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Research Article

Assessing the Readiness of Architects and Urban Planners for Smart Infrastructure in Enugu State, Nigeria

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Abstract

The global shift towards smart cities presents a strategic pathway for sustainable urban development, particularly in developing countries such as Nigeria. While Lagos and Abuja have initiated smart-city programmes, South-East state capitals such as Enugu remain largely peripheral to this transition despite rapid urban growth and increasing infrastructure demands. This study assessed the readiness of architects and urban planners for smart infrastructure development in Enugu Metropolis, including their perceptions of government and institutional preparedness. A quantitative, cross-sectional survey was conducted using a proportionate stratified sample of 183 registered architects and urban planners, with 175 valid responses analysed (95.6% response rate). Data were summarised using frequencies and percentages, while associations were examined using the chi-square test and Cramér's V. Findings revealed high awareness of smart infrastructure, with 92.5% of respondents familiar with the concept, 83.6% willing to adopt smart public services, and 89.1% believing smart technologies would improve living conditions. However, implementation readiness was considerably lower: only 47.3% had access to GIS or BIM tools, 29.1% had received ICT-related training, and 20.0% were aware of relevant government policies. Major barriers included inadequate funding (32.7%), weak inter-professional collaboration (30.9%), and insufficient infrastructure (18.2%). Professional discipline was significantly associated with awareness, $\chi^2(2, N = 175) = 12.87$, $p = .003$, Cramér's $V = .27$, indicating a moderate association. Since institutional officials were not surveyed, institutional readiness reflects professionals' perceptions rather than a direct assessment.The study proposes an Enugu Smart Infrastructure Readiness Framework with phased implementation, collaborative governance, and pilot smart-city initiatives.

Keywords: Smart infrastructure; Architects; Urban planning; Digital readiness; Sustainable development; Enugu State.

Highlights

- Awareness was high (92.5%), but implementation readiness was limited.
- GIS/BIM access (47.3%) and ICT-enabled training (29.1%) were low.
- Funding and weak collaboration were the leading adoption barriers.
- A phased readiness framework and implementation roadmap are proposed.

1 Introduction

Rapid urbanisation defines the twenty-first century, presenting complex challenges for urban management, sustainability, and quality of life (United Nations, 2018). Smart infrastructure has emerged as a key vehicle through which digital technologies enhance service delivery, infrastructural efficiency and community engagement (Ismagilova et al., 2019). Globally, cities deploy information and communication technology (ICT) to create responsive urban environments, integrating smart solutions into mobility, energy and governance (Anthopoulos, 2017). In Africa, the movement is gaining ground through pilot programmes in Nairobi, Kigali and Cape Town, which demonstrate the potential of digital innovation in the region (Odendaal, 2021). In Nigeria, however, this innovation is unevenly distributed: metropolitan centres such as Lagos and Abuja host projects in surveillance and e-governance, while South-Eastern state capitals remain largely marginal to the transition (Odebiyi et al., 2025; Mba et al., 2024; Olokesusi et al., 2018). Enugu State, a rapidly urbanising area served by institutions such as the Enugu Capital Territory Development Authority (ECTDA), still lacks a comprehensive plan for smart infrastructure (Okeke et al., 2020; Igwe et al., 2025). This gap motivates the present study, which examines the preparedness of architects and urban planners for smart innovation amid mounting developmental pressures.

In Enugu, the case for smart-city development is primarily need-driven rather than an uncritical adoption of a global trend. The metropolis is experiencing rapid spatial expansion, traffic-management difficulties, inadequate waste and water services, unreliable electricity, fragmented development-control information and limited digital coordination among urban institutions (Okeke et al., 2025). Smart infrastructure is therefore relevant to Enugu, where it directly improves these existing services, rather than where technology is introduced merely to project a modern image (Chukwurah et al., 2025). This study consequently adopts a problem-orientated, context-sensitive conception of smart-city development, and it grounds the assessment of professional readiness in the practical service gaps that residents and institutions already experience.

The transition to smart infrastructure nonetheless faces well-documented challenges, chief among them inadequate foundational infrastructure. Systems that depend on Internet of Things (IoT) sensors and real-time analytics require stable electricity and broadband connectivity (Yigitcanlar et al., 2019), and their absence constrains intelligent transport, smart grids, and data-driven platforms to isolated, fragmented efforts (Mora et al., 2017). Initiatives such as the New Enugu City project signal political will but have yet to articulate the digital strategies needed for coordinated data-sharing (City People Magazine, 2025). Institutional and governance hurdles compound the problem: cross-sector coordination and integrated policy remain elusive (Kitchin, 2016), and planning practice in Enugu is characterised by isolated operations, weak regulatory control, and limited ICT integration (Mba et al., 2025; Chukwu, 2025). Human-capital constraints add a further layer of difficulty, since high smartphone penetration in the state contrasts sharply with limited access to advanced digital tools and stable internet, revealing a persistent skills gap (Igwe et al., 2025). Financial constraints further complicate matters, as the substantial investment that smart systems require strains public-private partnerships operating under tight fiscal limits (Haliru & Desy, 2026). Finally, the socio-cultural and equity dimensions of smart-city development remain under-researched: little evidence exists on how residents perceive digital tools, and people-centred design is correspondingly underdeveloped (Cardullo & Kitchin, 2019). Without inclusive planning, smart infrastructure risks deepening existing inequalities by privileging the urban core over peri-urban areas (Cugurullo, 2018) — a risk already visible in Enugu's sprawling and informally developed peripheries (Mba et al., 2025; Uttah et al., 2024).

Despite this global momentum and evident local potential, a significant gap remains in understanding how prepared Nigeria's urban professionals are for the smart-infrastructure transition. Existing literature has documented infrastructural deficits in general terms, but a dedicated assessment of the readiness of architects and urban planners — their awareness, technical capacity and the practical barriers they encounter — has not yet been undertaken for Enugu or comparable South-Eastern cities. This study addresses that gap by assessing the professional and institutional readiness required for smart-infrastructure implementation in Enugu Metropolis. Specifically, it seeks to: (1) evaluate professional awareness and understanding of smart-city innovations; (2) assess technical readiness and access to relevant digital tools and training; (3) examine professionals' perceptions of government and institutional preparedness, including policy visibility and inter-agency coordination; and (4) identify barriers and opportunities and, on that basis, develop a context-specific readiness framework, implementation roadmap, governance model, competency priorities and measurable policy indicators. Guided by Diffusion of Innovation theory, the study anticipates that differences in professional education, responsibilities and exposure to digital planning technologies will shape awareness of smart-city innovations across disciplines. Accordingly, the following hypotheses were tested:

H0: Professional discipline has no significant association with awareness of smart-city innovations.

H1: Professional discipline has a significant association with awareness of smart-city innovations.

Confirming this association provides a basis for targeted intervention, since architects and urban planners occupy distinct professional roles that may call for differentiated training approaches to close awareness gaps and foster the interdisciplinary collaboration that successful smart-infrastructure implementation requires. For architects and urban planners, the findings identify concrete capacity gaps in current practice; for policymakers in Enugu State, they offer data-driven evidence to inform state-level strategy and investment decisions. This study was conducted in Enugu, the capital of Enugu State in South-Eastern Nigeria, located between latitudes 6°27′10″N and 7°30′40″N. As a former regional capital and a rapidly growing urban centre, Enugu serves as an important economic and cultural hub for the wider region (Okeke et al., 2020; Nwachukwu et al., 2023). Its built environment and natural resources face considerable pressure amid ongoing urban transformation, which makes it a particularly instructive case (Nnaemeka-Okeke & Okeke, 2024). The study focuses on the metropolis's main urban areas, comprising the Enugu East, Enugu North and Enugu South Local Government Areas (Figure 1).

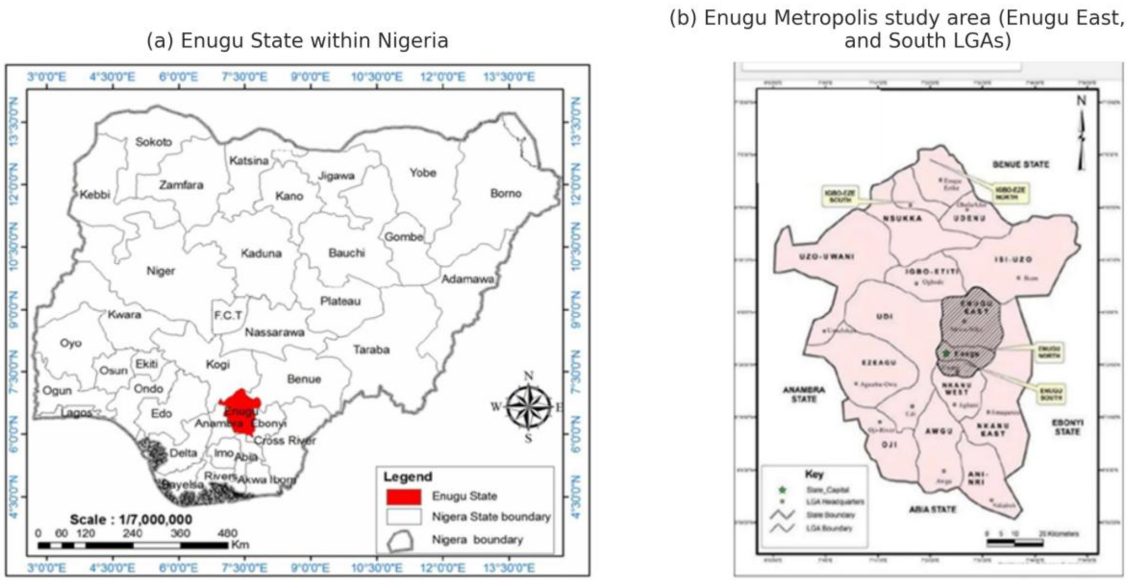

Figure 1. Location of Enugu Metropolis, Enugu State, Nigeria (Okeke et al., 2020)

Enugu also offers contextual advantages for a phased approach to smart-city implementation. These include its status as a state capital, the presence of ECTDA and other urban-management institutions, a concentration of universities and built-environment professionals, an emerging technology ecosystem, and current urban-development initiatives (Okeke et al., 2025). Its relatively manageable metropolitan scale further allows pilot projects to be tested, evaluated and refined before any state-wide expansion is attempted.

2 Literature Review

2.1 The Concept of Smart Infrastructure

Smart infrastructure denotes the planning of urban development around technology, data and sustainability (Kitchin, 2016). It marks an advance from a purely technology-centred model towards a more holistic approach that emphasises collaboration and social innovation among citizens (Trencher, 2019); technology is a crucial enabler, not the sole focus. A smart infrastructure is best understood as one that uses ICT to enhance urban services, economic growth and quality of life while ensuring the sustainable management of resources (Martin et al., 2020; Haliru & Desy, 2026). Allam and Newman (2018) define smart infrastructure as a system of connected physical, digital and social systems designed to support urban efficiency, innovation and resilience, typically organised into six interdependent sectors: smart governance, smart economy, smart mobility, smart environment, smart living and smart people (Anthopoulos, 2017). Smart governance is characterised by transparent, participatory decision-making through e-government platforms, open data and digital participation (Kankanhalli et al., 2019; Usman et al., 2025); 'smart economy' refers to enhanced competitiveness and innovation in the global digital marketplace, driven by entrepreneurship and high-technology support (Barrionuevo et al., 2012); 'smart mobility' describes integrated, sustainable and efficient transport systems that use real-time data to improve flow and provide multimodal alternatives (Benevolo et al., 2015; City People Magazine, 2025); and the 'smart environment' dimension emphasises the sustainable management of natural resources through smart grids, environmental sensors and intelligent waste systems (Yigitcanlar et al., 2019; Appio et al., 2019). Smart living captures a high overall quality of life (encompassing culture, health, public safety and housing), while smart people highlight the role of a socially inclusive, educated, creative and digitally literate community in generating urban solutions (Cardullo & Kitchin, 2019; Mora et al., 2017a). Taken together, these dimensions show that technological infrastructure should create an environment in which technology strengthens human capital and technical capacity, rather than substituting for it (Allam & Newman, 2018; Bibri & Krogstie, 2020).

2.2 Components of Smart Infrastructure

Smart infrastructure technologies that are applied to urban systems in order to enhance performance, reliability, and sustainability can be grouped into four broad areas. Smart energy and utilities. The transformation of the centralised energy grid into an intelligent smart grid underpins urban digitalisation. It relies on a network of IoT sensors, smart meters and two-way communication to achieve the real-time management of electricity (Yigitcanlar et al., 2019), enabling the integration of consumer-focused services and renewable energy and the rapid detection of faults, and thereby creating a more resilient and efficient energy system. Comparable innovations in water management use sensors and data analytics to monitor quality, detect leaks in real time and apply pricing mechanisms that encourage conservation (Appio et al., 2019; Ugwuoti et al., 2023). Intelligent Transport Systems (ITS). ITS are essential to addressing urban congestion, pollution and road-safety challenges (Benevolo et al., 2015). They integrate real-time traffic monitoring, adaptive signal control and public-transport management into an organised, data-driven mobility network (Kim et al., 2023), and their application can significantly reduce average travel times, lower vehicle emissions, improve road safety through better traffic flow, and provide real-time information to both users and managers (Mohanty et al., 2016).

Smart waste management. Smart technologies are transforming waste collection. IoT-enabled bins track fill levels and relay this information to a central platform (Appio et al., 2019), which can then optimise vehicle routing and move services from fixed timetables to on-demand collection — reducing operating expenses, fuel consumption and associated environmental impact. E-governance and citizen platforms. This component involves deploying digital platforms to make government more accessible, transparent and responsive (Kankanhalli et al., 2019), including online portals for transactions and mobile applications that allow residents to report problems and participate in consultations (Allam & Newman, 2018; Zindi, 2024). E-governance enhances administrative efficiency, reduces opportunities for corruption, and promotes civic involvement and trust (Balaji, 2025; Kankanhalli et al., 2019).

2.3 Need and Benefits of Smart Infrastructure in Enugu State

Transitioning from traditional to smart infrastructure is an essential developmental need for Enugu State (Chukwu, 2025). For many years the state's economy depended mainly on public-sector spending and dispersed trade, functioning as a civil-service state; the present administration, by contrast, is actively pursuing GDP growth (Eneiga et al., 2025; Nwanonyere, 2025). Achieving this requires a departure from traditional design and planning methods, since conventional infrastructure lacks the capacity, adaptability and data-driven functionality needed to attract major investment, support lucrative business activity and promote economic growth (Adenuga et al., 2023); integrating smart infrastructure could position Enugu State as a more competitive economic centre.

The pressure on Enugu's urban area makes this transition increasingly necessary. Rapid population growth has produced urban congestion, traffic bottlenecks and overburdened public facilities (Mba et al., 2025), and the traditional reactive model of 'building first, modifying afterwards' has consistently resulted in poor planning outcomes. A smart-infrastructure framework offers a route out of these limitations: unstable electricity supply and persistent water scarcity have long hindered industrial development in the state (Uttah et al., 2024), and smart energy and utility systems could transform both challenges through digital utility networks, smart grids, automated telemetry for water-pipeline monitoring, and automated power management (Chukwu, 2025). Enugu State can similarly manage security threats, narrow the digital divide, and address bottlenecks in public safety, education, and healthcare by integrating solar-powered smart schools, centralised surveillance, and electronic governance platforms (Nwandu et al., 2026). The Enugu State Geographic Information System (ENSGIS), which digitises land registries, title applications and spatial mapping, already represents a significant step forward for state administration, while new smart-construction standards enforced by ECTDA are intended to safeguard urban sustainability.

2.4 Role of Architects and Urban Planners in Smart Infrastructure Delivery

Smart infrastructure has reshaped the roles and competencies expected of architects and urban planners (Akande et al., 2026). Beyond designing physical spaces, these professionals are now required to integrate technology, data and diverse community needs into their work; their role is evolving towards that of smart-infrastructure planners or urban data managers who bridge the gap between technology and urban liveability (Odebiyi et al., 2025). This evolution demands a broader skill set, including proficiency in data analytics to interpret real-time information generated by urban sensors (Allam & Newman, 2018; Akande et al., 2026) and competence in advanced spatial technologies such as Geographic Information Systems (GIS) and Building Information Modelling (BIM), both of which are essential for simulation and effect evaluation in city-making (Bibri & Krogstie, 2020; Dembski et al., 2020). Interdisciplinary collaboration is equally important for achieving spatial and social balance in smart-infrastructure projects (Cardullo & Kitchin, 2019; Martin et al., 2020), positioning architects and planners as initiators who bring together stakeholders, utility providers, community representatives and residents around shared solutions.

In Enugu State specifically, architects and urban planners carry the professional responsibility of creating physical spaces that prevent the metropolis from deteriorating into unplanned sprawl (Okeke et al., 2023), which increasingly requires cyber-physical integration in spatial design. For architects, this means moving from two-dimensional drafting towards building management systems and multi-dimensional BIM (Chukwu, 2025) and integrating intelligent nodes and physical sensors into building designs so that structures can communicate directly with centralised data centres, enabling real-time monitoring of energy use, structural integrity and water-conservation systems, among other functions (Odebiyi et al., 2025). For urban planners, it means applying an infrastructure-first approach to spatial design, using GIS to produce master layouts that anticipate utility routing, protect rights-of-way for fibre-optic networks and water-telemetry pipelines, and thereby avoid the wasteful cycle of repeatedly excavating already paved roads (Haliru & Desy, 2026; Kitching, 2020). Collaboration between the two professions (spanning mixed-use and high-density zoning, smart energy and utilities, intelligent transport and smart waste management) is essential if Enugu State is to become a resilient smart city while preserving its cultural identity and landscape.

2.5 Contextualising Readiness: Six Domains

For this study, readiness was contextualised using six Enugu-specific domains that together capture the breadth of what "readiness" implies in a developing-country setting: institutional readiness, measured through policy, leadership, budget and inter-agency coordination; digital readiness, measured through electricity, broadband and GIS/BIM access and data systems; professional readiness, measured through training and technical competence; financial readiness, measured through public budgets and public-private partnership (PPP) capacity; service readiness, measured through the suitability of smart interventions for transport, waste, water and street lighting; and social readiness, measured through public participation, affordability and the inclusion of peri-urban communities. These domains structured both the questionnaire design and the interpretation of findings reported in later sections.

2.6 Existing Situation of Smart Infrastructure in Enugu State

Enugu State is undergoing technological and infrastructural growth as part of a broader effort to transform the state from a traditional civil-service centre into a digitised economy (Ugada, 2025; Eneiga et al., 2025). The current administration has introduced several technological projects, including a 10,000-hectare new smart-city layout, smart green schools, sustainable mass transit and an AI-driven security apparatus. Infrastructure efforts are focused on laying smart distribution lines into urban neighbourhoods such as Independence Layout and Trans-Ekulu, which is laying the technical groundwork for digital water metering and real-time leak-detection telemetry (Punch Newspapers, 2026; Ojienon & Wehke, 2025; Ugwuoti et al., 2023). To protect these commercial and civic investments, the state has introduced an automated surveillance grid that integrates high-definition CCTV cameras across the town, feeding live video directly into a centralised control room and giving law enforcement real-time situational awareness and automated emergency-dispatch capability (This Day Newspapers, 2026). The Enugu State Geographic Information System (ENSGIS), a digital land-administration platform, has likewise been launched to modernise, secure and streamline property and land transactions (ENGIS, 2026). Against this backdrop of active but fragmented digitisation, assessing the readiness of architects and urban planners — the professionals expected to translate these initiatives into practice — becomes a necessary and timely undertaking.

2.7 Assessing Smart Infrastructure Readiness

Smart-infrastructure transformation requires an understanding of a city's starting point, for which readiness assessments serve as essential analytical tools (Das, 2025; Ugada, 2025). Recognised frameworks include the Smart City Readiness Index (SCRI) and the ISO 37122:2019 standard for sustainable cities, both of which provide comprehensive indicators across multiple domains (International Organization for Standardisation, 2019). Because such international benchmarks were not designed with developing urban contexts in mind, readiness assessment in these settings must move beyond general international indicators to incorporate local factors (Ugada, 2025). Three considerations are particularly relevant. Infrastructural readiness concerns the accessibility, dependability and cost of essential infrastructure (data-centre capacity, high-speed broadband and steady electricity) since inequitable access risks concentrating the benefits of smart services among a privileged few (Cardullo & Kitchin, 2019; Yigitcanlar et al., 2019; Ugada, 2025). Technical readiness concerns the digital literacy of the population alongside the technical competence, awareness and adaptive capacity of urban-planning professionals with respect to smart-infrastructure tools, given that a professional skills gap is often the principal weakness in implementation (Tanantong et al., 2024). Financial and economic readiness concerns the availability of funding mechanisms, including public budgets and the potential for PPPs to finance large-scale ICT investment (World Bank, 2018; Haliru & Desy, 2026).

2.8 Potentials and Constraints in Enugu State

Within Nigeria, smart-infrastructure development remains led by Lagos and Abuja (Odebiyi et al., 2025; Olokesusi et al., 2018), while other state capitals face substantial deficits stemming from erratic power supply, limited internet coverage, low digital literacy and conventional urban-planning systems (Brown & Ikiriko, 2025). Enugu State embodies this sharp division between potential and constraint (Nnaemeka-Okeke & Okeke, 2024). As a historical administrative centre and a rapidly growing urban area, it possesses several of the attributes needed for viable smart-infrastructure development: the presence of ECTDA provides a necessary implementation structure (ECTDA, 2026), and its growing technology sector offers a potential source of local talent (Mba et al., 2025; Chukwu, 2025). Recent state initiatives such as the New Enugu City project further demonstrate political willingness to invest in urban infrastructure (City People Magazine, 2025). These opportunities are nonetheless offset by real constraints, including uneven urban management, weak enforcement of planning regulations, and a persistent gap in the integration of digital tools into planning processes (Mba et al., 2025; Odebiyi et al., 2025); rapid urbanisation and sprawl make effective deployment both more difficult and more costly (Adeleke et al., 2025). Enugu therefore serves as a critical and representative case for assessing the smart-infrastructure readiness of planning professionals, with lessons that may extend to comparable urban centres across sub-Saharan Africa.

2.9 Theoretical Framework and Research Gap

To assess the readiness of architects and urban planners, this study draws on three complementary theories of technological and social change. Diffusion of Innovation (DOI) theory explains how an innovation is communicated and adopted within a social system. It provides a lens for analysing how smart-infrastructure concepts and technologies are perceived and adopted by architects and urban planners and offers a framework for understanding levels of awareness and resistance that helps identify points at which adoption might be accelerated (Trencher, 2019). The Theory of Planned Behaviour (TPB) suggests that an individual's intention to perform a specific behaviour — such as designing or approving a smart-infrastructure project — is shaped by attitude, subjective norms and perceived behavioural control (Kankanhalli et al., 2019). This theory is highly relevant to decision-making among architects and urban planners in Enugu State, as it moves the analysis beyond awareness to the beliefs and perceived barriers that shape professional action.

Ecological Modernisation Theory (EMT) holds that contemporary societies can address ecological crises by treating environmental protection and economic development as mutually reinforcing forces (Yigitcanlar et al., 2019). It frames investment in smart infrastructure as a driver of economic innovation, job creation in technology sectors and long-term cost savings through improved resource efficiency, thereby articulating an economic case for adoption that can resonate with architects, urban planners, policymakers and private investors. Together, these three theories inform the study's hypotheses and provide complementary lenses — cognitive, behavioural and economic — through which the discussion in Section 5 interprets the survey findings.

The literature reviewed above demonstrates a solid understanding of global smart-infrastructure patterns, but significant gaps persist for developing countries and sub-Saharan African cities in particular. Existing Nigerian research concentrates disproportionately on megacities such as Lagos, leaving the human and technical dimensions of readiness in smaller, rapidly growing centres such as Enugu comparatively unexamined (Odebiyi et al., 2025; Olokesusi et al., 2018); findings from larger cities are frequently generalised in ways that overlook the distinct social and technical capacities of South-Eastern states. This study addresses that gap by conducting a dedicated assessment in Enugu State that moves beyond a simple inventory of infrastructural deficits. Its principal contribution is an evidence base on the professional readiness of architects and urban planners – the professionals central to urban transformation – interpreted through the established theoretical lenses of DOI, TPB and EMT. In doing so, the study contributes both empirical data and a practical framework for professional training, technical capacity-building and planning towards smarter, more sustainable urban development in Enugu State and Nigeria more broadly.

3 Methodology

3.1 Research Design

This study employed a quantitative, descriptive cross-sectional survey design to investigate the smart-infrastructure readiness of architects and urban planners in Enugu Metropolis. The design was selected because it enables the systematic collection of standardised data from a large sample, allowing statistical analysis of trends and relationships within the population at a single point in time (Creswell & Creswell, 2023). This approach was well suited to assessing the perceptions, awareness levels and preparedness of architects and urban planners with respect to smart-infrastructure development, though it necessarily captures a snapshot of professional readiness rather than change over time; this limitation is revisited in Section 3.4.

3.2 Study Population and Sampling Procedure

The target population comprised professionally qualified architects and urban planners practising in Enugu Metropolis. According to the official registers of the Architects Registration Council of Nigeria (ARCON, 2023) and the Town Planners Registration Council of Nigeria (TOPREC, 2023), the state had 203 licensed architects and 134 registered urban planners, giving a population of 337 professionals. The Taro Yamane formula (Yamane, 1973) was used to determine an appropriate sample size at a 95% confidence level and a 5% margin of error:

$$n = N \div [1 + N(e)^2],$$

where n = sample size, N = population size (337) and e = margin of error (0.05).

$$n = 337 \div [1 + 337(0.05)^2]$$

$$= 337 \div 1.8425 = 182.9 \approx 183.$$

A stratified random sampling technique was then used to ensure proportional representation from each professional group (Taherdoost, 2016). The population was divided into two strata – urban planners and architects – and the sample size for each stratum was calculated proportionally: urban planners, (134/337) × 183 ≈ 73 respondents; architects, (203/337) × 183 ≈ 110 respondents (Table 1).

Table 1. Population and sample size distribution.

Professional group	*Population*	*Sample size*
Urban planners	*134*	*73*
Architects	*203*	*110*
Total	*337*	*183*

Within each stratum, participants were selected by simple random sampling from the respective official registers, using a random number generator to ensure unbiased selection and to support the generalisation of findings to the wider professional population (Pallant, 2020).

3.3 Research Instrument, Validity and Reliability

Data were collected using a structured questionnaire developed through an extensive review of the smart-city and urban-development literature. The instrument comprised four sections: socio-demographic characteristics of respondents; awareness and understanding of smart-infrastructure concepts, measured on a five-point Likert scale; technical readiness, covering access to digital tools and training; and perceived challenges and opportunities, including a small number of open-ended items for qualitative insight.

Content validity was established through expert review by a three-member panel comprising a senior academic in urban planning, a practising architect with more than fifteen years of experience in sustainable design, and a public-policy expert specialising in urban governance. The panel evaluated the questionnaire for clarity, relevance and comprehensiveness in addressing the study's objectives, and their feedback was incorporated to refine the final instrument. Reliability was assessed through a pilot study administered to 20 professionals who were excluded from the main survey; the internal consistency of the Likert-scale items, measured using Cronbach's alpha, was 0.84, indicating satisfactory reliability (Taber, 2018).

3.4 Data Collection Procedure

Data collection ran for four weeks using a mixed-mode approach: physical copies of the questionnaire were distributed to professional offices, while an electronic version was administered through Google Forms. This dual strategy was adopted to improve accessibility and response rates across the two professional groups (Taherdoost, 2021). Of the 183 questionnaires distributed, 175 were completed and returned in usable form, giving a response rate of 95.6% (Table 2); all subsequent descriptive and inferential analyses are based on this analytic sample of 175 respondents.

Table 2. Questionnaire distribution and response rate.

Professional group	*Distributed*	*Returned (usable)*
Urban planners	*73*	*70*
Architects	*110*	*105*
Total	*183*	*175*

3.5 Case Study

Data were analysed using SPSS version 25. Descriptive statistics — frequencies, percentages, means and standard deviations — were computed to summarise socio-demographic characteristics and to identify patterns in smart-infrastructure awareness and preparedness. Awareness of smart-infrastructure innovations was assessed through a composite awareness score derived from responses to the awareness section of the questionnaire; the total score was converted to a percentage of the maximum attainable score, and, in line with a modified Bloom's cut-off criterion, respondents scoring 60% or above were classified as having adequate (high) awareness while those scoring below 60% were classified as having inadequate (low) awareness. This categorisation is widely used in knowledge and awareness studies to distinguish acceptable from inadequate levels and to enable categorical statistical analysis (Choudhury et al., 2025).

Two inferential tests were used to evaluate the study's hypotheses. First, a chi-square goodness-of-fit test compared the observed distribution of adequate versus inadequate awareness against an equal (50:50) distribution to establish whether awareness in the sample departed significantly from chance. Second, because the study additionally hypothesised that awareness would vary by professional discipline, a chi-square test of independence was applied to the two-way classification of professional discipline (architect/urban planner) by awareness level (high/low), with Cramér's V computed as a measure of effect size given the test's statistical significance. This second test directly addressed the study's H0/H1 hypotheses. The significance level for all tests was set at α = 0.05, consistent with conventional practice in social-science research (Field, 2023).

Several limitations were acknowledged. Sampling bias may exist because professionals in informal practice or unregistered with ARCON or TOPREC were necessarily excluded from the sampling frame, and response bias may have arisen if professionals with greater interest in smart-infrastructure concepts were more inclined to participate. The high response rate (95.6%) and the use of proportionate stratified sampling help to mitigate both concerns and support the validity and generalisability of the findings within the target professional population; nonetheless, as a cross-sectional design based on self-reported perceptions, the study cannot establish causal relationships between the variables examined, and its institutional-readiness findings reflect professionals' perceptions rather than a direct audit of government agencies, which were not sampled in this study.

4 Results

4.1 Socio-Demographic Profile of Respondents

Of the 175 respondents analysed, a majority were male (60.5%) and 39.5% were female. The largest age bracket was 26–35 years (34.3%), followed by 36–45 years (29.7%), 46 years and above (23.4%) and 18–25 years (12.6%). Respondents were highly educated: 50.8% held a master's degree, 42.9% held a bachelor's degree or Higher National Diploma, and 6.3% held a PhD. In terms of professional experience, 44.5% had 6–10 years of practice, 28.6% had 0–5 years, and 26.9% had more than 10 years (Table 3). Overall, the sample reflects a relatively young, well-educated and professionally experienced cohort, suggesting a workforce with both the technical grounding and the practical exposure needed to engage meaningfully with smart-infrastructure concepts.

Table 2. Socio-demographic characteristics of respondents (n = 175).

Characteristic	*Category*	*Frequency*	*Percent (%)*
Gender	*Male*	*106*	*60.5*
	Female	*69*	*39.5*
Age (years)	*18–25*	*22*	*12.6*
	26–35	*60*	*34.3*
	36–45	*52*	*29.7*
	46 and above	*41*	*23.4*
Level of education	*HND/B.Sc.*	*75*	*42.9*
	M.Sc.	*89*	*50.8*
	PhD	*11*	*6.3*
Years of practice	*0–5 years*	*50*	*28.6*
	6–10 years	*78*	*44.5*
	Above 10 years	*47*	*26.9*

4.2 Awareness and Understanding of Smart Infrastructure

A significant majority of respondents (92.5%) reported being aware of the smart-infrastructure concept, and over 70% agreed or strongly agreed that they understood it (Figure 2a). Perceptions of relevance were even stronger: over 90% of respondents believed that smart infrastructure is relevant to the future development of Enugu State (Figure 2b).

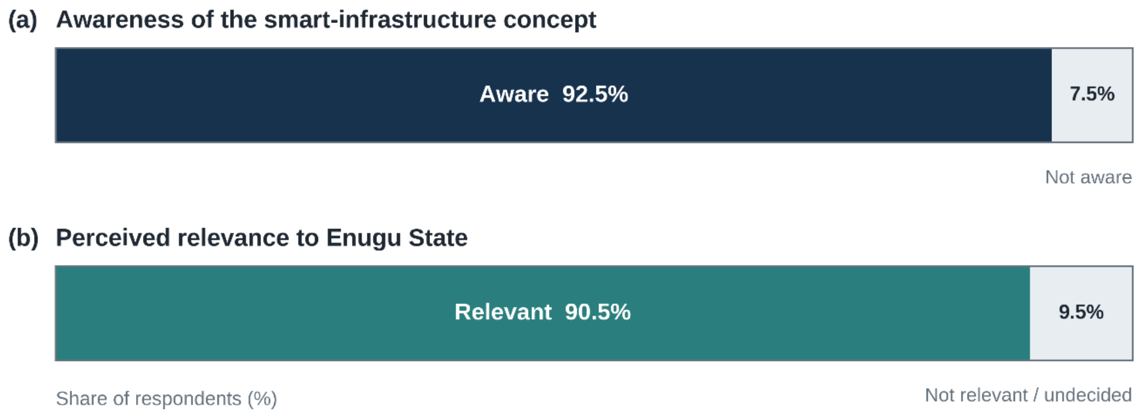

Figure 2. Awareness and perceived relevance of smart infrastructure among architects and urban planners

4.3 Technical Readiness

Architects and urban planners demonstrated only moderate technical readiness. Less than half (47.3%) reported access to digital planning tools such as GIS or BIM, and just 29.1% had received relevant ICT-enabled training (Figure 3a). When asked directly about their perceived technical readiness for smart-infrastructure implementation in Enugu State, only 20.0% considered themselves ready, 61.8% were "not sure", and 18.2% considered themselves not ready (Figure 3b). This combination—strong conceptual awareness alongside limited technical preparation— recurs throughout the results and is examined further in the Discussion.

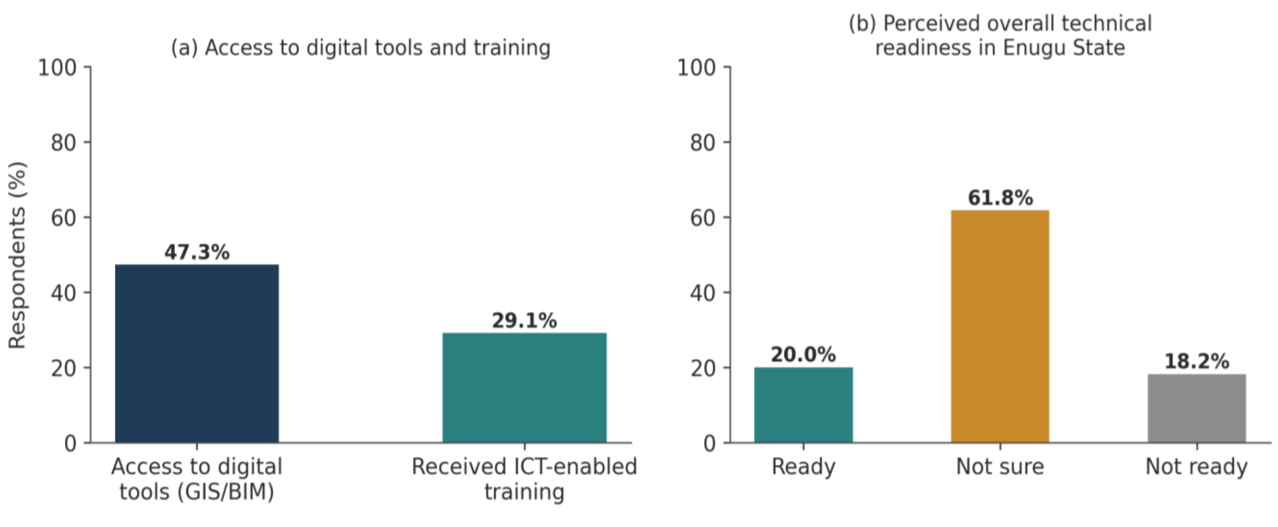

Figure 3: Technical readiness of architects and urban planners for smart-infrastructure implementation

4.4 Perceptions of Institutional and Policy Preparedness

Consistent with the study's third objective, respondents were also asked about their awareness of government policy relating to smart infrastructure. Only 20.0% of respondents reported awareness of an existing government policy on smart infrastructure in Enugu State, indicating that, notwithstanding the technological initiatives described in Section 2.6, formal policy remains poorly visible to the professionals expected to implement it. This low level of policy awareness is treated in this study as a perception held by architects and urban planners rather than as a direct assessment of government or institutional capacity, since officials from relevant government agencies were not sampled.

4.5 Perceptions of Institutional and Policy Preparedness

Respondents identified funding, collaboration and infrastructure as the principal barriers to smart-infrastructure adoption in Enugu State. Poor funding was the most frequently cited constraint (32.7%), followed by weak interprofessional collaboration (30.9%); lack of digital infrastructure (18.2%) and inadequate physical infrastructure (18.2%) were also prominent (Figure 4).

Figure 4. Perceived barriers to smart-infrastructure adoption in Enugu State (n = 175).`

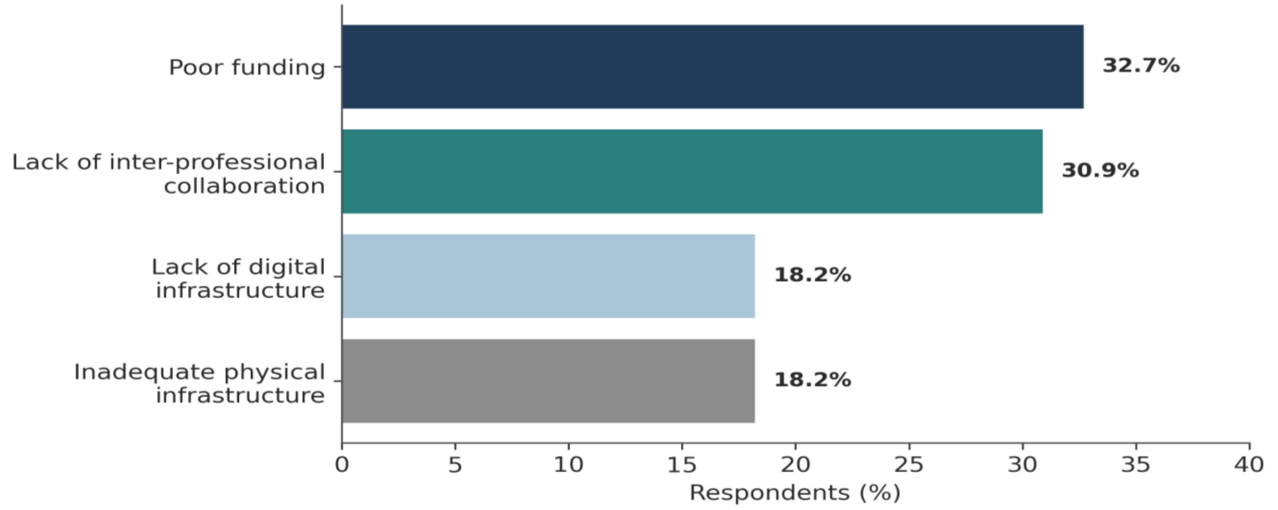

Figure 4. Perceived barriers to smart-infrastructure adoption in Enugu State (n = 175).

Despite these constraints, professional attitudes towards adoption were markedly positive. Combining response categories, 83.6% of respondents were open to adopting smart public services (61.8% agree, 21.8% strongly agree), and 89.1% believed smart technologies would improve living conditions (50.9% agree, 38.2% strongly agree). Regarding financing, 54.5% of respondents indicated a willingness to pay taxes to support smart infrastructure, while a further 32.7% responded "maybe" (Figure 5).

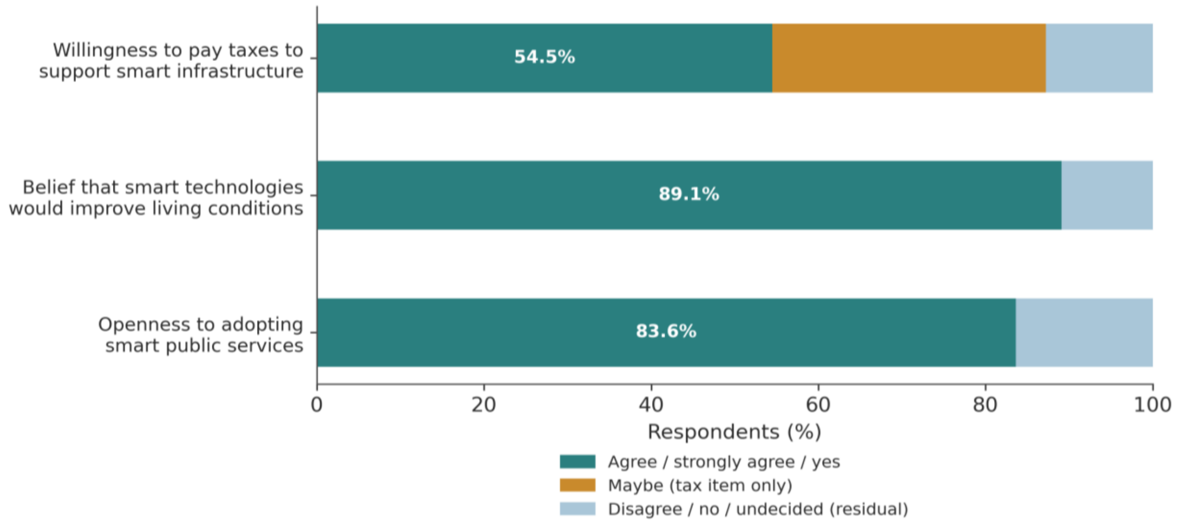

Figure 5. Professional attitudes toward smart-infrastructure adoption in Enugu State (n = 175).

Respondents expressed a clear preference for technologies capable of delivering quick, tangible benefits: waste and water management applications (78.2%), public Wi-Fi (56.4%), digital traffic control (52.7%) and smart street lighting (50.9%) were the most preferred options, with 7.2% selecting other technologies (Figure 6).

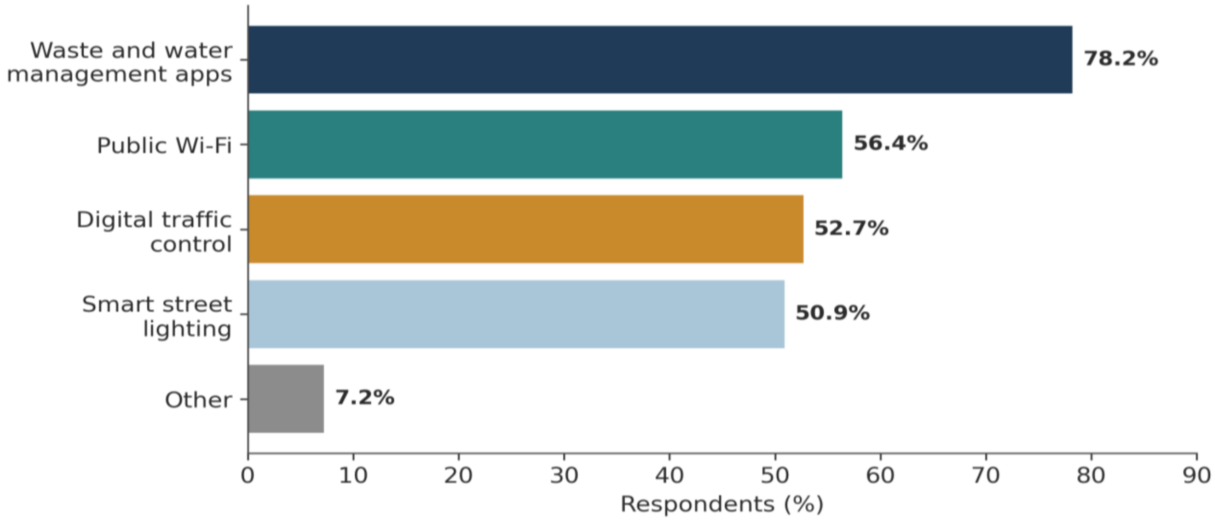

Figure 6. Preferred smart-infrastructure technologies for pilot implementation in Enugu State (n = 175).

4.6 Hypothesis Testing

A chi-square goodness-of-fit test was used to determine whether the distribution of awareness levels in the sample departed from an equal (50:50) distribution. Significantly more respondents demonstrated adequate awareness of smart-infrastructure innovations (126, 72.0%) than inadequate awareness (49, 28.0%), $\chi^2(1, N = 175) = 33.88$, $p < .001$, indicating that awareness among the professionals surveyed was generally high and not attributable to chance.

A chi-square test of independence was then used to test H0 and H1 directly, examining the association between professional discipline (architect/urban planner) and awareness level (high/low). A statistically significant association was found, $\chi^2(2, N = 175) = 12.87$, $p = .003$, Cramér's V = .27, indicating a moderate effect size. The null hypothesis (H0) was therefore rejected in favour of the alternative hypothesis (H1): professional discipline is significantly associated with awareness of smart city innovations. As with all cross-sectional survey data, this result indicates a statistical association rather than a causal relationship between discipline and awareness.

5 Discussion

The sample's socio-demographic profile — predominantly male, concentrated in the 26–45 age range, highly educated and substantially experienced (Table 3) — is broadly consistent with the composition of Nigeria's architecture and urban planning professions and suggests a workforce well placed, in terms of training and industry exposure, to engage with emerging smart-infrastructure concepts. This profile provides useful context for interpreting the awareness, technical-readiness and attitudinal findings discussed below.

5.1 Awareness and Understanding of Smart Infrastructure

The high level of awareness recorded among respondents (92.5%) likely reflects their professional training and routine engagement with planning and infrastructure-related activity, both of which expose them to emerging smart-infrastructure concepts. This interpretation aligns with Diffusion of Innovation theory, which holds that individuals with greater access to technical knowledge, professional networks and innovation-related information are more likely to become aware of and adopt new technologies (Nam & Pardo, 2011); professional knowledge and stakeholder capacity are similarly recognised as fundamental to the successful planning and implementation of smart infrastructure initiatives (Yigitcanlar et al., 2020). This finding corroborates research on the acceptability and knowledge of smart-building concepts among architects in Lagos State, which found moderate-to-high knowledge levels, with half of the respondents rating their own knowledge as moderate and 62.8% describing knowledge in this area as very important (Odebiyi et al., 2025).

That over 90% of respondents believed smart infrastructure to be relevant to Enugu State's future development indicates strong agreement on its potential and necessity, a conclusion supported by Yigitcanlar et al. (2019), who emphasise the importance of thorough conceptual grounding for smart-city policy and practice. Smart infrastructure has also been shown to improve the experience of both building occupants and built-environment professionals more broadly (Odebiyi et al., 2025), and a related study on smart building technologies and real-estate management in Enugu State similarly concluded that such technologies significantly improve real-estate management outcomes (Chukwu, 2025; Mba et al., 2024). Odebiyi et al. (2025) further emphasise that architects' perceptions of smart-building concepts directly influence the rate at which smart technologies are adopted within the construction sector — a point echoed by Sarki et al. (2025), who argue that technology adoption alone is insufficient and that integrated planning is essential to realising the benefits of urban sustainability.

5.2 Technical Readiness for Smart Infrastructure Implementation

The assessment of technical readiness revealed a more modest picture than the awareness findings alone would suggest: only 47.3% of respondents reported access to digital planning tools such as GIS or BIM, and just 29.1% had received relevant training. This gap between awareness and technical capacity aligns with Chukwu (2025), who argues that training programmes are needed to educate stakeholders on the functions and benefits of smart infrastructure and how such systems can improve satisfaction and operational effectiveness. Accelerating digital transformation within the architectural profession similarly requires focused investment in both infrastructure and digital-skills training (Akande et al., 2026), and a strong positive relationship has been observed between architectural design methods and the uptake of emerging technologies (Akande et al., 2026).

That a majority of respondents (61.8%) were "not sure" of their own technical readiness, with a further 18.2% reporting a lack of readiness, points to a state of professional ambivalence that can itself hinder investment and long-term planning. Omokhua et al. (2025) similarly emphasise the importance of early adoption for driving transformation and digital-skills development, while Usman et al. (2025) identify comparable constraints across the Nigerian built environment, including inadequate infrastructure, gaps in digital skills, financial limitations, regulatory uncertainty and data-governance concerns. The Theory of Planned Behaviour offers a useful lens here: readiness can be understood as a function of professionals' attitudes, subjective norms and, crucially, their perceived behavioural control (Kankanhalli et al., 2019) — and it is precisely this sense of control, rather than motivation or awareness, that appears weakest among the respondents surveyed.

5.3 Perceptions of Institutional and Policy Preparedness

Only one respondent in five (20.0%) reported awareness of a government policy on smart infrastructure, despite the range of technological initiatives already under way in the state (Section 2.6). This disconnect between visible technological activity and low policy awareness among the professionals expected to implement it suggests that Enugu State's smart-infrastructure agenda has so far been driven more by discrete project announcements than by a codified, widely communicated policy framework. Because government officials were not directly sampled in this study, this finding is best interpreted as evidence of a policy-visibility gap from the perspective of built-environment professionals, rather than as a definitive statement about the extent or quality of government planning itself. It nonetheless emphasises the necessity of formal, well-publicised policy instruments — a theme taken up directly in the readiness framework proposed in Section 6.

5.4 Perceived Challenges and Opportunities

Poor funding (32.7%), weak inter-professional collaboration (30.9%) and inadequate infrastructure (18.2%) emerged as the leading constraints on smart-infrastructure adoption, indicating that both resource and technical limitations must be addressed before large-scale implementation can proceed. These findings corroborate Odebiyi et al. (2025), who identify cost as a significant factor affecting adoption (75.7%), and Ayegbo et al. (2025), who similarly highlight high implementation costs, restricted access to dependable infrastructure and a shortage of technical skills. Collaboration — through citizen participation, sustainability initiatives and technology integration — is widely regarded as essential to successful smart-city development (Almulhim, 2025a), and a multi-stakeholder strategy encompassing public-private partnerships, infrastructure audits and improved ICT literacy is often recommended as the route to resilient, technology-driven urban systems (Sarki et al., 2025). Comparable research on smart technologies in Lafia metropolis reports similar constraints, including unstable power supply and inadequate data infrastructure (Sarki et al., 2025).

Alongside these constraints, the findings also point to genuine opportunity: architects and urban planners expressed strong professional willingness to adopt smart services and demonstrated meaningful public support for financing them. Ecological Modernisation Theory offers a useful framework for converting these challenges into policy opportunities, suggesting that economic development and environmental sustainability can be mutually reinforced through strategic investment (Julkovski et al., 2021). Read through this lens, respondents' preference for quick-win projects such as smart waste management and traffic control is not merely pragmatic but strategic: such projects deliver immediate, visible improvements in quality of life and resource efficiency, thereby building public trust and demonstrating the economic case for smart infrastructure, and in doing so generate the political and financial capital needed for more complex investments later (Kim et al., 2023;

Bibri & Krogstie, 2020). This pattern is corroborated by Odebiyi et al. (2025), who found that the most desirable features of smart buildings were efficiency (80.4%), security (77.0%) and energy savings (73.0%), and by Sarki et al. (2025), who report that smart technologies can improve infrastructure efficiency by up to 32% and reduce service response times by up to 25%. Adamu et al. (2017) similarly recommend integrating smart technologies across health, transport, training, security and other services in Nigerian urban communities to address the pressures of urbanisation, while Ayegbo et al. (2025) emphasise the need for strategic investment in infrastructure and human capital to realise the transformative potential of smart infrastructure. Taken together, these findings suggest that Enugu State can avoid compounding existing infrastructure deficits by adopting smart infrastructure for service delivery and data collection, generating both environmental and economic benefits in the process.

Overall, the readiness of architects and urban planners for smart-infrastructure development in Enugu State reflects a mixture of genuine strengths and persistent weaknesses. Strengths include established urban-planning institutions such as ECTDA (2026), a growing professional body of architects and planners, and local academic institutions such as the University of Nigeria, which serve as key sources of research and capacity-building. Weaknesses, by contrast, include underfunding and technological and data-analytics skill gaps among practising professionals (Mba et al., 2025; Chukwu, 2025), isolated institutional operations with poor data-sharing (Balaji, 2025; Zindi, 2024), an unreliable electricity grid and inequitable broadband penetration (Almulhim, 2025b), cybersecurity vulnerabilities within a weak data-protection ecosystem (Kankanhalli et al., 2019; NITDA, 2023), macroeconomic volatility that raises the cost of imported technology and hardware, and a digital divide that risks widening existing social and spatial inequalities (Cardullo & Kitchin, 2019; Martin et al., 2020). Set against these weaknesses, several opportunities stand out: the National Digital Economy Policy and Strategy offers a route into public-private partnerships for infrastructure financing (World Bank, 2018; NITDA, 2023; Haliru & Desy, 2026); high mobile-phone penetration provides a ready platform for community engagement and service delivery (GSMA, 2023); and Enugu is well placed to learn from and adapt global smart-infrastructure best practices (Anthopoulos, 2017; Trencher, 2019).

5.5 Comparative and Contextual Interpretation

Enugu appears to be at an earlier implementation stage than Lagos, where smart-infrastructure research and ICT-based urban initiatives have received considerably greater empirical and policy attention. Even so, studies of Lagos also identify infrastructure deficits, informality, urban sprawl and stakeholder-coordination problems, and comparable experiences from Nairobi, Johannesburg, Kigali and other African cities show that technology-led projects can deliver limited benefit when disconnected from local needs, institutional capacity, inclusion and accountable governance. Enugu's combination of high professional awareness and limited implementation capacity thus reflects a wider African pattern rather than a uniquely local shortfall. Its principal advantage lies in the opportunity to adopt a phased, service-orientated approach from the outset, avoiding the costly, technology-led projects that have struggled elsewhere for want of institutional and community support.

6 Proposed Frameworks and Implementation Strategy

Building on the readiness gaps identified above, this section sets out three complementary contributions intended for practical use by professional bodies, government agencies and development partners: a professional competency framework, an Enugu Smart

Infrastructure Readiness Framework, and a phased implementation roadmap with an accompanying governance model and measurable policy indicators.

6.1 Professional Competency Framework

The proposed competency framework is designed to assess and prepare architects and urban planners to implement smart infrastructure in Enugu State (Figure 7). It is aligned with local priorities—including the ongoing transformation of ENSGIS and the New Enugu City master plan—as well as national standards such as the National Data Protection Regulation (NDPR). The framework comprises four components. Technology and Data Literacy (TDL) assesses proficiency with the digital platforms and data-integration skills required for sustainable urban design, including spatial AI, automated GIS and IoT sensor networks. Smart and Resilient Infrastructure (SRI) assesses the ability to design low-carbon infrastructure that responds to regional climate challenges. Ethical and Regulatory Considerations (ERC) ensures compliance with Nigerian statutory requirements, local zoning regulations and data-ethics obligations. Collaborative Systems and Operations (CSO) emphasises cross-industry integration, financing literacy and modern project-delivery methods. Together, these four components define the competencies that Continuing Professional Development (CPD) programmes should target if they are to close the readiness gaps documented in Section 4.

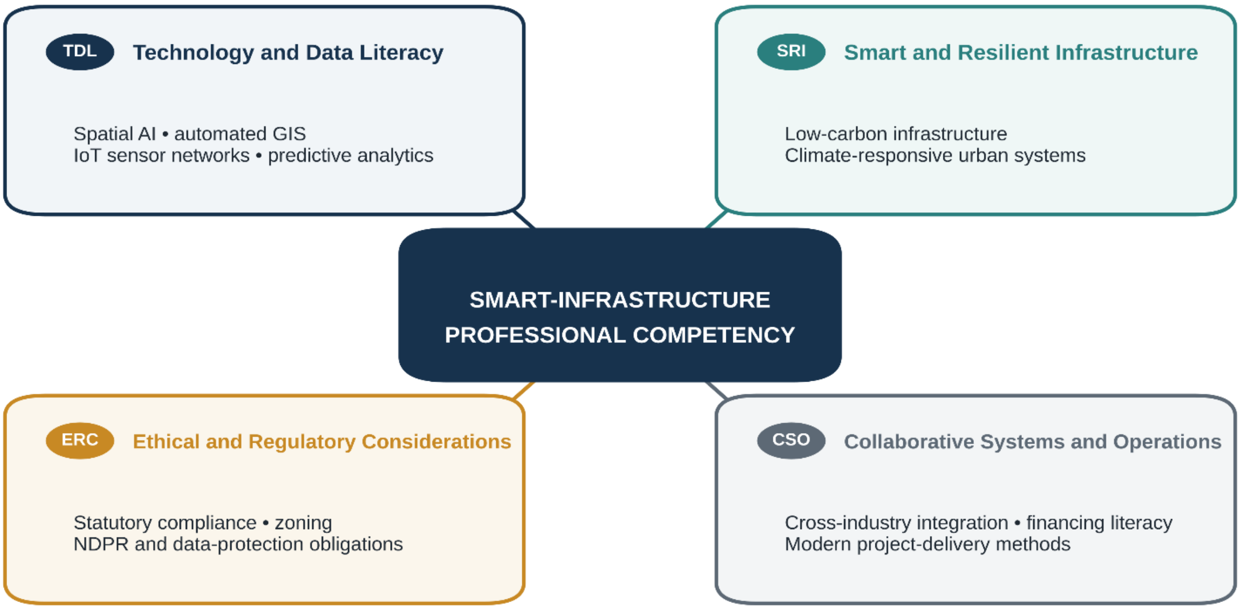

Figure 7. Proposed professional competency framework for architects and urban planners in smart-infrastructure practice.

6.2 Enugu Smart Infrastructure Readiness Framework (ESIRF)

The proposed Enugu Smart Infrastructure Readiness Framework (ESIRF) organises the study's findings into five mutually dependent pillars: governance and policy; foundational digital and physical infrastructure; professional and institutional capability; finance and partnerships; and inclusion, data governance and public value (Figure 8). The pillars are deliberately interdependent: professional training delivered without reliable infrastructure will not translate into functioning services, while infrastructure investment made without governance and inclusion safeguards risks deepening inequality or producing disconnected systems. The framework therefore begins with a baseline institutional audit and concludes with independently measured public outcomes, reflecting the sequence of actions set out in the implementation roadmap below.

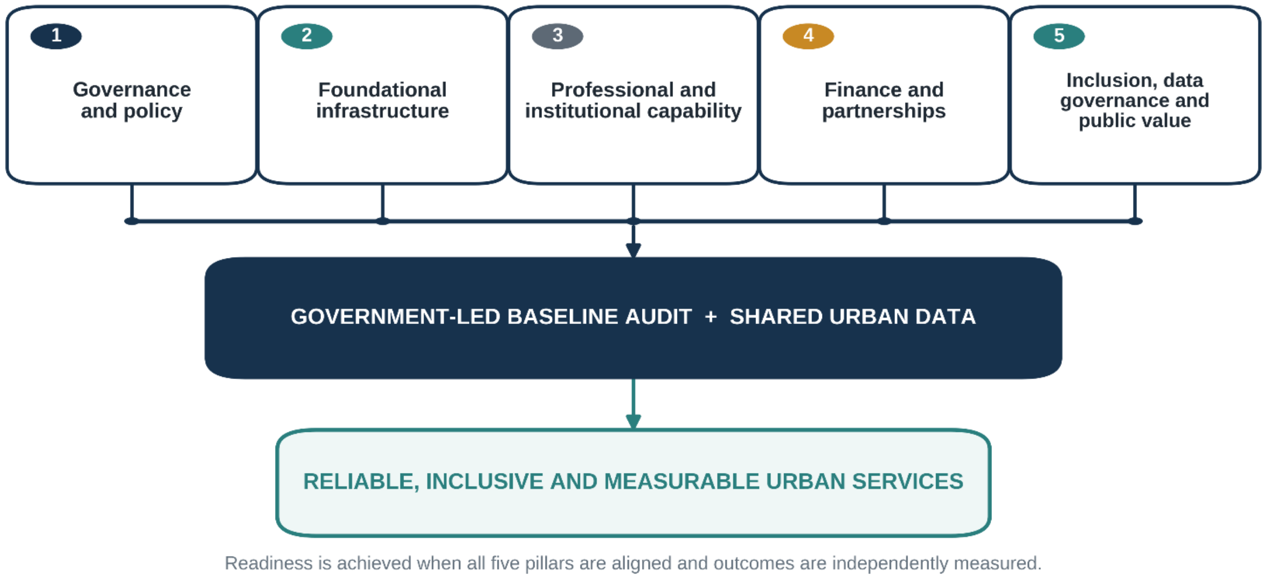

Figure 8. Enugu Smart Infrastructure Readiness Framework (ESIRF).

6.3 Enugu Smart Infrastructure Readiness Framework (ESIRF)

Implementation is proposed in three phases (Table 4). During the first twelve months, the state should establish a cross-sector steering council, undertake an agency and infrastructure baseline audit, approve data-sharing and privacy principles, define pilot selection criteria, and publish a concise smart-infrastructure policy—directly addressing the policy-visibility gap identified in Section 4.4. Between years one and three, the focus should shift to delivering pilot projects in the highest-demand service areas identified in Section 4.5, training professionals and agency staff, establishing an interoperable urban data platform, and structuring transparent public-private partnerships. Between years three and five, we should scale successful pilots across districts, integrate them into development control and capital budgeting, and subject them to independent evaluation.

Table 4. Proposed implementation roadmap for Enugu State.

Phase	*Priority actions*
0–12 months: Establish	*Government-led institutional audit; cross-sector steering council; publication of a smart-infrastructure policy; data inventory; privacy and interoperability rules; pilot-selection criteria.*
1–3 years: Demonstrate	*Pilot projects in waste/water management, traffic control, public Wi-Fi and street lighting; BIM/GIS and data training for professionals and agency staff; an interoperable urban data platform; and transparent PPP and lifecycle-funding arrangements.*
3–5 years: Integrate and scale	*Scale proven pilots across districts, integrate outcomes into development control and capital budgeting, publish performance dashboards, and commission independent evaluation.*

6.4 Governance Model

A practical governance model for implementing ESIRF is a State Smart Infrastructure Council, supported by a technical secretariat and five working groups covering governance and data, infrastructure, professional capability, finance and PPPs, and citizen inclusion. Membership should draw on relevant state agencies and local governments, professional institutes, universities, utility providers, private technology and finance partners, and civil-society representatives. Within this structure, government retains policy leadership and accountability, professional bodies set competency and ethical standards, universities support research and evaluation, and private partners provide technology and finance under clearly defined public-interest safeguards. The professional competency framework in Section 6.1 should anchor this council's training remit, ensuring that capability-building keeps pace with infrastructure investment rather than lagging behindg.

6.5 Measurable Policy Indicators

To track progress against the roadmap and governance model, Table 5 proposes a concise set of measurable indicators spanning governance, finance, infrastructure, professional capability, service outcomes, and equity and public trust. These indicators are intended to provide policymakers and professional bodies a shared, auditable basis for assessing whether the readiness gaps identified in this study are closing over time.

Table 5. Proposed measurable policy indicators.

Domain	*Illustrative indicators*
Governance	*Published policy; designated lead agency; number of active data-sharing agreements.*
Finance	*Annual budget allocation; private capital mobilised; lifecycle-funding provision.*
Infrastructure	*Electricity uptime; broadband availability and affordability; platform interoperability.*
Capability	*Agency and professional training completion; proportion of projects using BIM/GIS.*
Service outcomes	*Pilot uptime; response time; cost or resource savings; user satisfaction.*
Equity and trust	*Coverage across districts; accessibility; participation rate; privacy and security incidents.*

7 Conclusion

This study assessed the readiness of architects and urban planners for smart infrastructure in Enugu State, Nigeria, focusing on their awareness, technical readiness, and perceptions of institutional and policy preparedness. The findings show that while awareness and professional enthusiasm for smart urban infrastructure are strong, technical, institutional and infrastructural barriers continue to impede effective implementation. A clear gap exists between professional knowledge and practical implementation capability, which calls for comprehensive capacity-development programmes alongside continued investment in physical infrastructure. The results further highlight the crucial role of stable electricity and reliable digital connectivity as prerequisites for smart-infrastructure adoption, both in Enugu and in Nigeria more broadly.

These conclusions should be read alongside the study's limitations. The cross-sectional design captures professional readiness at a single point and cannot establish causal relationships between the factors examined; the reliance on a single inferential model (chi-square testing and Cramér's V) constrains the depth of relationships that could be explored between socio-demographic characteristics, discipline and readiness; and, because government officials were not directly sampled, institutional-readiness findings reflect professional perceptions of policy visibility rather than a verified audit of government capacity. Notwithstanding these limitations, the study offers a theoretically grounded evidence base — and, in the Enugu Smart Infrastructure Readiness Framework, implementation roadmap, governance model and policy indicators proposed in Section 6, a practical set of tools — for architects, urban planners, professional bodies, government agencies and private stakeholders seeking to close the readiness gap and position Enugu State to realise its smart-infrastructure potential.

7.1 Recommendations and Future Research

Advancing the readiness of architects and urban planners for smart infrastructure in Enugu State will require sustained collaboration between both professions, their professional bodies, academic institutions, government and other relevant stakeholders. As part of their

Continuing Professional Development (CPD) requirements, the Enugu chapters of the Nigerian Institute of Architects (NIA) and the Nigerian Institute of Town Planners (NITP) should mandate accredited training modules in digital-twin modelling and urban informatics, directly targeting the technical-readiness gap documented in Section 4.3. Higher institutions should likewise strengthen architecture and urban-planning curricula to incorporate computer science, data analytics and sensor technology alongside spatial design and planning. To make essential digital tools accessible to small and medium-sized firms, the state government should consider subsidising software licensing for GIS and BIM platforms. A reliable power supply is a further precondition for progress: off-grid solar installations for digital workstations and servers would help offset the effects of recurring national-grid failure. Finally, the government should consider targeted financial incentives — such as tax relief and fast-tracked planning approval — for architects, urban planners and developers who integrate smart infrastructure into their projects, reinforcing the quick-win, trust-building approach identified as strategically valuable in Section 5.4.

Future research should build on this study in four main directions: comparative analyses of smart-infrastructure readiness across other Nigerian urban centres, to test how far the Enugu findings generalise; direct assessment of institutional perspectives by sampling government agencies rather than relying solely on professionals' perceptions of policy visibility; longitudinal tracking of readiness indicators over time, to move beyond the cross-sectional snapshot presented here; and closer investigation of financing mechanisms and data-governance models, including the factor-analytic and multivariable approaches that a larger, more granular dataset would support.

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Data Availability Statement
Detail where the data supporting your research results can be accessed, including links to publicly archived datasets. If data is unavailable, provide a clear statement explaining the reasons, such as privacy or ethical restrictions.

Conflicts of Interest
Declare any potential conflicts of interest or state, "The authors declare no conflict of interest." Include details about the role of funders in the research, data collection, analysis, writing, or publication decisions if applicable.

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