European Science Review 2026,
No 9–10
ISSN 2310-5577

PREMIER Publishing
ppublishing.org

DOI:10.29013/ESR-26-9.10-9-12

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DIGITAL TRANSFORMATION OF THE URBAN ECONOMY BASED ON SMART TECHNOLOGIES: PROSPECTS FOR THE SUSTAINABLE DEVELOPMENT OF GANJA CITY

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Cite: *Hajiyeva N.A., Huseynova N.V., Yusifova Sh.A., Allahverdi A.J., Mehtiyeva S.I. (2026). Digital Transformation of the Urban Economy Based on Smart Technologies: Prospects for the Sustainable Development of Ganja City. European Science Review 2026, No 9–10.* https://doi.org/10.29013/ESR-26-9.10-9-12

Abstract

This article considers how smart technologies could support the economic development of Ganja, one of the principal industrial, educational and cultural centers of Azerbaijan. The analysis rests on a literature review, a comparative reading of the Smart City concept and a SWOT assessment. On this basis the authors outline a conceptual Smart Ganja model in which digital infrastructure, urban data, analytics, digital governance and smart services form a connected chain, and relate it to the Master Plan for the Development of Ganja City until 2040. Priority areas, implementation stages and performance indicators are proposed. The conclusions are conceptual and have not been tested empirically.

Keywords: *Smart City, urban economy, digital transformation, digital governance, sustainable development, Ganja*

Introduction

Cities have become the main setting of economic life, bringing together industry, education, trade and services. As urban populations grow, demand for transport, energy, water and administrative services rises faster than many municipalities can expand their networks, and conventional management built around separate departments responds slowly. Digital technologies (sensors, geographic information systems (GIS), cloud platforms and analytics) allow urban processes to be observed continuously and decisions to rest on current data. The Smart City concept describes this as a change in the way a city is run, not merely the purchase of equipment (Bibri, 2021a, 2021b, 2021c; Carro-Suárez et al., 2023). Azerbaijan has begun to apply smart-city approaches within wider digital modernization and the growth of the digital economy (Hacıyeva et al., 2021), although researchers note that the idea remains hard to define and implement (Huseynova & Mazanova, 2023; Valiyev, 2022).

Ganja combines industry, higher education, cultural heritage and tourism, and

its long-term development is framed by the Master Plan for the Development of Ganja City until 2040 (Cabinet of Ministers of the Republic of Azerbaijan, 2026). The plan sets a spatial and infrastructural framework but does not determine how information about the city will be collected, shared and used. This gap is the starting point of the article, which aims to clarify which elements of the Smart City concept matter for urban economic development, to assess the conditions in Ganja, and to propose a conceptual model with implementation stages and indicators aligned with the Master Plan.

Research Methodology

The study is conceptual and qualitative. A systemic approach treated the city as a set of interdependent subsystems. A comparative analysis of the literature identified the dimensions, technologies and obstacles most often associated with smart and sustainable cities (Bibri, 2021 a, 2021 b, 2021 c; Carro-Suárez et al., 2023; Huseynova & Mazanova, 2023; Valiyev, 2022). A SWOT analysis organized the factors affecting digital transformation in Ganja. No primary survey or statistical dataset was collected, so the article makes no quantitative claims about the present state of the city's infrastructure.

Smart City Concept and Economic Effects

Later work on the smart city shifted the emphasis from devices to outcomes, treating technology as a means of improving economic performance, environmental quality and public services (Carro-Suárez et al., 2023). Most frameworks distinguish six interrelated dimensions: economy, mobility, environment, governance, living conditions and people. They cannot be improved in isolation: an electronic service helps little if residents lack the skills to use it. Data are the connecting element. Urban analytics allows planning to combine long-term strategy with short-term decisions (Bibri, 2021 a), and the institutional arrangements around data are as important as the technology (Bibri, 2021 b).

The economic case rests on three mechanisms. The first is lower operating costs and resource losses, since continuous monitoring of water, heating and electricity networks finds faults earlier than periodic inspection. The second is a gain in time and accessibility through traffic management and public transport information. The third is lower transaction costs, since electronic services, digital permits and online payments reduce the time firms and residents spend on administrative procedures. These mechanisms depend on one another, so the economic effect depends less on any single technology than on how well technologies are integrated (Bibri, 2021 a, 2021 c; Huseynova & Mazanova, 2023).

Digitalization Premises in Ganja and the Master Plan

The character of the city shapes which solutions are likely to matter. Industrial enterprises could use monitoring and automation to improve efficiency. Universities train specialists in information technology, analytics and management and can partner with the municipality and business in pilot projects; the local supply of qualified people may prove a tighter constraint than the cost of equipment. Digital maps, multilingual guides and environmental monitoring could make the city's heritage easier to find. These premises are favorable but require network coverage, funding, coordination and trained staff.

The Master Plan decides what is to be built and where, while digital tools show how the city functions in the meantime and supply evidence for adjusting course (Cabinet of Ministers of the Republic of Azerbaijan, 2026). A GIS-based information system would keep data on land parcels, utilities, roads and social facilities in one spatial database, and remote monitoring would help locate network failures. The two are thus complementary (Bibri, 2021a; Huseynova & Mazanova, 2023).

SWOT Assessment

The SWOT assessment is qualitative and rests on the socio-economic profile of the city, the Master Plan and problems described in the literature (Bibri, 2021 a; Huseynova & Mazanova, 2023; Valiyev, 2022). The strengths are industrial and entrepreneurial activity, educational institutions, cultural and tourism resources and an adopted planning framework. The weaknesses are mostly organizational: infrastructure needing mod-

ernization, unequal digital competence, weak coordination between digital projects and the risk of piecemeal procurement producing incompatible systems. The main opportunity is that infrastructure built or renewed under the Master Plan can be equipped with digital capabilities at lower cost than if added later. Threats include cybersecurity and personal-data protection, high acquisition and maintenance costs, technological obsolescence and a widening gap between those who can use digital services and those who cannot.

The Smart Ganja Model, Implementation and Indicators

The proposed conceptual model is a chain of six links. Digital infrastructure (networks, sensors, GIS and computing resources) generates urban data from transport, energy, land use, municipal services and the environment. Analytics turns these data into information for decisions. Digital governance is the institutional link: it determines who owns data, who may use them and which procedures turn findings into decisions. Smart services are the visible result through which residents, businesses and visitors meet the system, and the socio-economic effects (lower costs, better accessibility, more business activity) are where the model is judged. Priority service areas are mobility, energy, environment, governance, tourism and business (Bibri, 2021 a, 2021 b, 2021 c).

Implementation should be gradual: an inventory of existing digital infrastructure; pilot projects beginning with an integrated data platform; evaluation against measurable indicators; integration of successful systems into a common data architecture; and, finally, advanced analytics where feasible and economically justified. Indicators should be defined and baseline values recorded before pilots begin. Suggested measures include the share of municipal services available online, request-processing time, public transport waiting time, network losses, air-quality readings and digital-service use among different groups of residents. They are proposed for future assessment and are not measured results. Public authorities should own data policy, businesses supply technology and investment, universities provide research and training, and cybersecurity must be built into every system (Bibri, 2021 b; Huseynova & Mazanova, 2023; Valiyev, 2022).

Discussion and Conclusion

The study is conceptual and has not been tested with municipal data, a resident survey or interviews with officials. Within these limits, the observation that smart cities in Azerbaijan are hard to conceptualize (Valiyev, 2022) points to the value of a model with explicit links and responsibilities, and the emphasis on institutions in the literature (Bibri, 2021b) suggests that the most valuable early investment may be in coordination and skills rather than equipment.

Smart technologies can contribute to modernizing the urban economy of Ganja by making infrastructure more efficient, reducing resource losses and improving access to services, but only if projects are integrated into one coordinated system. The city's resources and the Master Plan provide a sound basis, while financing, cybersecurity, skills and unequal access remain the main constraints. A phased approach with pilots, measurable indicators and clear institutional roles is the most prudent way to proceed. Future research should collect baseline data, test the proposed indicators and evaluate the first implemented projects.

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submitted 09.10.2026;
accepted for publication 23.10.2026;
published 31.10.2026
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