent-pentru-infrastructura-de-transport-22629421>

<sup>6</sup> <https://www.capital.ro/record-istoric-pentru-romania-cati-km-de-autostrada-si-drum-expres-s-au-inaugurat-in-2024.html>



These developments highlight Romania's ongoing efforts to enhance its road network and support national mobility.

## 4.2 Overview of Digital Solutions Landscape

This section provides a comprehensive analysis of the current digital solutions landscape in Romanian cities, highlighting key trends, regional disparities, and areas of concentration. Understanding these aspects is essential for identifying both thriving smart city initiatives and existing gaps, offering valuable insights into potential opportunities for future development and investment.

The summary of the main identified Smart City solutions is as follow:

Project Name	Category	Objective	Location	Status
<b>Smart Mobility Hub</b>	Urban Mobility	Optimize urban transportation and reduce congestion	București	In Testing Phase
<b>Data-Driven Waste Management System</b>	Waste Management	Optimize waste collection routes and improve recycling	Cluj-Napoca	Pilot Program
<b>Smart Street Lighting and Energy Efficiency Initiative</b>	Energy Efficiency	Enhance energy savings and public safety	Iași	In Progress
<b>Coastal Environmental Monitoring System</b>	Environmental Monitoring	Protect coastal ecosystems and monitor water quality	Constanța	Ongoing
<b>Smart Health Monitoring Stations</b>	Public Health	Monitor health indicators and improve public health	Timișoara	Initial Stages
<b>Digital Cultural Heritage Platform</b>	Cultural Heritage	Preserve and promote cultural heritage	Sibiu	Development Phase
<b>Smart Emergency Response System</b>	Emergency Response	Enhance emergency response and public safety	Brașov	Fully Implemented

<b>Citizen Engagement Platform</b>	Citizen Engagement	Improve citizen engagement and municipal services	Oradea	Operational
<b>Renewable Energy-Powered Public Transport System</b>	Sustainable Transport	Reduce emissions and promote sustainable mobility	Ploiești	Pilot Phase

### General Trends in Digital Solutions for Cities in Romania

#### 1. Growth in Smart Mobility Solutions:

- Romanian cities are increasingly adopting smart mobility initiatives such as public transport optimization, electric vehicle (EV) charging stations, and bike-sharing systems.
- Notable examples include Bucharest, Cluj-Napoca, and Timișoara, where digital platforms for real-time fleet management and mobile apps for public transit information have been implemented.
- *PNRR (National Recovery and Resilience Plan) Component 6* supports smart mobility projects by funding the development of intelligent traffic management systems and electric mobility infrastructure.

#### 2. Expansion of E-Governance Platforms:

- Many Romanian municipalities are investing in e-governance platforms to simplify public service access, such as online tax payments, permit applications, and information portals
- This shift is supported by the *National Urban Development Strategy* and e-governance regulations aimed at increasing transparency and reducing bureaucracy.
- *PNRR (National Recovery and Resilience Plan) Component 7* provides funding for digital platforms designed to enhance public service accessibility and promote transparent governance.

#### 3. Focus on Environmental Monitoring and Management:

- Increasing public awareness of environmental issues has led to the adoption of digital solutions for air quality monitoring, waste management optimization, and water quality control.
- Cities such as Bucharest and Brașov have installed IoT sensors that monitor pollutants like PM2.5, PM10, and CO2 in real time, providing public access to pollution data and supporting rapid intervention when needed.

- *PNIESC (National Integrated Energy and Climate Plan)* encourages the use of IoT sensors for real-time pollution monitoring and the development of data-driven environmental strategies.

#### 4. Adoption of Energy Efficiency Solutions:

- Energy efficiency projects are on the rise, including the modernization of public lighting with smart LED systems and the implementation of energy management technologies in public buildings.
- The *PNIESC (National Integrated Energy and Climate Plan)* promotes these measures, with incentives for installing solar panels and smart HVAC systems in public infrastructure.

#### 5. Increasing Use of Data-Driven Public Safety Solutions:

- Cities are investing in public safety technologies such as CCTV networks with AI-powered facial recognition and real-time emergency response systems.
- Bucharest has implemented a smart surveillance system that uses behavioural analysis to detect potential threats, while Timișoara utilizes IoT sensors to enhance emergency response times.
- *PNRR (National Recovery and Resilience Plan)* Component 7 includes funding for public safety solutions, such as smart surveillance systems and integrated emergency response networks.

### *Overview of Regional Disparities and Concentrations of Digital Solutions*

#### 1. Concentration of Smart City Initiatives in Major Urban Centres:

- Romania's largest cities—Bucharest, Cluj-Napoca, Timișoara, Iași, and Constanța—are leading in smart city implementations due to larger budgets, better access to technology providers, and stronger partnerships with academic institutions and the private sector.
- This concentration, however, creates a digital divide, with smaller cities and rural areas often lacking access to advanced technologies.
- *PNRR (National Recovery and Resilience Plan)* Component 7 aims to reduce this gap by funding digital infrastructure expansion in underserved regions.

#### 2. Disparities in Funding and Resource Availability:

- Larger cities typically have better access to national and EU funding, supporting a wider range of smart city projects.
- Smaller municipalities, particularly those in economically disadvantaged regions, often face challenges in securing funding and expertise for digital transformation.
- *PNRR (National Recovery and Resilience Plan)* Component 11 focuses on balanced resource distribution, offering targeted funding for digital innovation in rural areas.

### 3. Variations in Infrastructure Readiness:

- The availability of digital infrastructure, such as high-speed internet and IoT sensor networks, varies significantly across regions.
- While urban centres like Bucharest and Cluj-Napoca benefit from advanced infrastructure, rural areas continue to struggle with limited connectivity, which hinders the implementation of smart technologies.
- *PNRR (National Recovery and Resilience Plan)* Component 6 supports broadband expansion and 5G deployment in underserved regions.

### 4. Regional Focus on Specific Smart City Solutions:

Certain regions in Romania have prioritized specific types of smart solutions based on local needs and industries.

- **Cluj-Napoca and Timișoara:** Emphasis on smart mobility and e-governance, leveraging their strong tech sectors.
- **Constanța:** Focus on environmental monitoring and waste management due to its status as a port city.
- **Bucharest:** Diverse initiatives, including public safety, environmental monitoring, and e-governance.
- **Sibiu and Brașov:** Specializing in energy efficiency and tourism-related smart solutions.

### 5. Emerging Interest in Public-Private Partnerships (PPPs):

- Public-private partnerships are becoming increasingly common, especially in larger cities, where technology firms collaborate with local governments to deliver customized solutions.
- Examples include smart lighting systems, EV charging infrastructure, and digital waste management platforms.
- *PNRR (National Recovery and Resilience Plan)* Component 7 supports the expansion of PPPs for technology-driven urban projects, encouraging long-term collaborations between municipalities and private firms.

## 4.3 Solution Categories and Examples

This section presents the primary categories of smart city solutions implemented across Romanian cities, with representative examples in each area.

Each example highlights innovative uses of technology designed to address urban challenges and improve sustainability and quality of life, aligned with Romania's strategic frameworks.

## Urban Mobility Solutions

Urban mobility solutions aim to streamline transportation, reduce congestion, and promote environmentally friendly travel options.

- **Public Transit Management:**

Cities like Bucharest and Cluj-Napoca have implemented advanced public transit management systems using GPS tracking and real-time data analytics. Cluj-Napoca's smart transit system provides live updates on bus arrival times and optimizes routes based on traffic data, enhancing public transport efficiency and reliability.

- *Technology & Innovation:* GPS, real-time data analytics, mobile apps for commuter information.
- *PNRR Component 6* (National Recovery and Resilience Plan) supports smart mobility projects, including intelligent traffic management systems and digital public transport platforms.

- **EV Charging Stations:**

Bucharest and Timișoara have installed multiple EV (Electric Vehicle) charging stations in strategic urban areas to support electric vehicle adoption. These stations are integrated with mobile apps for charger availability and charging progress.

- *Technology & Innovation:* IoT-enabled chargers, mobile app integration, renewable energy sources.
- *PNRR Component 6* supports investments in EV charging infrastructure and sustainable mobility development.

- **Bike-Sharing Systems:**

Cities like Iași and Brașov offer bike-sharing services with app-based booking and tracking to reduce car use and encourage eco-friendly travel.

- **Technology & Innovation:** GPS tracking, app-based payment systems, user data collection for optimizing bike distribution.

## Energy Efficiency and Renewable Solutions

These solutions focus on reducing energy consumption and integrating renewable energy into urban infrastructure.

- **Smart Grids:**

Bucharest is piloting a smart grid project that enables real-time energy usage monitoring and allows utility providers to manage supply efficiently based on demand.

- *Technology & Innovation:* IoT sensors for real-time monitoring, AI for predictive demand management.
- *PNIESC 2021-2030* (National Integrated Energy and Climate Plan) encourages the implementation of smart grids for energy efficiency.

- **Energy-Efficient Buildings:**

Cities such as Timișoara and Sibiu have retrofitted public buildings with energy efficient technologies like LED lighting, smart HVAC systems, and solar panels.

- *Technology & Innovation:* Smart HVAC systems, energy-efficient LEDs, automated energy monitoring.
- *PNIESC 2021-2030* supports the modernization of public infrastructure with energy-efficient systems.

- **Renewable Energy Initiatives:**

Constanța has implemented solar panel installations on municipal buildings, taking advantage of the area's high solar potential to reduce dependency on non-renewable sources.

- **Technology & Innovation:** Solar panels, battery storage for energy backup, smart energy management systems.
- *PNRR Component 10* promotes renewable energy integration in public infrastructure.

### *Waste and Water Management*

These solutions address efficient waste collection, recycling, and water quality monitoring to minimize environmental impact.

- **Smart Waste Collection:**

Cluj-Napoca has implemented a smart waste collection system with IoT sensors that track bin fill levels, optimizing collection routes.

- *Technology & Innovation:* IoT sensors for monitoring fill levels, route optimization algorithms.
- *PNRR Component 7* supports smart waste management technologies and digital infrastructure for waste optimization.

- **Water Quality Monitoring:**



Timișoara has implemented a real-time water quality monitoring system using IoT sensors to track parameters like pH, temperature, and contamination levels.

- *Technology & Innovation:* IoT sensors, mobile alerts, AI data analytics.
- *PNIESC 2021-2030* promotes the use of smart monitoring for water resource management.

### *Citizen Engagement and E-Governance*

These solutions aim to improve transparency, streamline government services, and increase citizen participation in governance.

- **Platforms for Citizen Feedback:**

Cities such as Iași and Oradea have developed digital platforms where residents can report public service issues and give feedback on municipal services.

- *Technology & Innovation:* Mobile apps with geolocation, automated service tracking.
- *PNRR Component 7* funds digital platforms for increased citizen participation and administrative efficiency.

- **E-Government Services:**

Bucharest and Cluj-Napoca have digitized multiple public services, including online tax payments and permit applications.

- *Technology & Innovation:* Secure digital records, e-payment systems, userfriendly portals.
- *PNRR Component 7* supports digital transformation for public service efficiency.

### *Urban Safety and Security*

Safety and security solutions enhance public safety and improve emergency response capabilities in urban areas.

- **Surveillance Systems:**

Bucharest has deployed smart CCTV (Closed-Circuit Television) systems with AI-powered facial recognition and behavior analysis for public safety.

- *Technology & Innovation:* AI facial recognition, real-time video analytics, automated threat alerts.

- *PNRR Component 7* supports AI-based public safety technologies and infrastructure.

- **Emergency Response Systems:**

Timișoara has integrated an emergency response system using IoT sensors and GPS technology for rapid responder dispatching.

- *Technology & Innovation:* GPS tracking, IoT-enabled emergency alerts, AI-assisted route optimization.

### *Environment and Air Quality Monitoring*

These solutions monitor environmental factors and air quality, contributing to better health outcomes and pollution management.

- **Solutions for Real-Time Pollution Monitoring:**

Bucharest and Brașov have deployed air quality monitoring systems with IoT sensors measuring pollutants like PM2.5, PM10, and CO2.

- *Technology & Innovation:* IoT sensors, data dashboards, AI-based data analysis.
- *PNIESC 2021-2030 encourages environmental monitoring using advanced digital technologies.*

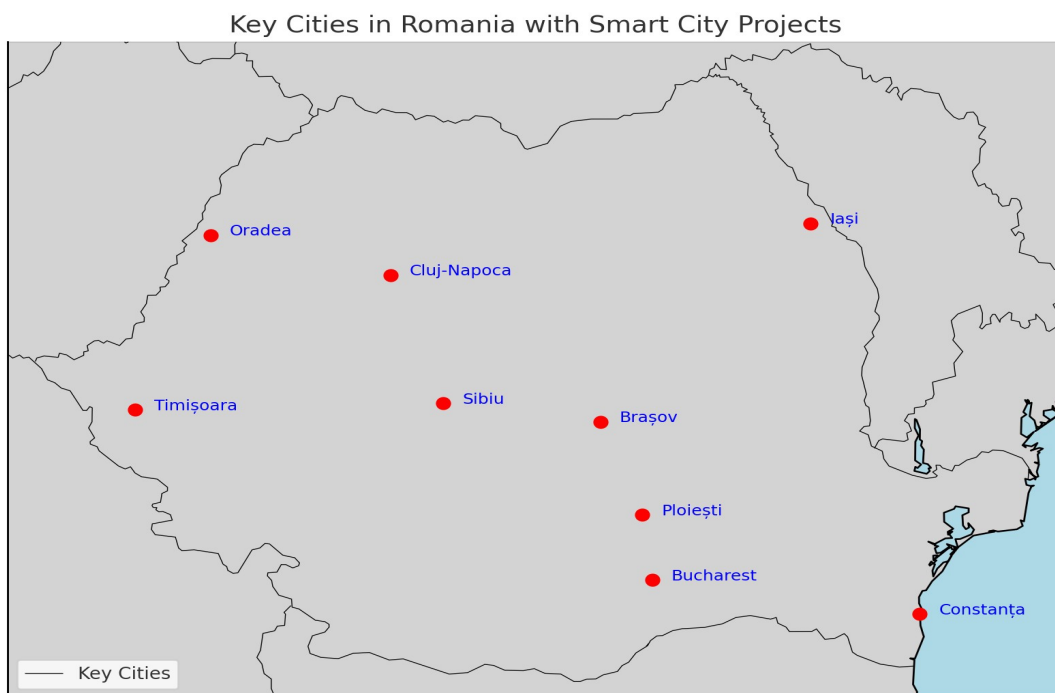
Each category represents a strategic area where technology is leveraged to address urban challenges, improve sustainability, and enhance the quality of urban life in Romanian cities. By adopting these solutions, cities can create more efficient, eco-friendly, and resilient urban environments.



## 5. Mapping of Solutions in Progress

### 5.1 Current Development Projects

This section highlights notable smart city solutions currently under development across various cities and regions in Romania. These projects represent innovative approaches to addressing urban challenges, focusing on sustainability, efficiency, and improving the quality of life for residents, while aligning with the National Recovery and Resilience Plan (PNRR) and the National Integrated Energy and Climate Plan (PNIESC).



#### 1. Bucharest – Smart Mobility Hub

- **Overview:**

Bucharest is developing a centralized Smart Mobility Hub aimed at optimizing urban transportation and reducing congestion. The project integrates multiple transport modes, including public transit, bike-sharing systems, and electric vehicle (EV) infrastructure, all accessible through a unified digital platform for residents and visitors. <sup>1</sup>

- **Key Features:**

<sup>1</sup> [https://urban-mobility-observatory.transport.ec.europa.eu/news-events/news/bucharest-implement-hub-share-data-and-information-2023-04-24\\_en](https://urban-mobility-observatory.transport.ec.europa.eu/news-events/news/bucharest-implement-hub-share-data-and-information-2023-04-24_en)

Real-time public transit tracking, access to EV charging stations, and integration with ride-sharing services.

- **Expected Impact:**

Reduced traffic congestion, lower emissions, and improved commuter convenience.

- **Status:**

Currently in the testing phase, with an anticipated launch by mid-2025.

- **Sources of information:**

*PNRR Component 6* supports the development of smart mobility hubs and multimodal digital platforms for improved urban mobility infrastructure.

Bucharest is implementing a Mobility and Urban Management Hub to support the digitalization of public transport, providing users with open data and real-time information.<sup>1</sup>

## 2. Cluj-Napoca – Data-Driven Waste Management System

- **Overview:**

Cluj-Napoca is implementing a smart waste management system using IoT sensors placed in bins throughout the city. The system tracks fill levels and waste composition, allowing for optimized collection routes and improved recycling rates.

- **Key Features:**

IoT-enabled bins, predictive analytics for waste collection, and a mobile app for waste tracking.

- **Expected Impact:**

Reduced waste collection costs, fewer emissions from collection trips, and improved recycling efficiency.

- **Status:**

Pilot program in selected neighbourhoods, with citywide rollout planned for 2024.

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<sup>1</sup> <https://www.themayor.eu/en/a/view/mobility-and-urban-management-hub-to-bring-bucharest-closer-to-digitalisation-11712>

- **Sources of information:**

*PNRR Component 7* funds data-driven waste management systems and IoT integration for sustainability initiatives.

Cluj-Napoca is exploring IoT solutions for smart waste management to protect the environment<sup>1</sup>.

### 3. Iași – Smart Street Lighting and Energy Efficiency Initiative

- **Overview:**

Iași is implementing a smart street lighting system with LED lights equipped with sensors that adjust brightness based on pedestrian and vehicle activity. The system also integrates renewable energy sources like solar panels for enhanced sustainability.

- **Key Features:**

Motion-sensor LED lights, solar panel integration, and energy usage tracking.

- **Expected Impact:**

Significant energy savings, reduced emissions, and enhanced public safety.

- **Status:**

Smart lighting installation has begun in selected areas, with plans for citywide implementation by 2025.

- **Sources of information:**

*PNRR Component 10* supports the expansion of energy-efficient public infrastructure, including smart lighting systems and renewable energy integration.

Information on Iași's specific smart street lighting project is limited. However, similar initiatives in Romania are discussed in the context of smart city solutions.<sup>2</sup>

### 4. Constanța – Coastal Environmental Monitoring System

- **Overview:**

Constanța city is developing a comprehensive Coastal Environmental Monitoring System aimed at improving the management of port infrastructure and protecting the

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<sup>1</sup><https://cluj.com/articole/iot-protejarea-mediului/>

<sup>2</sup> [https://www.bzi.ro/primariile-din-iasi-investesc-20-de-milioane-de-lei-in-iluminatul-public-lucrarile-incep-anul-viitor-4846255#google\\_vignette](https://www.bzi.ro/primariile-din-iasi-investesc-20-de-milioane-de-lei-in-iluminatul-public-lucrarile-incep-anul-viitor-4846255#google_vignette)

coastal ecosystem. This initiative includes a geospatial information system for port operations, coastal erosion protection projects, and water quality monitoring efforts. <sup>1</sup>

- **Key Features:**

- **Geospatial Information System:**

The National Company "Maritime Ports Administration" SA Constanța has awarded a contract for a geospatial data system for integrated port resource management.

- **Coastal Erosion Protection:**

Projects to protect the Romanian coastline from erosion include artificial beach nourishment and the construction of coastal protection structures, reducing risks related to climate change.

- **Coastal Water Monitoring:**

The Copernicus Marine Environment Monitoring Service provides real-time data on the Black Sea's physical and biochemical state, aiding in maritime safety and environmental protection.

- **Coastal Water Monitoring:**

The Copernicus Marine Environment Monitoring Service provides periodic and systematic information on the physical and biochemical state of European regional seas, including the Black Sea. This data supports marine applications such as maritime safety and coastal environmental protection.

- **Expected Impact:**

Improved management of port resources, enhanced protection of marine biodiversity, and reduced climate risks related to coastal erosion.

Improved management of port resources, protection of marine biodiversity, and reduced climate risks related to coastal erosion.

- **Status:**

The geospatial system is currently under development, while coastal erosion protection measures and water quality monitoring initiatives are ongoing.

- **Sources of information:**

*PNIESC 2021-2030* supports environmental monitoring systems and coastal protection measures, aligning with EU climate resilience strategies.

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<sup>1</sup> <https://www.ziuaconstanta.ro/stiri/actualitate/sistem-informatic-geospatial-pentru-portul-constanta-intergraph-computer-services-srl-va-incasa-pesto-2-milioane-de-lei-cn-apm-sa-constanta-document-866277.html>

*PNRR Component 7* provides funding for data-driven environmental protection projects, emphasizing water and coastal ecosystem sustainability.

## 5. Timișoara – Smart Health Monitoring Stations

- **Overview:**

Timișoara has introduced the *Smart City and Digital Transformation Strategy 2022-2027*, focusing on public health, digital governance, and environmental sustainability. This initiative includes the development of smart health monitoring stations, alongside air quality monitoring infrastructure and digital tools for public service efficiency. <sup>1</sup>

- **Key Features:**

- **Smart Health Monitoring Stations:**

Designed to monitor key health indicators and provide real-time data for public health decision-making.

- **Air Quality Monitoring Initiatives:**

Timișoara participates in the *National Air Quality Monitoring Network*, which includes 148 automatic stations across Romania, providing real-time data on pollutants like PM2.5 and CO2. <sup>2</sup>

- **Digital Governance Tools:**

The city has developed a unique digital portal connecting citizens with public services and a Digital Twin platform for data visualization and city management.

- **Environmental Health Initiatives:**

The city uses IoT-enabled air quality sensors to track pollution levels and promote proactive health measures.

- **Expected Impact:**

- Enhanced public health through data-driven air quality management.

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<sup>1</sup> <https://smartcity.primariatm.ro/>

<sup>2</sup> [https://www.calitateair.ro/public/home-page/?\\_\\_locale=en](https://www.calitateair.ro/public/home-page/?__locale=en)

- Improved accessibility to public services via integrated digital platforms.
- Increased environmental awareness and proactive community health initiatives.

- **Status:**

The initiative is in the initial stages of development, with broader implementation planned as part of the *2022-2027 Smart City Strategy*.

- **Sources of information:**

- *PNIESC 2021-2030* emphasizes the importance of real-time air quality monitoring and digital health solutions for public welfare.
- *PNRR Component 7* supports smart health monitoring and environmental data platforms, aligning with Timișoara’s strategy for health-focused digital transformation.

## 6. Sibiu – Digital Cultural Heritage Platform

- **Overview:**

Sibiu is developing a *Digital Cultural Heritage Platform* aimed at documenting and promoting local cultural sites, traditions, and historical assets. This initiative leverages augmented reality (AR) and virtual reality (VR) technologies to create an engaging, interactive experience for residents and tourists.

- **Key Features:**

- **AR/VR Experiences:** Interactive digital tools for exploring Sibiu's historical landmarks and cultural artifacts.
- **Digital Collections:** The *Lucian Blaga University of Sibiu* has digitized significant portions of its collections, contributing to *Europeana*, Europe’s digital library, to make cultural heritage widely accessible.
- **Sibiu Culture Factory:** A project repurposing former industrial spaces into cultural venues while preserving architectural heritage.
- **Cultural and Heritage Information:** The *official Sibiu County Tourism website* provides comprehensive details about local historical sites and cultural events, enhancing tourism promotion and accessibility.
- **Mobile Accessibility:** The platform is mobile-friendly, ensuring access for diverse audiences.

- **Expected Impact:**

- Increased tourism and economic benefits for the local community.
- Greater preservation of cultural heritage through digital documentation and educational tools.

- Enhanced civic pride and community engagement in cultural initiatives.

- **Status:**

Currently in the development phase, with a planned launch in early 2025. Pilot projects such as the *Sibiu Culture Factory* and the *Lucian Blaga University Digital Archive* are actively contributing to the platform's content.

- **Sources of information:**

- *PNRR Component 11* supports cultural digitization projects, emphasizing the use of AR/VR for tourism promotion.
- *PNIESC 2021-2030* encourages the preservation of cultural heritage through digital tools and educational platforms.

## 7. Braşov – Smart Emergency Response System

- **Overview:**

Braşov is one of the first European cities to implement a fully integrated *Smart Emergency Response System* using a remote lighting management platform. This innovative system enables real-time control and monitoring of the entire street lighting network, significantly improving energy efficiency and public safety. The city's approach positions it as a leader in Romania's smart city development.<sup>1</sup>

- **Key Features:**

- **Smart Street Lighting Management:**  
The system covers 10,481 streetlights across 399 streets and enables remote ON/OFF control, gradual dimming based on real-time traffic and pedestrian activity, and real-time energy monitoring.
- **Surveillance and Public Safety Integration:**  
The lighting system is integrated with **CCTV surveillance cameras** featuring AI-based behavior detection for proactive threat monitoring. Additionally, **panic buttons** have been installed in high-risk areas for immediate emergency assistance.
- **Real-Time Grid Monitoring:**  
The platform monitors grid parameters continuously, notifying maintenance teams immediately of faults or unauthorized energy consumption, reducing downtime and service disruption.

<sup>1</sup> <https://inteligent.eu/brasov-first-smart-city-in-romania/>

- **Energy Efficiency:**  
The city has achieved a **30% reduction in energy consumption** and a **42% decrease in maintenance costs** due to proactive system monitoring and optimized lighting patterns.
- **Expected Impact:**
  - **Public Safety:**  
Enhanced security through immediate alerts and improved night-time visibility.
  - **Energy Efficiency:**  
Reduction in operational costs and energy waste.
  - **Smart Infrastructure:**  
More efficient management of public infrastructure through real-time data analytics.
- **Ongoing and Planned Projects in Braşov:**
  - **InteliLIGHT Smart Lighting Platform:**  
The smart lighting management system implemented in Braşov includes full remote management of the city's lighting infrastructure.
  - **Integrated Safety Platform:**  
The city is expanding its platform to combine **smart lighting, video surveillance, and emergency response systems** for better public safety management.
  - **AI-Enhanced Monitoring:**  
Braşov is exploring **AI-based behavioral analytics** for crowd monitoring, incident prevention, and further public safety enhancements.
- **Expected Impact:**
  - **Public Safety:**  
Enhanced security through immediate alerts and improved night-time visibility.
  - **Energy Efficiency:**  
Significant reduction in operational costs and energy waste.
  - **Smart Infrastructure:**  
Improved management of public infrastructure using real-time data analytics and proactive monitoring.



- **Status:**

The smart lighting system is fully implemented, with further expansions planned to include **predictive analytics for energy optimization** and **AI-enhanced public safety features**.<sup>1</sup>

- **Sources of information:**

- *PNRR Component 10* promotes energy-efficient public infrastructure, including smart street lighting and grid monitoring systems.
- *PNIESC 2021-2030* emphasizes public safety technologies such as AI-enhanced monitoring and integrated emergency response platforms.

## 8. Oradea – Citizen Engagement and Feedback Platform

- **Overview:**

Oradea has developed a citizen engagement platform called "**Oradea City Report**", designed to improve communication between residents and local authorities. The platform enables citizens to report issues, submit feedback on city services, and participate in real-time opinion polls. This initiative supports digital governance objectives outlined in **PNRR Component 7**, which emphasizes the development of digital tools to increase transparency and public participation in local decision-making processes.

- **Key Features:**

- **Issue Reporting:** Users can report issues such as infrastructure damage (e.g., potholes, broken streetlights), as well as public safety concerns and environmental hazards, directly to the municipality.
- **Public Opinion Polling:** The platform offers real-time polls and feedback tools for citizens to express their views on local projects and policies, supporting urban planning consultations in line with *PNRR Component 7*.
- **Service Transparency:** Real-time notifications provide citizens with updates on the status of reported issues and their resolutions, while city officials can access feedback dashboards for proactive decision-making.

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<sup>1</sup> [https://www.esmap.org/sites/esmap.org/files/DocumentLibrary/TRACE\\_Romania\\_Brasov\\_Optimized.pdf](https://www.esmap.org/sites/esmap.org/files/DocumentLibrary/TRACE_Romania_Brasov_Optimized.pdf)

- **Expected Impact:**

- **Improved Responsiveness of Municipal Services:** Faster resolution of reported issues through digital feedback systems.
- **Increased Transparency in Local Governance:** Real-time updates and issue tracking capabilities foster public trust and accountability.
- **Greater Citizen Involvement in Decision-Making Processes:** The platform encourages active participation in decision-making and urban planning through accessible feedback channels.

- **Status:**

The *Oradea City Report* platform is currently operational and available for download by residents on both **iOS** and **Android** devices. Detailed information about the application's features and functionalities can be accessed on the official **Oradea City Hall** website<sup>1</sup>.

- **Legislative Alignment:**

- PNRR Component 7 supports the digitalization of public services and citizen engagement platforms, promoting transparent feedback systems for local governance.
- PNIESC 2021-2030 encourages the use of smart technologies for improving service efficiency and community involvement in local decision-making processes.

- **Public Information:**

- Detailed information about the *Oradea City Report* and its functionalities can be found on the official **Oradea City Hall** website: <https://www.oradea.ro/>
- Additional insights about the app's functionalities and benefits are also available on the **AppBrain** platform<sup>2</sup>

These resources provide comprehensive information about the "Oradea City Report" application and its role in facilitating citizen engagement and feedback.<sup>3</sup>

## 9. Ploiești – Renewable Energy-Powered Public Transport System

- **Overview:**

Ploiești is piloting a **renewable energy-powered public transport system** aimed at reducing urban emissions and promoting sustainable mobility. The initiative integrates

<sup>1</sup> <https://www.oradea.ro/>

<sup>2</sup> <https://www.appbrain.com/app/oradea-city-report/ro.oradea.cityconnect>

<sup>3</sup> <https://www.appbrain.com/app/oradea-city-report/ro.oradea.cityconnect>

solar energy solutions by installing solar panels at bus depots and stations to power electric buses and hybrid vehicles. This project supports **PNRR Component 10**, which encourages renewable energy adoption and sustainable transport solutions for urban infrastructure.

- **Key Features:**

- **Solar-powered electric buses and hybrid vehicles:** The city's fleet includes electric buses powered by solar energy and hybrid vehicles to reduce fuel consumption and emissions.
- **Solar panels installed at transport facilities:** Solar panels have been strategically installed at bus depots and transport stations to generate renewable energy, powering both the vehicles and facility operations.
- **Real-time energy tracking:**

An advanced energy management system allows real-time tracking of energy production and consumption, improving operational efficiency and reducing energy waste.

- **Expected Impact:**

- **Reduction in greenhouse gas emissions:**  
By shifting to solar-powered vehicles, Ploiești aims for a significant decrease in CO<sub>2</sub> emissions from its public transport system.
- **Lower operational costs:**  
Renewable energy integration is expected to reduce fuel and electricity expenses, contributing to long-term financial savings for the municipality.
- **Enhanced urban sustainability:**  
The project promotes a cleaner, more efficient public transport network, aligning with PNIESC 2021-2030 objectives for urban sustainability and climate neutrality.

- **Status:**

The project is currently in the pilot phase, with several electric buses already operational. Expansion of the initiative depends on the success of the initial phase and securing additional funding under PNRR Component 10 and other EU programs.

- **Legislative Alignment:**

- PNRR Component 10 supports the development of renewable energy infrastructure and the decarbonization of public transport.
- PNIESC 2021-2030 encourages integrating clean energy sources in public transport systems to reduce urban pollution and increase energy efficiency.

- **Public Information:**

While specific details on the full implementation timeline are limited, Ploiești has been identified as part of the World Bank's **TRACE (Tool for Rapid Assessment of City Energy)** program, which assessed the city's energy efficiency measures across multiple sectors, including public transport.<sup>1</sup>

These projects demonstrate Romania's commitment to digital and sustainable urban solutions, emphasizing regional strengths and addressing specific local needs. Through these ongoing efforts, cities across the country are progressing toward more sustainable, resilient, and citizen-centred urban environments.

## 6. Challenges and Opportunities

### 6.1 Key Challenges

The deployment of smart city solutions in Romania faces several significant challenges across technical, financial, regulatory, and social dimensions.

Additionally, gaps in skills and knowledge within local public administrations (LPAs) can further hinder the successful implementation and scaling of these solutions. This section provides an in-depth analysis of the key obstacles that must be addressed to ensure the successful development of smart city initiatives across the country.

#### *Technical, Financial, Regulatory, and Social Barriers Hindering Smart City Solution Deployment*

##### 1. Technical Barriers

- **Limited Digital Infrastructure:**

In many areas, especially smaller cities and rural regions, the existing digital infrastructure is inadequate to support advanced smart city solutions. Insufficient broadband internet, limited IoT connectivity, and inadequate sensor networks hinder the integration of smart technologies.

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<sup>1</sup> <https://www.esmap.org/node/235> & <https://www.esmap.org/node/4368>

*PNRR Component 7* addresses these challenges by prioritizing investments in high-speed broadband expansion and 5G connectivity, particularly targeting underserved regions to support the rollout of smart city projects.

○ **Standardisation (Interoperability)**

Smart city solutions often rely on multiple, disparate systems that may not be designed to work together. Lack of interoperability across platforms complicates data sharing and integration, making it challenging to develop cohesive, citywide solutions.

*PNRR Component 7* encourages standardization of smart city platforms and the adoption of interoperable systems to streamline data sharing across public services.

Interoperability remains a significant challenge in the deployment of cohesive smart city solutions across Romanian municipalities. Without standardized protocols, the integration of diverse technologies becomes cumbersome, leading to inefficiencies and limited scalability.

- **Lack of National Standards:** Romania lacks a unified framework for smart city initiatives, resulting in fragmented systems that are difficult to integrate. This inhibits seamless data sharing and cross-regional collaboration.
- **Data and System Integration Challenges:** Disparate platforms and technologies, often implemented without considering interoperability, hinder the development of comprehensive smart city ecosystems.
- **Cybersecurity Risks Linked to Interoperability:** The absence of standard security protocols across systems exposes municipalities to increased cyber risks.

**Recommendations**

- Develop national guidelines for interoperability, focusing on data exchange standards, system compatibility, and security frameworks, as outlined in *PNRR Component 7*.
- Promote the adoption of open-source platforms and collaborative development to ensure flexibility and scalability.
- Establish a centralized task force to oversee the alignment of municipal technologies with national and EU standards.

○ **Cybersecurity Risks:**



Smart city initiatives involve vast amounts of data, making them vulnerable to cyber threats. Many municipalities lack the advanced cybersecurity protocols necessary to protect sensitive data, raising concerns about data breaches and privacy.

*PNIESC 2021-2030* mandates the implementation of robust cybersecurity frameworks, including encryption standards, secure storage protocols, and regular system audits for smart infrastructure projects.

## 2. Financial Barriers

- **High Initial Costs:**

Implementing smart city solutions requires substantial initial investment, including the purchase of sensors, software, infrastructure upgrades, and staff training. Many municipalities, especially those with limited budgets, struggle to allocate resources for these upfront costs.

*PNRR Component 10* provides dedicated financial support for smart city technologies and energy-efficient infrastructure, reducing financial strain on local budgets.

- **Dependency on External Funding:**

Many smart city projects rely heavily on EU or private funding, creating dependency and delaying projects when external resources are unavailable.

*PNRR Component 6* promotes a diversified funding model through publicprivate partnerships (PPPs) and private sector collaborations to reduce this dependency and ensure project sustainability.

- **Cost of Maintenance and Upgrades:**

Smart technologies require continuous financial investment for maintenance, software updates, and system expansions. Insufficient budget planning often results in outdated or poorly maintained infrastructure.

*PNIESC 2021-2030* highlights the need for long-term financial strategies that include dedicated maintenance funds for smart city infrastructure.

## 3. Regulatory Barriers

- **Lack of National Standards:**



Romania currently lacks a unified national framework for smart city initiatives, resulting in fragmented efforts across cities and regions. Without standardized guidelines, municipalities often face inconsistent implementation strategies.

*PNRR Component 7* calls for the creation of a national smart city framework with standardized technologies and implementation guidelines.

- **Data Privacy Regulations:**

Compliance with GDPR and other data privacy laws presents challenges for municipalities collecting and processing large amounts of personal and environmental data. Many local governments lack clear guidelines on data protection practices.

*PNIESC 2021-2030* emphasizes GDPR compliance by promoting mandatory data protection training and encryption standards for public authorities.

- **Bureaucratic Delays:**

Approval processes for implementing new technologies in public spaces can be slow and complex. Lengthy regulatory procedures and multiple approval levels often delay project timelines.

*PNRR Component 6* introduces measures to simplify approval processes through e-governance tools and digitized workflows, reducing administrative burdens for smart city projects.

#### 4. Social Barriers

- **Citizen Concerns over Privacy:**

Public skepticism regarding data privacy and surveillance can hinder the adoption of smart city solutions, especially those involving personal data collection. Transparency and GDPR compliance are essential to building public trust.

*PNIESC 2021-2030* advocates for clear anonymization protocols, ensuring citizen data protection while still enabling data-driven insights.

- **Lack of Public Awareness and Engagement:**

Many citizens remain unaware of the benefits smart city projects can offer, leading to low participation and skepticism toward digital transformation initiatives.

*PNRR Component 11* encourages public awareness campaigns and active community involvement to foster a culture of trust and engagement.

- **Digital Divide:**

Socioeconomic disparities impact access to smart city services, particularly in regions where digital literacy and access to technology remain limited.

*PNRR Component 7* specifically addresses this issue by funding digital literacy programs and subsidizing access to smart devices in underserved communities.

### *Skills and Knowledge Gaps in Local Government or LPAs (Local Public Administration)*

#### 1. **Limited Technical Expertise**

- **Shortage of Skilled Personnel:**

Many LPAs lack personnel with the necessary technical skills to manage, operate, and maintain smart city technologies. This skills gap can lead to dependency on external consultants or contractors, increasing project costs and reducing self-sufficiency in managing solutions.

- **Lack of Data Analysis Capabilities:**

Smart city solutions generate vast amounts of data that require skilled analysis for effective use. However, LPAs often lack data analysts or IT staff proficient in big data analytics, machine learning, or AI, resulting in underutilized data assets and missed opportunities for data-driven decision-making.

*PNRR Component 6* supports the creation of digital skills development programs for public administration staff, focusing on AI, data analytics, and cybersecurity to address these gaps.

#### **Recommendations:**

- Establish partnerships with academic institutions and technology providers to design comprehensive training modules for municipal staff.
- Develop certification programs in smart city technologies, supported by EU funding, to standardize competencies.
- Encourage knowledge-sharing platforms to facilitate peer learning among municipalities.

These additions emphasize the critical role of skills development and system standardisation in overcoming existing barriers, ensuring the success and scalability of smart city initiatives in Romania. Let me know if you'd like me to include these in the main report or prepare a separate document.



## 2. Insufficient Training and Capacity-Building Programs

- **Lack of Specialized Training:**

Many LPAs do not have structured training programs for smart city technologies, leaving existing staff without the skills needed to operate and troubleshoot these systems. Training programs on emerging technologies, data management, and cybersecurity are essential for building in-house expertise.

- **Limited Knowledge of Best Practices:**

The lack of exposure to global best practices in smart city development means LPAs may not be fully aware of efficient implementation strategies, which could lead to inefficiencies or ineffective deployment.

*PNRR Component 7* emphasizes the need for structured digital capacity-building programs and workshops focused on smart city technology best practices.

## 3. Gaps in Project Management Skills

- **Challenges in Managing Multi-Stakeholder Projects:**

Smart city projects often involve collaboration between multiple stakeholders, including public institutions, private technology providers, and NGOs. LPAs may lack the project management expertise needed to coordinate these collaborations effectively, leading to project delays or miscommunication.

- **Difficulty in Long-Term Planning and Sustainability Management:**

Smart city projects require long-term vision, with clear planning for both initial deployment and future maintenance. Many LPAs lack the experience in planning for the sustainability of such projects, which can result in short-term implementations that do not yield sustainable results.

*PNRR Component 11* includes provisions for improving project management skills through dedicated workshops and leadership programs tailored to public administration contexts.

Addressing these challenges is essential to ensuring that smart city projects in Romania can be successfully implemented and sustained over the long term. By overcoming these technical, financial, regulatory, and social barriers, and bridging the skills gaps within LPAs, Romanian

cities can more effectively leverage smart city solutions to improve urban life and promote sustainable development.

## 6.2 Opportunities for Growth

While challenges exist in implementing smart city solutions across Romania, several opportunities can drive more sustainable, efficient, and citizen-focused urban development. This section explores technological advancements, regional potential, and collaborative strategies to accelerate smart city adoption.

### *Potential for Future Smart City Solutions*

#### **1. Expansion of Renewable Energy-Powered Infrastructure:**

Cities across Romania can significantly reduce greenhouse gas emissions by adopting renewable energy technologies such as solar panels and wind turbines. These technologies can be integrated into public infrastructure, including EV charging stations, street lighting, and public buildings. *PNRR Component 10* directly funds renewable energy projects aimed at promoting sustainability and energy independence.

#### **2. Advanced Mobility and Traffic Management Solutions:**

With increasing urbanization and traffic congestion, cities can implement AI-driven traffic management systems and smart intersections to optimize traffic flow and reduce emissions. *PNRR Component 6* supports investments in intelligent traffic lights, real-time public transit monitoring, and shared mobility platforms.

#### **3. Smart Waste and Recycling Initiatives:**

Implementing IoT-enabled waste bins and automated sorting systems can improve waste collection efficiency and recycling rates while reducing landfill use. *PNRR Component 7* promotes the use of smart waste technologies and data-driven optimization tools for enhanced municipal waste management.

#### **4. Integrated Health and Well-Being Solutions:**

Cities can improve public health outcomes through the deployment of real-time air quality sensors and smart health kiosks designed for preventive care. *PNIESC 20212030* encourages investments in environmental monitoring technologies to support data-driven health policies.

#### **5. Data-Driven Urban Planning and Resource Allocation:**

By utilizing predictive analytics and real-time data, cities can optimize resource allocation in areas such as water usage, energy consumption, and infrastructure maintenance. *PNRR Component 7* supports the development of predictive analytics platforms and digital dashboards to improve city management efficiency.

### *Untapped Areas and Regions with Significant Potential for Sustainable Urban Solutions*

Romania has several underutilized regions where smart city solutions can drive sustainable development and improve quality of life. This section explores key regions with significant potential for growth, along with targeted policy measures supporting their development.

#### **1. Secondary Cities and Smaller Municipalities:**

While larger cities like Bucharest, Cluj-Napoca, and Timișoara have led smart city development, smaller municipalities in regions like Moldova, Maramureș, and Oltenia remain largely untapped. These areas present opportunities for implementing scalable smart city solutions such as renewable microgrids, smart waste management programs, and localized digital platforms.

*PNRR Component 7* specifically addresses the expansion of smart city technologies into smaller municipalities, funding digital infrastructure improvements and capacity building programs.

#### **2. Tourist and Cultural Centres:**

Regions like Brașov, Sibiu, and Constanța, which attract significant tourist traffic, could benefit from smart technologies aimed at resource optimization and enhanced visitor experiences. Digital tourism platforms, crowd management systems, and virtual heritage experiences can contribute to improved tourism experiences while promoting cultural preservation.

*PNRR Component 11* supports the digital transformation of cultural heritage sites through funding for AR/VR technologies and digital archives.

#### **3. Industrial and Port Cities:**

Cities with significant industrial activity, such as Constanța and Galați, face unique challenges related to environmental sustainability and resource management. Smart energy grids, IoT-enabled pollution monitoring, and real-time water management systems can address these challenges.

*PNIESC 2021-2030* emphasizes the importance of smart energy solutions and real-time environmental monitoring in industrial zones.

#### **4. Rural and Agricultural Regions:**



Rural areas that depend on agriculture have untapped potential for smart agricultural solutions, such as IoT-based soil monitoring, drone technology for crop assessments, and water-saving irrigation systems. These innovations can boost agricultural productivity and sustainability.

*PNRR Component 10* provides funding for the implementation of precision agriculture technologies and smart irrigation systems in rural areas.

### *Opportunities for Public-Private Partnerships and Collaborations*

Public-private partnerships (PPPs) offer significant opportunities for accelerating smart city development in Romania. By leveraging private sector innovation and international funding, cities can access resources, expertise, and technologies essential for long-term urban transformation.

#### **1. Collaborations with Technology Companies and Startups:**

Partnering with technology firms and startups can drive smart city development through innovative solutions and access to the latest technologies. Startups often offer flexible, scalable tools tailored to specific city needs, while larger corporations can contribute both financial resources and infrastructure expertise.

*PNRR Component 7* supports collaborative partnerships with tech companies for digital transformation projects, including smart sensors, data platforms, and green technologies.

#### **2. Funding from International Organizations and EU Programs:**

Smart city projects in Romania can access financial resources and guidance through international programs like *Horizon Europe* and the *European Green Deal*. These initiatives offer funding for digitalization, climate-neutral technologies, and crossborder collaborations.

*PNRR Component 10* provides direct support for EU-aligned projects focusing on energy efficiency and smart infrastructure development.

#### **3. Engagement with Academic and Research Institutions:**

Collaborations with universities and research institutions can offer municipalities access to cutting-edge research, technical expertise, and pilot testing for new technologies. Academic partnerships can also provide capacity-building through workshops and specialized training for public officials.

*PNRR Component 6* promotes research collaborations for smart city innovations and supports funding for pilot programs and training sessions in partnership with academia.

#### 4. **Partnerships with Environmental NGOs and Civil Society:**

Environmental NGOs and local organizations can ensure that smart city solutions align with community needs and sustainability goals. These partnerships can promote citizen engagement, support awareness campaigns, and contribute to the co-design of urban projects.

*PNRR Component 11* encourages partnerships with civil society for sustainability campaigns, green space development, and public consultations.

#### 5. **Collaborative Models for Infrastructure Development:**

PPPs can also support large-scale infrastructure projects, such as energy grids, water management, and public transport systems. Collaborative models like *Build-Operate Transfer* (BOT) and concession agreements allow private companies to invest in infrastructure and recover costs through long-term contracts.

*PNRR Component 7* highlights the importance of cost-sharing models for smart infrastructure projects, particularly for EV charging stations and smart public lighting systems.

Addressing these challenges while leveraging Romania's legislative frameworks and funding opportunities can transform cities into more efficient, inclusive, and sustainable urban spaces.

## 7. Recommendations for Enhancing Smart City Solutions

### 7.1 Policy and Regulatory Recommendations

To facilitate the effective deployment of smart city solutions in Romania, targeted policy and regulatory changes are necessary. These recommendations aim to create a supportive legal environment, standardize practices, and streamline implementation processes, ensuring consistency and fostering innovation across the country.

#### 1. **Establish National Smart City Standards and Guidelines**

- **Policy Suggestion:**

Develop a national framework providing clear standards and guidelines for implementing smart city solutions. This framework should include:

- **Technical specifications** for IoT systems, digital infrastructure, and data exchange.

- **Interoperability protocols** to ensure systems can communicate across regions.
- **Data governance** strategies defining data ownership, usage, and sharing policies.
- **Cybersecurity requirements** for secure deployment of smart technologies.

- **Impact:**

- Consistency across cities, reducing implementation time and technical barriers.
- Enhanced interoperability between smart city systems.
- A unified approach to security, minimizing vulnerabilities across public infrastructure.

- **Legislative Alignment:**

- PNRR Component 7 emphasizes the need for national smart city standards and interoperability guidelines to reduce fragmentation and support scalability.
- PNIESC 2021-2030 calls for uniform data governance strategies across public sector initiatives.

## 2. Create Incentives for Sustainable and Green Technologies

- **Policy Suggestion:**

Introduce a set of financial mechanisms to encourage investment in sustainable smart city projects, such as:

- Tax incentives and grants for cities adopting renewable energy technologies (e.g., solar panels for public infrastructure, EV charging networks).
- Subsidies for pilot projects targeting energy efficiency and environmental monitoring.
- Green bonds to fund long-term sustainability projects.

- **Impact:**

- Accelerated adoption of energy-efficient technologies.
- Enhanced financial feasibility for municipalities to deploy green infrastructure.
- Increased collaboration with private sector innovators in the sustainability space.



- **Legislative Alignment:**

- PNRR Component 10 prioritizes funding for renewable energy-powered infrastructure and sustainability projects.
- PNIESC 2021-2030 promotes financial mechanisms for energy-efficient solutions and climate neutrality goals.

### 3. **Implement Data Privacy and Security Regulations Specific to Smart Cities**

- **Policy Suggestion:**

Adopt a tailored regulatory framework for data privacy in smart city initiatives to ensure the secure management of personal and environmental data. Key measures should include:

- Mandatory GDPR compliance for all smart city projects.
- Standardized data encryption and secure storage protocols.
- Clear guidelines on data ownership and citizen consent for data collection and use.

- **Impact:**

- Increased public trust in digital services.
- Protection of sensitive citizen data while maintaining the benefits of data-driven governance.
- Reduced risk of cybersecurity breaches through standardized protocols.

- **Legislative Alignment:**

- PNRR Component 7 mandates GDPR compliance and advanced cybersecurity frameworks for smart city initiatives.
- PNIESC 2021-2030 emphasizes secure data practices as a core element of public digital infrastructure.

### 4. **Streamline Approval Processes for Public-Private Partnerships**

- **Policy Suggestion:**

Simplify and accelerate the approval processes for smart city projects developed in collaboration with private partners by:

- Establishing dedicated PPP task forces within local administrations.
- Implementing fast-track approval mechanisms for projects aligned with national digitalization goals.
- Providing standardized PPP frameworks to facilitate transparent and consistent collaboration terms.

● **Impact:**

- Faster project initiation and reduced administrative delays.
- Increased private sector participation, innovation, and investment.
- Clearer collaboration terms, reducing legal and financial risks for both public and private stakeholders.

● **Legislative Alignment:**

- PNRR Component 6 emphasizes the creation of dedicated public-private collaboration offices to reduce bureaucratic barriers in smart city developments.
- PNIESC 2021-2030 recommends standardized PPP contracts to simplify the collaboration process and ensure fair distribution of risks and benefits.

## 7.2 Capacity-Building Initiatives

Capacity-building programs are essential to upskill local government staff, technical teams, and other stakeholders to handle the demands of smart city technologies effectively.

### 1. Establish Smart City Training Programs for Municipal Staff

● **Recommendation:**

Develop comprehensive **training programs** in collaboration with educational institutions, technology companies, and NGOs. These programs should focus on essential topics such as:

- Data Management and Analytics.
- IoT (Internet of Things) Systems Implementation.
- Cybersecurity Protocols and GDPR Compliance.
- Smart City Project Management.
- Climate Neutrality Strategies, as emphasized in the Legislative Framework for Climate Neutrality.

● **New Insight:**





The **PNRR (National Recovery and Resilience Plan) Component 7** specifically supports capacity-building initiatives for digital transformation in public administration, ensuring local staff can independently manage smart city systems without over-reliance on external consultants.

- **Impact:**

Upskilled municipal staff can manage smart city projects independently, reducing reliance on external consultants and improving project sustainability while aligning with **PNIESC 2021-2030's** goals for sustainable urban development.

## 2. Create a Knowledge-Sharing Platform for Best Practices

- **Recommendation:**

Launch a **national digital platform** where cities can share experiences, case studies, and success stories from smart city implementations. The platform should include:

- Forums for city-to-city collaboration.
- Case Study Libraries on successful projects like Brasov's Smart Lighting System and Cluj-Napoca's Waste Management Platform.

- Webinars and Training Modules for continuous learning.

- **New Insight:**

The PNRR Component 7 encourages the creation of collaborative digital platforms for local public administrations to exchange expertise and improve digital governance strategies.

- **Impact:**

A centralized knowledge base will enable smaller municipalities to learn from larger cities and avoid common pitfalls, fostering collaboration and innovation across regions.

## 3. Host Annual Smart City Workshops and Conferences

- **Recommendation:**

Organize **national and regional workshops** focusing on smart city development, co-financed through **PNRR Component 11**, targeting:

- Best practices in renewable energy infrastructure.
- Integration of smart public services and citizen feedback platforms.
- Regulatory updates on GDPR compliance for public data usage.

- **New Insight:**

The **Legislative Framework for Climate Neutrality** emphasizes knowledge transfer as a key pillar for achieving climate-neutral cities by 2050, promoting workshops and events as essential tools for stakeholder alignment.

- **Impact:**

- Promotes cross-sector collaboration between **public authorities, private sector innovators, and academia**.
- Strengthens networks for sharing digital transformation strategies across regions.

#### 4. Implement Certification Programs for Smart City Professionals

- **Recommendation:**

Collaborate with **universities and technical institutes** to develop **certification programs** covering:

- Smart Infrastructure Management.
- Data-Driven Decision Making and Analytics.
- IoT Integration for Public Services.
- Cybersecurity Protocols for Public Infrastructure.

- **New Insight:**

The **PNIESC 2021-2030** framework specifically calls for enhanced digital literacy and workforce certification to support energy-efficient infrastructure and climate-neutral technologies.

- **Impact:**

- Ensures a consistent standard of knowledge and expertise across municipalities.
- Creates a professional pathway for public administration staff to specialize in smart city management.

#### 5. Legislative Alignment:



- PNRR Component 7: Directly supports digital capacity-building for local public administration, emphasizing technical and data governance training.
- PNIESC 2021-2030: Highlights the importance of staff certification for energy efficiency and smart infrastructure projects.
- Legislative Framework for Climate Neutrality: Reinforces the need for continuous education and knowledge-sharing in the transition toward climate-neutral cities.

### 7.3 Funding and Resource Allocation

Identifying appropriate funding sources and optimizing resource allocation is crucial for the successful implementation of smart city projects, particularly in regions with limited financial resources. The following recommendations align with Romania’s climate neutrality goals and existing strategic frameworks such as the National Recovery and Resilience Plan (PNRR) and the Regional Operational Program (POR).

#### *Potential Funding Sources*

- **EU Funds:**

Leverage funding programs such as *Horizon Europe*, *European Green Deal*, and the *European Regional Development Fund (ERDF)* for sustainable and innovative urban projects. The PNRR’s Component 10 specifically targets sustainable mobility and infrastructure improvements.

- **Private Investments and PPPs:**

Encourage private sector investment through public-private partnerships. The *Legislative Framework for Climate Neutrality* framework highlights the importance of PPPs for energy efficiency projects.

- **Green Bonds and Climate Funds:**

Issue municipal green bonds and apply for international climate-focused funds such as the *Green Climate Fund*. Romania’s PNRR Component 6 promotes green budgeting for local authorities to prioritize renewable energy investments

- **Local Grants and Municipal Budget Reallocations:**

Explore reallocations from existing municipal budgets and local grant opportunities to fund smaller-scale projects that may not qualify for larger EU or private funding schemes.

### *Suggestions for Optimal Resource Allocation*

- **Prioritize High-Impact Projects in Underfunded Regions:**

Target investments toward smaller cities and rural areas that often lack access to advanced technologies and funding resources. PNRR Components 1 and 3 emphasize water and waste management improvements in rural regions.

- **Adopt a Phased Implementation Approach:**

Implement smart city projects in phases, starting with pilot programs. This strategy allows for smaller initial investments and gradual scaling while ensuring effective results.

- **Promote Co-Funding Models:**

Encourage shared cost models where both municipalities and private companies invest together, particularly for infrastructure-heavy projects such as smart grids and renewable energy systems.

### *Legislative Alignment*

- PNRR Component 10: Focuses on sustainable mobility solutions, such as zero-emission public transport and electric vehicle charging infrastructure.
- PNRR Component 6: Supports green budgeting and renewable energy investments at the municipal level.
- Regional Operational Program (POR) 2021-2027: Encourages local authorities to adopt energy efficiency and climate resilience projects with EU support.

### *Strengthening national support for Municipalities in accessing funding*

#### **Recommendation:**

To address the challenges municipalities face in applying for funding, particularly European funding, it is suggested to establish a national support framework. This framework could include:

- Organizing training workshops to guide municipalities on developing competitive funding applications
- Facilitating partnerships between municipalities and private or public stakeholders to strengthen funding proposals<sup>1</sup>
- Providing advisory services, including practical guidance on drafting applications and navigating funding requirements
- Offering simulated evaluations to help applicants identify and address weaknesses in their proposals

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<sup>1</sup> <https://portico.urban-initiative.eu/urban-matchmaker>

- Encouraging participation in initiatives like the New European Bauhaus (NEB) Prizes, which provide funding and recognition for projects that prioritize sustainability, inclusion, and aesthetics<sup>1</sup>

### Impact:

- **Increased Funding Access:** Improved quality of applications leads to higher success rates in securing European and national funding
- **Enhanced Collaboration:** Strengthened partnerships between municipalities and stakeholders foster comprehensive project development
- **Capacity Building:** Local governments develop greater expertise in planning, applying for, and implementing funded projects effectively
- **Recognition and Visibility:** Participation in initiatives like the NEB Prizes brings recognition to small municipalities, showcasing their contributions to sustainable development

## 7.4 Areas for Cross-Border Collaboration

Cross-border collaborations can significantly enhance the development and deployment of smart city solutions by providing access to international expertise, technology, and best practices. Partnering with Norwegian entities and other international organizations offers strategic opportunities for knowledge exchange and resource sharing, aligning with Romania's climate neutrality strategies and the National Integrated Urban Development Strategy.

### 1. Collaborations with Norwegian Smart City Innovators

#### ○ **Opportunities:**

Norwegian organizations, such as Nordic Edge, Innovation Norway, and EDIH Oceanopolis, have extensive experience in green urban technologies, including smart grids, renewable energy systems, and sustainable urban planning. Collaborations with such entities can provide valuable insights into successful implementations of renewable energy and efficient public services.

#### ○ **Example Initiatives:**

Joint pilot projects in renewable energy infrastructure, collaborative research on energy-efficient public buildings, and technology transfer for advanced environmental monitoring tools.

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<sup>1</sup> <https://prizes.new-european-bauhaus.europa.eu/guide-applicants-municipalities>

## 2. Joint Research Programs on Sustainable Urban Solutions

- **Opportunities:**

Developing collaborative research programs with Norwegian universities and research centres can facilitate shared advancements in smart city technologies. Areas of focus could include AI-driven urban planning, data-driven sustainability tools, and climate resilience strategies.

- **Example Initiatives:**

Co-developing predictive analytics tools for traffic management, researching IoT-based pollution monitoring systems, and climate-resilient infrastructure strategies.

## 3. Exchange Programs and Study Tours for Municipal Leaders

- **Opportunities:**

Establish exchange programs and study tours where municipal leaders and technical staff can visit Norway to gain hands-on experience with smart city technologies. This knowledge exchange can directly impact the design and implementation of Romanian urban initiatives.

- **Example Initiatives:**

Study tours focused on smart waste management, smart lighting systems, and public engagement platforms in Norwegian cities.

## 4. EU-Funded Cross-Border Projects

- **Opportunities:**

Leverage EU funding for cross-border collaborations through programs such as **Interreg Europe** and the **Horizon Europe Framework**. These grants support transnational projects, emphasizing sustainability and smart city infrastructure improvements.

- **Example Initiatives:**

Cross-border collaborations on shared urban mobility platforms, digital governance tools, and joint smart energy projects.

## 5. International Technology Transfer Programs

- **Opportunities:**

Establish technology transfer agreements where proven smart city solutions from Norway can be adapted for Romanian contexts. This can accelerate the deployment of advanced technologies while minimizing development costs. ○

- **Example Initiatives:**

Transfer of Norway's smart grid management software, IoT-based water quality sensors, and AI-driven traffic monitoring systems.

By actively pursuing these collaborative strategies, Romania can strengthen its capacity to implement effective smart city solutions, accelerate its progress toward climate neutrality, and foster sustainable urban development in alignment with national policies like PNIESC (National Integrated Energy and Climate Plan).

## 8. Case Studies analysis of Smart City Success stories in Romania and beyond

This chapter provides a detailed analysis of successful smart city projects both in Romania and internationally. The focus is on implementation strategies, impact measurement, and lessons learned. These case studies serve as practical examples for Romanian Local Public Authorities (LPAs) aiming to replicate or adapt such models for urban innovation and sustainable development.

### 8.1 Romanian Smart City case studies

#### *Cluj-Napoca – Data-Driven waste management and smart mobility integration*

- **Overview:**

Cluj-Napoca has emerged as a national leader in implementing smart city technologies, focusing on waste management optimization and smart mobility solutions. The city's smart waste management system uses IoT sensors placed in public bins to monitor fill levels and optimize collection routes, reducing operational costs and enhancing efficiency.

- **Key Features:**

- *Smart waste management*: IoT-enabled sensors in waste bins monitor fill levels and predict collection schedules, reducing unnecessary fuel consumption and operational costs.
- *Smart mobility solutions*: The city has integrated digital public transport management platforms, real-time GPS tracking, and contactless digital ticketing systems for enhanced commuter convenience.

- **Impact:**

- *Cost reduction*: Reduced fuel usage and improved collection efficiency, leading to operational cost savings.
- *Environmental impact*: Decreased emissions due to optimized waste collection routes and enhanced public transit use.
- *Public convenience*: Enhanced commuter experience with real-time transit updates.

- **Lessons Learned:**

- Strategic partnerships with private technology providers enhanced both implementation speed and quality.
- Real-time data analytics proved essential for continuous service improvement.

### *Timișoara – Smart Health monitoring stations and digital twin technology*

- **Overview:**

Timișoara has implemented multiple smart city projects under its "Smart City and Digital Transformation Strategy 2022-2027," focusing on public health monitoring and urban data management.

- **Key Features:**

- *Smart health monitoring stations*: Real-time air quality sensors and public health kiosks.
- *Digital Twin technology*: A virtual city model that aids in urban planning, resource management, and disaster preparedness.
- *Citizen engagement platforms*: Mobile apps and a digital portal for public feedback and municipal transparency.

- **Impact:**

- *Health improvements*: Air quality monitoring has contributed to proactive public health interventions.



- *Increased transparency:* Citizen feedback tools have boosted public participation in city governance.

- **Lessons Learned:**

- Digital twins and health monitoring tools can be integrated for more proactive city management.
- Engaging citizens through real-time data builds public trust and cooperation.

### *Braşov – Smart emergency response and energy management system*

- **Overview:**

Braşov implemented one of Romania's most advanced smart emergency response systems, integrating smart lighting management with public safety infrastructure.

- **Key Features:**

- *Smart lighting:* 10,481 smart streetlights controlled remotely for energy efficiency.
- *AI-Powered surveillance:* CCTV cameras with AI-based behaviour detection.
- *Real-Time grid monitoring:* Energy usage analytics and fault detection integrated with smart city management software.

- **Impact:**

- *Energy savings:* 30% reduction in electricity consumption and 42% lower maintenance costs.
- *Public safety:* Faster emergency response times and enhanced public safety with real-time incident monitoring.

- **Lessons Learned**

- Energy efficiency projects can be combined with public safety systems for dual benefits.
- AI-powered surveillance, while effective, requires strong data privacy policies to maintain public trust.

### *Oradea – Citizen engagement platform*

- **Overview:**

Oradea developed the "Oradea City Report," a free mobile application designed to facilitate citizen feedback and improve municipal services.

- **Key Features:**

- *Issue reporting*: Real-time reporting for infrastructure issues like potholes and streetlight failures.
- *Public polling*: Tools for collecting community feedback on municipal projects.
- *Service transparency*: Real-time updates on reported issues and their resolutions.

- **Impact:**

- *Increased transparency*: Real-time feedback improved public trust in local governance.
- *Enhanced service response*: Faster issue resolution due to real-time alerts.

- **Lessons Learned**

- Citizen participation tools can significantly increase local government accountability.
- Real-time reporting platforms are most effective when paired with proactive municipal responses.

## 8.2 Selected International Smart City Case Studies

### *Finnish Municipality (FM)*

#### **1. Smart Kalasatama, Helsinki**

Kalasatama is a living lab in Helsinki designed to test and implement smart city solutions in collaboration with residents, companies, and city officials. Projects include energy-efficient housing, IoT-enabled waste management, and real-time public transportation systems. A key focus is on saving residents' time and enhancing their quality of life through intelligent services.<sup>1</sup>

#### **2. Six Cities Strategy**

Six major Finnish cities (Helsinki, Espoo, Tampere, Vantaa, Oulu, and Turku) have collaborated on a unified strategy to implement smart urban technologies. Projects focus on open data platforms, smart mobility, and circular economy initiatives, enabling innovation and sustainable urban growth.

### *Norwegian Municipality (NM)*

#### **1. Sustainable Smart Cities in Norway**

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<sup>1</sup> <https://fiksukalasatama.fi/en/>

Norway has been at the forefront of developing smart cities with a focus on sustainability, quality of life, and reducing emissions. Initiatives include integrating green technologies into urban infrastructure, fostering citizen engagement, and adopting innovative mobility solutions. For instance, Bergen has implemented smart flood management systems, while Trondheim focuses on green energy integration across neighbourhoods. These projects align with the United Nations' Sustainable Development Goals, showcasing Norway's commitment to environmental and social innovation<sup>1</sup>.

## 2. Gnist – Innovation Project

The Gnist program is an initiative to address urban and rural development challenges by co-creating innovative solutions. Led by Nordic Edge and DOGA, this project brings together public authorities and private businesses to collaborate on smart city strategies. For example, pilot programs focus on inclusive urban planning and digital transformation of local services<sup>2</sup>.

## 3. Oslo's Sustainable Mobility Model

Oslo is a global leader in sustainable urban mobility, aiming to become the first zero-emission city by 2030. The city has eliminated parking spaces in its downtown area to promote walking and cycling and has transitioned to a fully electric public transportation system. Oslo's strategies serve as a model for other cities seeking to reduce emissions and enhance liveability.<sup>3</sup>

## 4. NTNU Smart Sustainable Cities

The Norwegian University of Science and Technology (NTNU) hosts an interdisciplinary research cluster that collaborates with municipalities and businesses to design and implement smart city solutions. Their projects emphasize renewable energy, smart housing, and citizen-centric design, contributing to sustainable urban living.<sup>4</sup>

### *Swedish Municipality (SM) and Sweden's smart city initiatives*

- *LoRa Network*: Developed by the local energy company for testing and implementing IoT technologies, with plans to expand future projects.
- *Inter-Municipal Collaboration*: Partnerships with other municipalities for digital solutions, including broadband infrastructure development.
- *Intelligent District Heating System in Karlshamn*: In Karlshamn, a collaboration between several organizations has created a sustainable, intelligent district heating

<sup>1</sup> <https://businessnorway.com/articles/smart-cities-in-norway-enhance-quality-of-life-and-reduce-emissions>

<sup>2</sup> <https://nordicedge.org/projects/gnist-an-innovation-project/>

<sup>3</sup> <https://www.worldfutureenergysummit.com/en-gb/future-insights-blog/blogs/oslo-a-model-for-sustainable-mobility.html>

<sup>4</sup> <https://www.ntnu.edu/smartcities>

system. The system is controlled using the latest AI technology and is constantly evolving to create a future-proof sustainable energy supply. <sup>1</sup>

- *Stockholm's Innovative District Heating Solutions*: Stockholm has developed one of Europe's largest district heating and cooling systems, with close to 90% of the city's buildings connected. The system utilizes innovative energy sources, such as excess heat from data centres and purified wastewater, contributing to a sustainable and low-carbon energy supply. <sup>2</sup>
- *Gothenburg's Sustainable District Heating*: Gothenburg has enhanced its district heating system by incorporating new technologies that enable heat storage to meet fluctuating demands. This approach has significantly reduced the need for fossil-based heating stations, moving the city closer to its goal of becoming fossil-free by 2025.<sup>3</sup>
- *Eco-City Augustenborg in Malmö*: The Augustenborg district underwent a transformation to address flooding issues and socioeconomic challenges. Implementing solutions based on ecosystem services, such as open storm water systems and green roofs, has turned the area into an attractive and resilient eco-city. <sup>4</sup>
- *Sustainable Ålidhem in Umeå*: The Sustainable Ålidhem project focuses on reducing energy usage and creating a safer, more comfortable environment. Initiatives include installing photovoltaic cells, energy-efficient systems, and the construction of the Winter Garden—a green, multipurpose meeting space heated by reused return heat.<sup>5</sup>
- *Western Harbour in Malmö*: Malmö's Western Harbour, previously an industrial area, has been redeveloped into a sustainable urban environment. The area features its own systems for energy supply and waste treatment, with minimized car traffic, emphasizing environmentally sustainable urban planning and mobility. <sup>6</sup>
- *Circular Water Solutions in Gotland*: Southern Gotland has implemented innovative circular water solutions to address water scarcity. Initiatives include rainwater harvesting, decentralized membrane treatment of raw wastewater for reuse, and climate neutral desalination powered by solar energy. <sup>7</sup>

<sup>1</sup> <https://smartcitysweden.com/best-practice/430/the-intelligent-district-heating-system-makes-use-of-ai/?utm>

<sup>2</sup> <https://smartcitysweden.com/best-practice/401/stockholm-innovates-district-heating-with-new-solutions-and-renewable-sources/?utm>

<sup>3</sup> <https://smartcitysweden.com/best-practice/309/gothenburg-smart-heating-and-cooling/?utm>

<sup>4</sup> <https://smartcitysweden.com/best-practice/329/eco-city-augustenborg-creating-an-attractive-and-resilient-district/?utm>

<sup>5</sup> <https://smartcitysweden.com/best-practice/227/umea-neighbourhood-integrates-all-aspects-of-sustainable-urban-development/?utm>

<sup>6</sup> <https://smartcitysweden.com/best-practice/161/the-environmentally-sustainable-city-of-tomorrow-in-malms-western-harbour/?utm>

<sup>7</sup> <https://smartcitysweden.com/best-practice/371/circular-water-solutions-in-southern-gotland/?utm>



These examples showcase Sweden's commitment to integrating sustainable and innovative solutions in urban development, serving as models for smart city initiatives worldwide.

### *Danish Municipality (DM)*

#### **1. Danish Outdoor Lighting Lab (DOLL)**

Located in Albertslund, DOLL is Europe's largest living lab for smart outdoor lighting solutions. The facility enables municipalities, businesses, and researchers to test and showcase cutting-edge technologies in street lighting, IoT-enabled sensors, and smart grids. The lab demonstrates how lighting can enhance safety, reduce energy consumption, and integrate with broader urban systems.<sup>1</sup>

#### **2. Nordhavn – The Five-Minute City**

Nordhavn, a district in Copenhagen, embodies the concept of a "five-minute city," where residents can access essential services within five minutes of walking or cycling. The area integrates smart energy systems, sustainable transport options, and green architecture to create an eco-friendly urban environment.<sup>2</sup>

These examples emphasize the importance of clear strategies, citizen engagement, and collaboration among municipalities, businesses, and academic institutions for successfully developing and implementing Smart City initiatives.<sup>3</sup>

### *Singapore – Smart Nation Digital Twin Initiative*

- **Overview:**

Singapore has developed one of the world's most comprehensive smart city strategies with its Smart Nation initiative, incorporating a national digital twin and data-driven infrastructure.

- **Key Features:**

- *3D city modelling:* Real-time data integrated with 3D GIS and BIM models.
- *Public services automation:* AI-powered decision-making tools for urban management
- *Open data access:* Public dashboards providing citizens access to environmental and energy data.

- **Impact:**

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<sup>1</sup> <https://stateofgreen.com/en/news/10-examples-of-smart-city-solutions/>

<sup>2</sup> <https://www.theguardian.com/lifeandstyle/2024/dec/10/the-five-minute-city-inside-denmarks-revolutionary-neighbourhood>

<sup>3</sup> <https://www.journal.riverpublishers.com/index.php/Nbjict/article/view/293/330>

- *Operational efficiency*: Real-time decision-making improved resource allocation across city departments.
- *Energy savings*: Significant reductions in energy consumption across public infrastructure.

### *Helsinki – Energy Efficiency and Climate Neutrality Project*

- **Overview:**

Helsinki developed a climate neutrality plan focused on smart energy management and reducing the city’s carbon footprint through data-driven policies.

- **Key Features:**

- *Energy mapping tools*: Real-time energy data visualization for public infrastructure.
- *Climate resilience programs*: AI-driven climate simulations for urban planning.

- **Impact:**

- *Carbon reduction*: Significant reductions in citywide emissions.
- *Public engagement*: Open access to energy data empowered citizen participation in climate strategies.

## 8.3 Insights and replicability for Romanian cities

- **Key insights:**

- *Data-Driven decision making*: Using real-time analytics for service optimization can enhance resource efficiency.
- *Public engagement tools*: Platforms like Oradea's feedback app show that citizen engagement improves accountability.
- *Climate action*: Helsinki’s focus on climate neutrality aligns well with Romania's PNIESC goals for sustainability.

- **Recommendations for replication:**

- *Leverage EU funding*: Maximize available funding such as Horizon Europe and Component 7 of PNRR for digital transformation.
- *Implement phased rollouts*: Start with pilot projects before city-wide expansion to manage financial risks.

- *Focus on regional needs:* Adapt strategies based on the unique challenges of each city, such as smart waste management in Cluj and emergency systems in Braşov.

## 8.4 Key Takeaways and Future Directions for Smart City Expansion

The analysis of successful smart city projects and case studies across Romania and internationally reveals several critical insights and strategic recommendations for the continued development of digital urban solutions. This section synthesizes the most significant lessons learned and outlines forward-looking strategies for expanding smart city initiatives across the country.

### *Key insights and lessons learned*

#### **1. Effective collaboration between stakeholders:**

- Successful smart city projects, such as those in Cluj-Napoca and Timișoara, have demonstrated that cross-sector collaboration between local governments, private technology providers, and research institutions is essential for long-term project sustainability.
- International case studies further highlight the importance of strategic partnerships with organizations such as Innovation Norway and Nordic Edge, emphasizing knowledge sharing and technology transfer.

#### **2. Importance of tailored regional approaches:**

- Different regions have unique challenges and opportunities, as seen in Constanta's coastal monitoring projects and Sibiu's focus on cultural heritage digitization.
- Customizing smart city solutions to address local priorities, such as traffic congestion in Bucharest or energy efficiency in Braşov, ensures greater relevance and impact.

#### **3. The role of policy Alignment and legislative frameworks:**

- The reviewed projects align with strategic frameworks such as PNRR (National Recovery and Resilience Plan) and PNIESC (National Integrated Energy and Climate Plan).
- Establishing standardized national guidelines and incentives for digital transformation, similar to EU frameworks, can drive cohesive progress and reduce disparities between regions.

#### **4. Financial innovation and sustainable funding:**

- The integration of diverse funding mechanisms, including EU structural funds, public private partnerships (PPPs), and green bonds, has been pivotal in the success of projects like Ploiești's renewable public transport system.
- Future smart city developments should explore co-financing models and dedicated innovation funds to ensure financial sustainability.

### **5. Data-Driven decision making and open data utilization:**

- Projects leveraging real-time data analytics, such as Cluj-Napoca's waste management system and Bucharest's Smart Mobility Hub, have showcased the potential of data driven governance.
- Expanding open data platforms and predictive analytics tools can further enhance decision-making efficiency and citizen engagement.

### **6. Citizen-Centric design and engagement:**

- The Oradea City Report platform exemplifies how digital solutions can empower citizens by providing direct channels for feedback and issue reporting.
- Enhancing public participation through user-friendly e-governance tools can promote transparency and foster trust in local administrations.

## *Strategic Directions for Smart City Expansion:*

### **1. Standardization and National Smart City framework development:**

- Develop a unified national smart city strategy, including standardized protocols for technology deployment, data governance, and sustainability metrics. • Align policy frameworks with the European Commission's Smart Cities Marketplace standards and integrate best practices from international collaborations.

### **2. Expanding capacity-building programs:**

- Strengthen partnerships with academic institutions and private technology firms to offer specialized training programs for municipal staff on topics like AI-driven urban management, IoT systems, and data security.
- Implement a continuous learning model with annual workshops and international exchange programs to ensure sustained knowledge sharing.

### **3. Encouraging scalable pilot programs:**

- Encourage cities to implement pilot smart city projects in a phased approach, beginning with smaller-scale implementations before expanding citywide.
- Adopt flexible funding mechanisms to support pilot projects and ensure iterative improvements based on performance analytics.



#### **4. Prioritizing inclusivity and regional balance:**

- Direct targeted investments towards underserved areas, including smaller municipalities and rural regions, to reduce the digital divide.
- Develop incentive programs for tech companies to collaborate with less-digitized regions, ensuring equitable access to smart city technologies.

#### **5. Enhancing Public-Private collaboration models:**

- Promote strategic PPP frameworks that balance public benefit with private sector innovation.
- Establish co-funding agreements where both public authorities and private firms share investment risks and long-term benefits.

#### **6. Strengthening international collaboration:**

- Expand partnerships with international organizations such as EDIH Oceanopolis, Innovation Norway, and Horizon Europe projects to leverage global expertise and technical support.
- Facilitate cross-border knowledge exchange programs, focusing on sustainable urban solutions and climate-neutral initiatives.

The insights gathered from both national and international smart city initiatives emphasize the transformative potential of well-coordinated, data-driven urban projects. By embracing a citizen-centric, regionally tailored approach supported by strategic policy alignment and sustainable funding models, Romania can accelerate its transition towards smarter, more resilient urban environments.

A holistic and collaborative strategy, with a focus on capacity-building and international partnerships, will ensure long-term success, creating more connected, efficient, and liveable cities for all Romanian residents.

## 9. Conclusion

This section summarizes the key findings and insights gained from the mapping exercise of smart city solutions in Romania, emphasizing their current impact and potential for driving sustainability, resilience, and overall quality of urban life in the country.

### *Summary of Key Findings and Insights from the Mapping Exercise*

#### 1. **Significant Progress in Key Urban Areas:**

Major cities like Bucharest, Cluj-Napoca, and Timișoara have made considerable strides in deploying smart city solutions, particularly in areas like urban mobility, public safety, and e-governance. These urban centres serve as models for innovation and showcase the scalability of digital technologies in addressing urban challenges.

#### 2. **Emerging Trends in Smart City Technologies:**

The mapping exercise identified prominent trends, including the increased adoption of renewable energy solutions, real-time environmental monitoring, data-driven waste management, and advanced mobility systems. These trends align with global shifts toward green urban technology and demonstrate Romania's alignment with sustainable urban practices.

#### 3. **Challenges Related to Funding, Skills, and Policy Gaps:**

Financial constraints, skills shortages, and regulatory hurdles remain significant barriers to the widespread adoption of smart city solutions across Romanian cities. Smaller municipalities in particular struggle to access funding and technical expertise, resulting in uneven development and a digital divide between urban and rural areas.

#### 4. **Need for Standardization and Strategic Policy Support:**

The lack of standardized guidelines and policies on smart city deployment presents challenges for cohesive implementation. Establishing national standards for technology interoperability, data privacy, and public-private partnerships could foster a more supportive environment for cities and private sector partners.

#### 5. **Untapped Potential in Secondary Cities and Rural Regions:**

Secondary cities, tourist destinations, and industrial hubs present significant opportunities for smart city solutions tailored to their specific needs. Regions like Brașov, Sibiu, and Constanța, for instance, could benefit from enhanced tourism management systems, energy-efficient infrastructure, and waste management solutions.

#### 6. **Opportunities for Cross-Border Collaboration:**

Partnerships with international organizations, especially Norwegian entities, offer opportunities for knowledge transfer, funding support, and access to innovative technologies. Cross-border collaborations are essential for building capacity within

local governments, enhancing technical expertise, and accelerating the adoption of best practices.

### *Final Remarks on the Potential Impact of Smart City Solutions for the Sustainability and Resilience of Urban Areas in Romania*

Smart city solutions have immense potential to transform Romania's urban landscape, enabling cities to operate more efficiently, sustainably, and resiliently. By embracing digital technologies and data-driven approaches, Romanian cities can tackle pressing issues like traffic congestion, energy waste, pollution, and public safety more effectively. Smart solutions not only improve quality of life but also create a strong foundation for sustainable economic growth and environmental stewardship.

#### **1. Enhanced Sustainability:**

Smart city technologies directly contribute to reducing the environmental impact of urban activities. Renewable energy integration, efficient public transport, and smart waste management support the transition to a low-carbon urban environment, aligning Romania's urban policies with European Union green objectives.

#### **2. Improved Resilience to Urban Challenges:**

The ability to monitor, predict, and respond to urban issues in real time strengthens a city's resilience. By implementing technologies for environmental monitoring, emergency response, and predictive maintenance, cities can better withstand crises, whether related to public health, infrastructure, or climate change.

#### **3. Increased Citizen Engagement and Quality of Life:**

E-governance platforms, citizen feedback channels, and health monitoring stations empower residents to participate in urban governance, enhancing trust and transparency. These solutions improve the quality of public services, making urban living more convenient, healthier, and safer.

#### **4. Potential to Bridge Urban-Rural Disparities:**

Smart city solutions can also help address the disparities between urban and rural regions by bringing tailored, scalable technologies to smaller municipalities. Targeted investments in secondary cities and underserved areas will foster more inclusive growth and ensure that the benefits of digital transformation reach all citizens.

By addressing the challenges and capitalizing on identified growth opportunities, Romania is well-positioned to advance its smart city agenda, creating cities that are not only technologically advanced but also environmentally and socially sustainable. The findings of this mapping exercise underscore the importance of policy support, capacity-building, and international partnerships in achieving this vision and establishing Romanian cities as leaders in the global smart city landscape.

## 10. Appendices

### Glossary of terms and definitions

#### *Acronyms and Abbreviations*

- **AI** – Artificial Intelligence
- **AR** – Augmented Reality
- **BEI** – Baseline Emissions Inventory
- **CEDO** – European Court of Human Rights
- **EU** – European Union
- **EV** – Electric Vehicle
- **ETS** – Emissions Trading System
- **FTTP** – Fiber to the Premises
- **GDPR** – General Data Protection Regulation
- **GHG** – Greenhouse Gas
- **GIS** – Geographic Information System
- **ICT** – Information and Communication Technology
- **IoT** – Internet of Things
- **LPAs** – Local Public Administrations
- **MAED** – Model for Analysis of Energy Demand
- **NGO** – Non-Governmental Organization
- **nZEB** – Nearly Zero Energy Building
- **PNAEE** – National Action Plan for Energy Efficiency
- **PNIESC** – National Integrated Energy and Climate Plan
- **PNRR** – National Recovery and Resilience Plan
- **PPP** – Public-Private Partnership
- **PUZ** – Zonal Urban Plan
- **PUG** – General Urban Plan
- **PATJ** – Territorial Planning Plan
- **PMUD** – Sustainable Urban Mobility Plan
- **RES** – Renewable Energy Sources
- **RRF** – Recovery and Resilience Facility
- **SECAP** – Sustainable Energy and Climate Action Plan
- **SRE** – Renewable Energy Sources (Romanian: Surse Regenerabile de Energie)
- **VR** – Virtual Reality

### *Key Terms*

- **Smart City** - A city that uses digital technologies and innovative solutions to improve the quality of life, sustainability, and efficiency of public services.
- **Smart Grid** - An advanced electricity distribution system that monitors and adjusts energy consumption in real time to optimize efficiency and resource use.
- **Smart Lighting** - A public lighting system that automatically adjusts brightness based on pedestrian and vehicle activity, enhancing energy efficiency and public safety.
- **Waste Management System** - Digital platforms and IoT-based solutions used for monitoring and optimizing waste collection processes in urban areas.
- **E-Governance** - The use of digital platforms to deliver public services such as tax payments, document issuance, and citizen participation in decision-making.
- **Data Analytics** - The process of collecting, analysing, and interpreting data generated by urban systems to improve decision-making and optimize city management.

## 11. References

1. European Commission, “The digital economy and society index ([DESI](#))”, [Online]. Available: <https://ec.europa.eu/digital-single-market/desi> [Accessed 8 Jan 2025]
2. Ida Cathrine Ringdal Lindtvedt, Ragnhild Skirdal Frøhaugand Per Jonny Nesse, “Smart City Development in Nordic Medium-sized Municipalities” Publication 21 May 2021,
3. <https://www.journal.riverpublishers.com/index.php/Nbjict/article/view/293/330> [Accessed 8 Jan 2025]
4. Best smart & sustainable city solutions from Sweden: <https://smartcitysweden.com/best-practice/>
5. <https://urbanizehub.ro/topul-celor-mai-eficiente-orase-din-romania/>
6. <https://citadini.ro/barometru-urban-2020>
7. <https://www.revistabiz.ro/topul-oraselor-din-romania-dupa-calitatea-vietii-in-2020>
8. [Top 10 Smart Cities and their Projects](#)

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