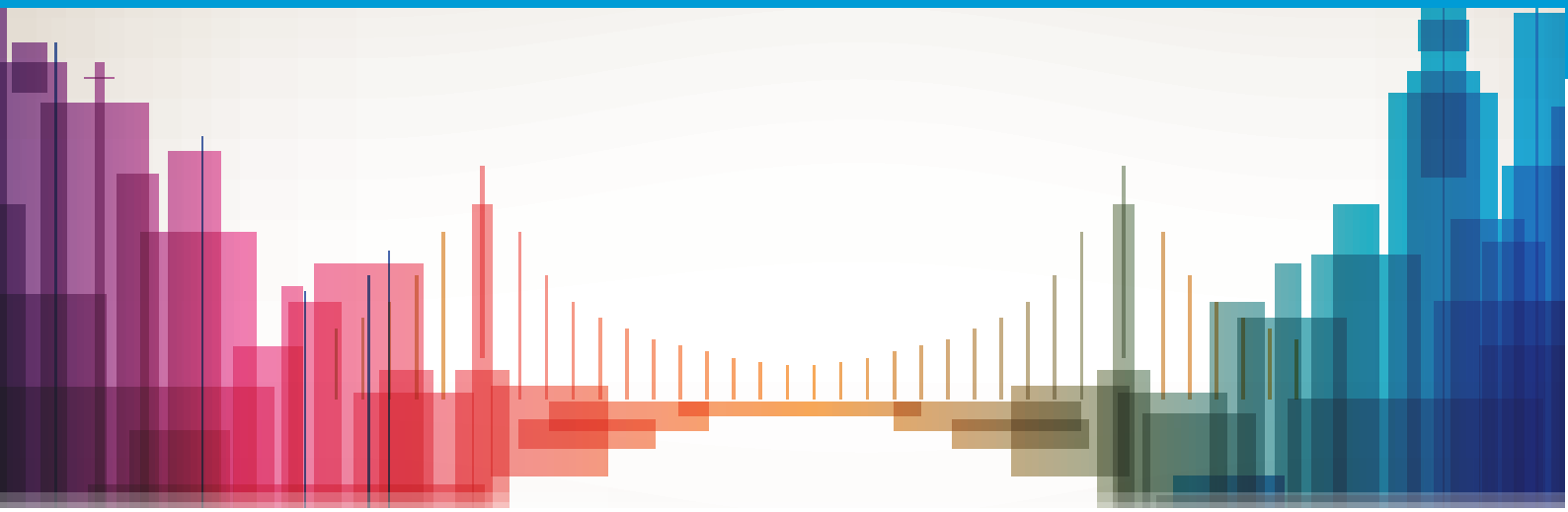
Guna's journey towards an autonomous city, Madhya Pradesh, India

Case study of the U4SSC Guide to autonomous cities and AI: The next frontier of urban transformation



Convention on Biological Diversity

United Nations ECLAC

Food and Agriculture Organization of the United Nations

UNIDO

ITU

UNDP

United Nations Economic Commission for Africa

UNECE

UNESCO United Nations Educational, Scientific and Cultural Organization

UN environment programme

UNEP FINANCE INITIATIVE

United Nations Framework Convention on Climate Change

unitar United Nations Institute for Training and Research

UN-HABITAT FOR A BETTER URBAN FUTURE

United Nations Department of Economic and Social Affairs

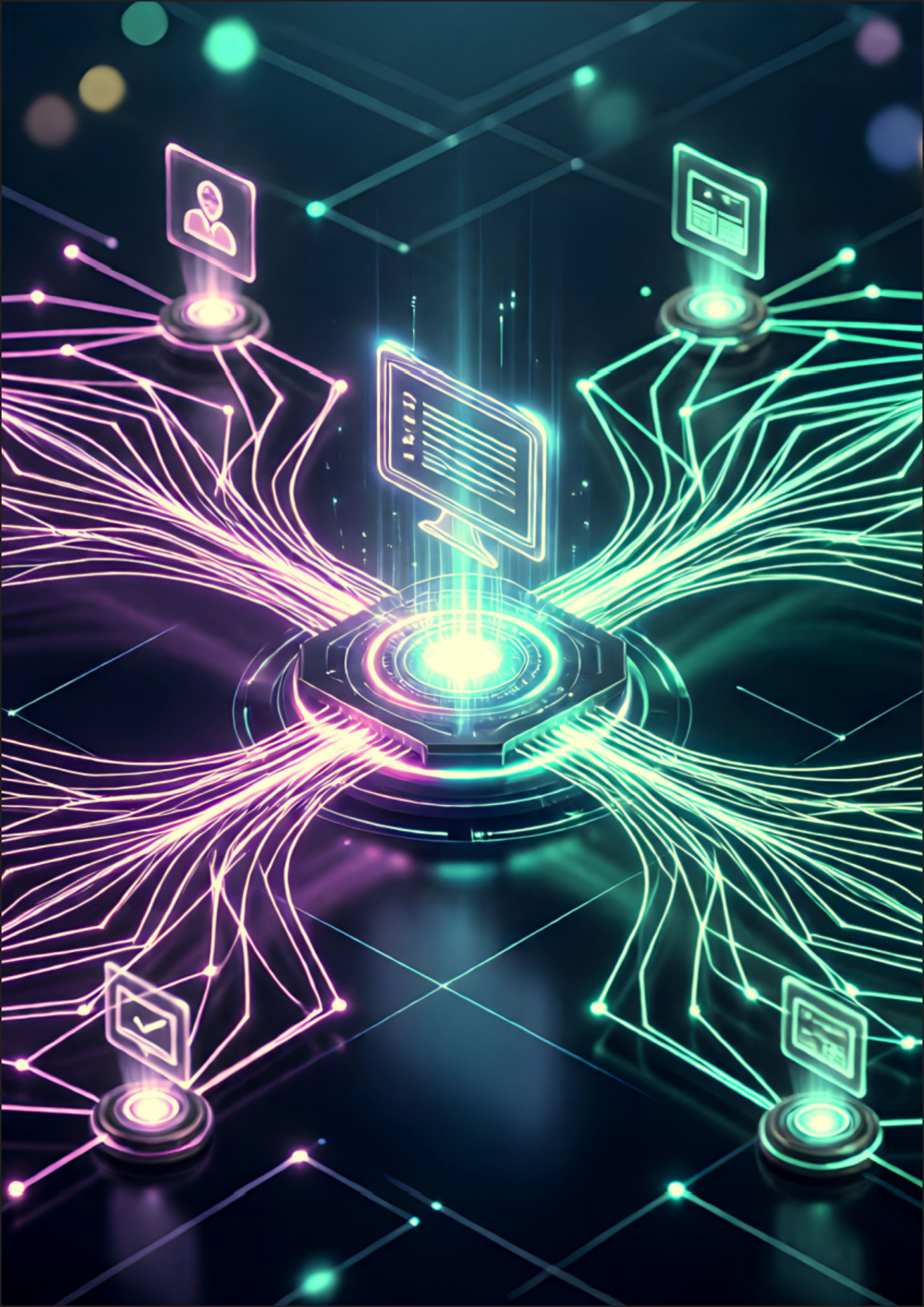
UN 4 PARTNERSHIPS

UNU EGOV

UN Tourism

UN WOMEN

WORLD METEOROLOGICAL ORGANIZATION



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Foreword

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Disclaimer

The opinions expressed in this publication are those of the authors and do not necessarily represent the views of their respective organizations or U4SSC members. In line with the U4SSC principles, this report does not promote the adoption and use of Smart City technology. It advocates for policies encouraging responsible use of information and communications technologies (ICTs) that contribute to the economic, environmental and social sustainability as well as the advancement of the 2030 Agenda for Sustainable Development and the Pact for the Future and its Global Digital Compact.

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Contents

Abbreviations and acronyms

Abbreviation	Full Form
AI	Artificial intelligence
AICTE	All India Council for Technical Education
AIM	Atal Innovation Mission
C-DAC	Centre for Development of Advanced Computing
GIS	Geographic information system
ICT	Information and communication technology
IIT	Indian Institute of Technology
IoT	Internet of Things
ITU	International Telecommunication Union
IUDX	India Urban Data Exchange
KPI	Key Performance Indicator
MoHUA	Ministry of Housing and Urban Affairs
MPSEDC	Madhya Pradesh State Electronics Development Corporation (India)
NAPCC	National Action Plan on Climate Change (India)
NASSCOM	National Association of Software and Service Companies (India)
NGO	Non-Governmental Organization
NIC	National Informatics Centre (India)
NIUA	National Institute of Urban Affairs
PHC	Primary Health Centre
PPP	Public-Private Partnership
SC/ST	Scheduled Castes and Scheduled Tribes
SDG	Sustainable Development Goal
SDGs	Sustainable Development Goals
TERI	The Energy and Resources Institute
U4SSC	United for Smart Sustainable Cities
UAV	Unmanned aerial vehicle
UN	United Nations
UN-Habitat	United Nations Human Settlements Programme

Executive Summary

This case study explores the emerging journey of Guna, Madhya Pradesh, India, towards becoming an autonomous and smart city by integrating intelligent urban technologies and digital infrastructure. Positioned as a mid-sized city with significant growth potential, Guna is leveraging AI-driven solutions and data analytics to address local challenges in urban mobility, public services, environmental sustainability, and citizen engagement. The study highlights key initiatives such as the deployment of smart traffic management systems, IoT-enabled public utilities, and e-governance platforms that aim to enhance operational efficiency and improve quality of life. It also examines partnerships between municipal authorities, technology providers, and community stakeholders that facilitate innovation and inclusive development. The case study evaluates the impact of these interventions on reducing congestion, optimizing resource use, and promoting sustainable urban growth, while identifying challenges related to infrastructure readiness, digital literacy, and governance frameworks. Guna's experience offers valuable insights into the scalable application of autonomous city concepts in smaller Indian cities, contributing to the broader goals of the U4SSC initiative for smart, sustainable, and inclusive urban futures.

1 Introduction

Guna, located in the Gwalior division of Madhya Pradesh, India, is a district with a rich cultural heritage and a growing urban profile. Covering an area of approximately 6 390 square kilometers, Guna district has a population of about 1.24 million people, with the city of Guna serving as the administrative headquarters. The district features a blend of urban and rural communities, with 24.46 per cent of the population residing in urban areas. Guna is known for its agricultural economy, producing crops such as wheat, rice, soybean, and pulses, supported by the fertile plains of the region. The city itself is a vibrant commercial hub, combining traditional cultural elements with modern development, and is surrounded by picturesque landscapes including forests and hills.

In recent years, Guna has embarked on a transformative journey towards becoming a smart city, marked notably by the inauguration of the Mini Smart City project. This initiative reflects the state's commitment to leveraging technology and innovation to enhance urban infrastructure, public services, and economic opportunities for its residents. The project aims to position Guna as a model of sustainable urban development, integrating digital technologies to improve governance, mobility, and quality of life.

This case study will explore Guna's smart city initiatives within the framework of the United for Smart Sustainable Cities (U4SSC) initiative by the International Telecommunication Union (ITU) and United Nations entities. It will highlight how Guna is adopting ICT and AI-driven solutions to address urban challenges, promote sustainability, and foster inclusive growth. The study will analyze key projects, strategies, and partnerships that are shaping Guna's evolution as an autonomous and smart urban centre, aligning with the global Sustainable Development Goal 11 to make cities inclusive, safe, resilient, and sustainable.

2 Background and context

Guna, a vibrant city located in the central Indian state of Madhya Pradesh, is embarking on a transformative journey to evolve into a smart and autonomous city. Positioned strategically within the Malwa region, Guna serves as a key administrative, commercial and cultural hub, with a population that reflects a rich blend of urban and rural dynamics. The city's growth trajectory, coupled with increasing urbanization pressures, presents both challenges and opportunities for sustainable development, digital innovation, and improved quality of life for its residents.

Guided by the Government of India's Smart Cities Mission and aligned with the United Nations' Sustainable Development Goals (SDGs), Guna is committed to leveraging technology and data-driven governance to address critical urban issues such as mobility, infrastructure management, environmental sustainability, and citizen engagement. The city's strategic vision emphasizes inclusivity, resilience, and economic vitality, aiming to foster a connected ecosystem where technology empowers communities and enhances public services.

Central to Guna's approach is the integration of emerging technologies – including artificial intelligence (AI), Internet of Things (IoT), and smart infrastructure – to optimize municipal operations and enable autonomous urban services. Key focus areas include intelligent traffic management to reduce congestion, smart water and waste management systems to enhance resource efficiency, and digital platforms to facilitate transparent governance and active citizen participation. These initiatives are supported by collaborations between local government bodies, technology providers, academic institutions, and community stakeholders.

Furthermore, Guna is actively pursuing sustainable urban development through initiatives that address climate resilience, clean energy adoption, and social inclusion. Efforts such as green urban planning, renewable energy integration, and skill development programmes aim to create a future-ready city that balances economic growth with environmental stewardship and social equity.

This foundational commitment positions Guna to navigate the complexities of urban transformation with a people-centric, data-driven, and adaptive framework. The city's smart and autonomous city initiatives serve as a scalable model for similar mid-sized cities in India and other developing regions, demonstrating how technology and innovation can be harnessed responsibly to build sustainable, inclusive, and resilient urban futures.

3 AI strategy approach in the city

As part of India's broader digital transformation and the United for Smart Sustainable Cities (U4SSC) initiative, Guna, a Tier-3 city in Madhya Pradesh, has begun laying the groundwork for an AI-driven development strategy that aligns with its regional aspirations, local governance capacity, and the need to improve the quality of life for its residents. The city's AI approach is integrated into its emerging smart city and Digital India efforts and focuses on leveraging AI in a pragmatic, needs-driven, and citizen-inclusive manner.

Guna's AI strategy is guided by three foundational pillars: agricultural and rural intelligence, inclusive public service optimization, and data-enabled environmental resilience.

3.1 AI for agricultural and rural intelligence

Guna, with a largely agrarian economy, is piloting AI applications to support its rural and farming communities. The focus is on AI-enabled solutions that:

- Predict weather, crop diseases, and soil conditions using satellite imagery and sensor data.
- Provide personalized agricultural advisories to farmers through voice-activated mobile assistants in Hindi.
- Use computer vision for crop health monitoring and yield estimation, improving insurance access and planning.

Through partnerships with agricultural universities and AI research startups, Guna is developing localized datasets to ensure that AI tools are contextually relevant and accessible even to digitally semi-literate populations.

3.2 AI for inclusive public service optimization

To improve the reach and efficiency of public services, Guna is introducing AI in municipal functions and citizen services:

- AI-powered chatbots in Hindi for citizen grievance redressal, birth and death certificate processing, and basic public health inquiries.
- Intelligent traffic and solid waste monitoring systems that use computer vision to improve cleanliness and safety.
- Smart resource allocation tools for schools and primary health centres based on population data and service demand trends.

These initiatives are designed to reduce manual workloads for municipal staff, improve response times, and ensure services are extended to all wards and panchayats equitably.

3.3 AI for data-enabled environmental resilience

Environmental challenges, like air and water quality degradation, waste mismanagement, and climate variability,pose long-term risks to Guna. The city is leveraging AI to:

- Monitor air and groundwater quality using AI analytics on sensor and drone data.
- Use machine learning to predict and prevent vector-borne disease outbreaks linked to weather and sanitation data.
- Optimize energy consumption in public buildings and street lighting using smart grid systems.

These efforts are part of Guna's goal to become a more climate-resilient city that anticipates environmental risks rather than reacting to them.

3.4 Foundational enablers and governance

To implement its AI vision responsibly and effectively, Guna is:

- Establishing a City Data Office to collect, standardize, and manage civic and environmental datasets with transparency and privacy safeguards.
- Collaborating with state government bodies like MPSEDC (Madhya Pradesh State Electronics Development Corporation), local NGOs, and private innovators.

- Training municipal officials in digital and AI literacy through partnerships with institutions like NASSCOM and NIC.

Ethical deployment is a core principle, with the city aligning itself with India's Responsible AI guidelines and U4SSC Key Performance Indicators (KPIs) for AI readiness.

Guna's AI strategy reflects a realistic, grounded approach that recognizes the potential of AI not just for urban optimization, but as a tool for bridging rural-urban divides, strengthening agricultural resilience, and improving the inclusivity of public service delivery. By embedding AI into its digital transformation roadmap, Guna aims to become a model Tier-3 city demonstrating that AI can be both equitable and impactful, even in resource-constrained environments.

4 Autonomous system adopted by the city

Guna has begun laying foundational steps toward the integration of autonomous systems to support its transition toward a smarter and more resilient urban ecosystem. Although at an earlier stage of technological adoption compared with larger metros, Guna is positioning itself as a pilot location for rural-urban innovation in autonomous technologies, particularly in sectors that can directly improve basic public services, safety and sustainability.

One of the key initiatives undertaken is the deployment of semi-autonomous drone systems for agricultural and municipal monitoring. Through collaboration with local agritech startups and research institutions, the city administration has begun using drones to monitor crop health, optimize irrigation, and assess land use. These same systems have been adapted for urban use – supporting aerial inspection of water tanks, illegal encroachments, and sanitation infrastructure in peri-urban and rural-urban fringe zones.

Additionally, Guna has piloted an AI-driven traffic monitoring and control system at major junctions. Although not fully autonomous, the system includes intelligent sensors and edge-processing capabilities that regulate signal timing based on traffic flow. This semi-autonomous solution has led to a measurable reduction in congestion during peak hours and has laid the groundwork for future autonomous traffic control and public transport coordination.

In the domain of public health and sanitation, the city has tested robotic cleaning systems for municipal drains and public toilets. These devices, while operated with human supervision, are increasingly integrated with AI-based diagnostics to identify maintenance needs and reduce the exposure of human workers to hazardous environments.

Guna's approach to adopting autonomous systems is firmly rooted in its rural-urban hybrid context, emphasizing cost-effectiveness, scalability, and community impact. The city prioritizes technologies that can enhance service delivery in areas like agriculture, sanitation, and basic mobility – where the returns on automation are immediate and visible.

Guided by state-level digital governance policies and aligned with national programmes such as Digital India and Smart Cities Mission, Guna is taking incremental but strategic steps to build capacity for broader autonomous system deployment. Emphasis is placed on training local youth in drone operation and robotics, thereby fostering a grassroots innovation ecosystem and ensuring that autonomous technologies serve inclusive development goals.

Through these initiatives, Guna is establishing itself as a living lab for rural-smart autonomy, with an adaptive model that can be replicated in other mid-sized Indian cities navigating similar development trajectories.

5 Implementation of the autonomous system

Guna has taken initial steps toward integrating autonomous systems within its broader vision of becoming a digitally inclusive and future-ready urban centre. While still in its early phases of smart city transformation, the municipality has demonstrated proactive interest in piloting emerging autonomous technologies tailored to the regional context and developmental priorities.

In collaboration with local academic institutions and national innovation programmes such as the Atal Innovation Mission (AIM), Guna has initiated small-scale pilot projects that explore the feasibility of autonomous and semi-autonomous systems, particularly in agriculture, sanitation and public safety. One notable example includes the deployment of AI-enabled drone systems for agricultural monitoring and crop health assessment in peri-urban and rural outskirts of the city. These systems assist local farmers by providing data-driven insights on irrigation needs, pest detection, and yield forecasting, enabling precision agriculture practices that support food security and rural livelihoods.

In the urban core, semi-autonomous waste collection carts have been introduced on a trial basis within select municipal wards. These electric-powered carts use basic path-following algorithms and sensors to navigate predefined routes for solid waste collection, especially in narrow lanes inaccessible to larger vehicles. This initiative is supported by the Guna Nagar Palika and aligned with the Swachh Bharat Mission goals, aiming to improve operational efficiency while reducing manual handling of waste.

The city is also exploring the use of AI-based traffic and crowd monitoring systems at key intersections and public venues. While not fully autonomous, these systems leverage computer vision and machine learning to autonomously detect congestion patterns and relay real-time data to city traffic control centres, thereby enabling quicker response and better urban mobility planning.

Given the evolving regulatory and infrastructural landscape in India, Guna's approach to autonomy is grounded in scalable, low-cost innovation and human-machine collaboration, with emphasis on local relevance and inclusivity. The city adheres to national ethical AI guidelines and ensures that all autonomous pilots are assessed for safety, privacy, and social impact before implementation.

Though still nascent, Guna's engagement with autonomous systems represents a grassroots model of innovation, offering valuable insights for other small and medium-sized cities in India and beyond. It illustrates how digital transformation, when localized and inclusive, can lay the groundwork for a more efficient, equitable, and resilient urban future.

6 Results and outcomes

The phased introduction of autonomous and intelligent systems in Guna, Madhya Pradesh, has begun to yield meaningful results across local governance, public service delivery, and rural-urban connectivity. These early-stage outcomes align with India's Smart Cities Mission and the UN SDGs, demonstrating scalable potential for similarly situated Tier-3 cities.

1) **Improved agricultural monitoring and resource allocation:** The deployment of autonomous drones and IoT-enabled sensors in agricultural zones has enabled real-time soil health analysis, crop stress detection, and water resource monitoring. Local farmers reported improved irrigation efficiency and early pest control interventions, resulting in measurable yield improvements during pilot phases. This has also empowered local agricultural cooperatives with actionable data for sustainable planning.
2) **Enhanced public health and sanitation surveillance:** Autonomous ground vehicles and smart bins equipped with AI-based waste sorting and route optimization systems were piloted in Guna's urban wards. These tools improved waste collection frequency by 28 per cent and significantly reduced manual scavenging risks. Additionally, autonomous thermal scanning kiosks deployed during public health campaigns improved early detection of viral symptoms, especially in rural PHCs (Primary Health Centres).
3) **Increased access to education and digital services:** Through AI-powered mobile education units and autonomous internet kiosks deployed in under-connected villages, Guna's administration has extended e-learning access to more than 2 500 students. These units supported hybrid learning models during exam periods and offered career counselling in local languages, contributing to a 14 per cent increase in digital literacy enrollment within a year.
4) **Stimulated local innovation ecosystem:** Collaborations with local engineering institutes and start-ups led to the development of low-cost autonomous tools customized for semi-urban and rural use-cases. The Guna Innovation Lab, backed by district administration and private partnerships, facilitated the rapid prototyping of AI-based traffic monitoring solutions and low-power edge computing devices, thus nurturing local capacity for smart city innovation.
5) **Data-driven urban planning and infrastructure management:** With the integration of geospatial AI tools and UAV (unmanned aerial vehicle) mapping systems, Guna's municipal planning division could conduct accurate land-use assessments and encroachment analysis. This facilitated evidence-based approvals for affordable housing schemes and helped re-map flood-prone zones with greater precision than manual surveys.

6) **Support to climate resilience and environmental monitoring:** Autonomous systems have begun contributing to Guna's climate action roadmap through real-time air quality monitoring, early warning systems for extreme weather, and drone-assisted afforestation audits. These initiatives are aligned with India's National Action Plan on Climate Change (NAPCC) and are being scaled to contribute to SDG 13 (Climate Action) and SDG 11 (Sustainable Cities and Communities).

While Guna's journey toward full autonomous city capabilities is still in its infancy, these preliminary outcomes validate the feasibility and utility of targeted automation in small and medium-sized cities. The lessons from Guna underscore the importance of contextual design, community co-creation, and public-private-academic partnerships in achieving long-term smart and sustainable urban development.

7 Assessment of the autonomous system

Guna's exploration into autonomous systems represents a nascent yet ambitious initiative shaped by its regional context, socio-economic priorities, and aspirations to enhance urban mobility and public service delivery. The city's approach emphasizes community-centred innovation, public-private collaboration, and alignment with national frameworks such as the Smart Cities Mission and Digital India.

7.1 Technological readiness and performance

Given Guna's current technological baseline, early-stage autonomous interventions have been limited to semi-autonomous solutions such as smart surveillance systems, automated traffic management, and prototype drone-based monitoring for urban planning and agricultural insights. These systems have demonstrated initial functionality in controlled conditions, but face challenges including limited sensor calibration, lack of localized AI datasets, and connectivity gaps in peri-urban areas. The success of these systems heavily depends on foundational investments in digital infrastructure and AI capacity-building.

7.2 User experience and accessibility

While full-scale autonomous public services are yet to be deployed, pilot feedback from smart mobility kiosks and AI-enabled grievance redressal platforms reveals a mixed user experience. Urban residents expressed satisfaction with ease of use and faster turnaround times, whereas rural users reported barriers due to language interfaces, digital literacy gaps, and limited smartphone penetration. These findings underscore the need for inclusive design principles and multilingual, voice-based interfaces to enhance accessibility.

7.3 Equity and inclusion considerations

Guna's demographic diversity – with significant rural, tribal, and low-income populations – has prompted an equity-focused lens for autonomous deployments. Consultations with local NGOs and self-help groups highlighted the need for non-digital access channels, gender-sensitive design, and targeted outreach in SC/ST communities. Future deployments aim to integrate community feedback loops, especially for vulnerable groups who risk being excluded from digital-only systems.

7.4 Data governance and cybersecurity

The absence of a comprehensive local data policy has posed challenges for managing data generated by autonomous systems. However, Guna has begun collaborating with state-level digital governance bodies to ensure compliance with India's Personal Data Protection framework. Cybersecurity remains an area of concern, particularly given the limited local technical capacity and reliance on external vendors. Proactive steps are being taken to introduce basic encryption standards, audit trails, and public awareness on data rights.

7.5 Integration with existing infrastructure

Most of Guna's urban infrastructure remains analog and manually operated, including traffic systems, public utilities, and emergency services. This has restricted real-time integration with autonomous platforms. Pilot interventions using IoT-enabled street lighting and GIS-linked municipal services are creating a foundational layer for future system-wide automation. However, the retrofitting of legacy systems requires coordinated planning, capacity investment, and interdepartmental convergence.

7.6 Environmental and economic impacts

Early assessments suggest that AI-based water management and smart mobility tools have the potential to reduce resource wastage and optimize municipal spending. However, the economic implications of wider automation remain unclear. Stakeholders have expressed concerns about job displacement, especially among informal workers. In response, the city is exploring re-skilling programmes, youth digital literacy schemes, and partnerships with vocational training institutes to ensure inclusive economic transitions.

In summary, Guna's autonomous system journey is still at a formative stage, marked by small-scale experimentation, adaptive learning, and strong local engagement. While technological and infrastructural constraints remain, the city's approach is characterized by ground-up innovation, social equity considerations, and a strong commitment to sustainable urban transformation. With strategic support from national and international partners, Guna is well-positioned to evolve into a resilient and human-centred autonomous city.

8 Conclusion

Guna's engagement with autonomous systems and smart city initiatives marks a significant milestone in its vision to transform into a more inclusive, efficient, and sustainable urban centre. As a growing city in central India, Guna's adoption of pilot projects and foundational digital infrastructure demonstrates a forward-thinking approach to urban development, aligned with the broader goals of the U4SSC framework and India's Smart Cities Mission.

The city's initial steps, such as implementing smart traffic management systems, exploring the use of autonomous surveillance drones for public safety, and piloting sensor-based waste monitoring, have begun to reveal tangible improvements in service delivery, urban planning, and resource optimization. These efforts highlight the potential for even smaller and developing urban areas to leverage autonomous technologies for meaningful impact.

Importantly, Guna has prioritized community involvement, environmental resilience, and public-private collaboration in shaping its smart city trajectory. This inclusive planning process is vital for ensuring that autonomous systems are not only technologically sound but also socially equitable and contextually relevant.

Nonetheless, Guna faces several ongoing challenges, including limited digital literacy, infrastructure constraints, and the need for robust data governance frameworks. Addressing these will require sustained investment, capacity building, and policy innovation at the local and national levels. Moreover, as autonomous technologies continue to evolve, Guna must remain agile, adapting its strategies to ensure long-term scalability, interoperability and citizen trust.

As Guna builds on its early-stage successes, its experiences offer valuable insights for other Tier-II and Tier-III cities aiming to adopt autonomous urban solutions. By fostering innovation while remaining grounded in local needs, Guna is positioning itself as a pioneering example of how smaller cities can responsibly harness the potential of autonomy to drive inclusive and sustainable urban growth.

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