Smart and Sustainable Traditional African Cities: A Critical Review of Geospatial Approaches to Urban Transformation

Oladimeji Adegboye Ojo
ojooladegboye@gmail.com[1];

Oluwamuyiwa Folayinka Osuntoye
osuntoyefolayinka@gmail.com [2];

Joshua Ife Olodude olodudeji@gmail.com [3]
[1] Department of Urban and Regional Planning,
Obafemi Awolowo University, Ile-Ife
[2] Department of Geographic Information Science
African Regional Institute for Geospatial
Information Science and Technology,
Obafemi Awolowo University, Ile-Ife
[3] Department of Geography, Obafemi Awolowo University, Ile-Ife

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Abstract
African cities are experiencing rapid and often unregulated urban growth, intensifying infrastructural deficits, environmental degradation, and governance challenges, particularly within traditional and informal urban systems. Although smart-city and sustainable-urban-development frameworks have gained global prominence, their direct transfer to African contexts remains problematic because of socio-cultural, institutional, and spatial specificities that differ markedly from the Western and Asian settings in which most of these frameworks were conceived. This paper provides a critical review of the conceptual foundations, theoretical perspectives, methodological approaches, and geospatial applications underpinning smart and sustainable urban development in traditional African cities. Drawing on recent interdisciplinary literature, the review synthesizes dominant research trends and identifies persistent gaps relating to contextual adaptability, citizen participation, data governance, and informal urban dynamics. It argues that geospatially enabled, context-sensitive, and community-centred frameworks are needed to support inclusive, resilient, and sustainable urban transformation across the continent, and it proposes a research agenda to close the identified gaps.

Keywords: *Smart cities; urban sustainability; geospatial technologies; African cities; urban transformation*

1. Introduction

Africa's urban landscapes are undergoing unprecedented change, driven by rapid population growth, rising infrastructural demand, and the persistence of informal settlements and socioeconomic inequality. Projections vary in their specifics but converge on the same trajectory:

Africa's urban population is expected to nearly triple by 2050, with estimates placing the urbanised share of the continent's population at just under 60 percent (UN-Habitat, 2010), as cited in United Nations Economic Commission for Africa (UNECA, 2017) of a population projected to exceed 2.5 billion (United Nations, 2018). Whichever estimate is used, the direction of change is unambiguous: within a generation, most Africans will live in cities. This shift presents substantial opportunities for economic growth and social development, but it also places immense strain on infrastructure, governance systems, and environmental resources, particularly where urbanisation has outpaced formal planning (UN-Habitat, 2020).

Globally, the smart and sustainable city paradigm has emerged as a strategic response to comparable pressures. Smart cities leverage digital technologies, data-driven governance, and participatory management to improve service delivery, mobility, and quality of life (OECD, 2008), typically through the integration of information and communication technologies (ICT) across transportation, energy, waste management, public safety, and citizen engagement (Wright, Shea, and Burns, 2025). Sustainability, in turn, emphasises environmental protection, resource efficiency, and social equity, so that present development does not compromise the ability of future generations to meet their own needs (World Commission on Environment and Development, 1987). Together, these principles underpin Sustainable Development Goal 11, which calls for cities and human settlements that are inclusive, safe, resilient, and sustainable (United Nations, 2015).

Most smart city frameworks, however, were designed for Western and Asian contexts and often overlook the spatial, socioeconomic, and cultural dynamics distinctive to African cities, many of which contend with extensive informal settlement and historically rooted inequality (Frankema *et al.*, 2023). Recent scholarship argues that African cities instead require localised planning paradigms that prioritise urban resilience, socio-spatial equity, and community participation over purely technocratic, infrastructure-led models (Kamana, Radoine, and Nyasulu, 2023). Realising this requires the deliberate integration of spatial, economic, and environmental policy through coordinated, multi-sectoral governance (UNECA, 2017), and it requires harnessing Africa's youthful population as a demographic dividend through inclusive digital access, participatory governance, and affordable, climate-resilient infrastructure suited to informal and vulnerable urban contexts (UN-Habitat, 2010; UNECA, 2017).

1.2 Problem Statement

Transforming traditional African cities into smart and sustainable cities is therefore not simply a matter of adopting global urban-development trends. It requires a participatory, integrated approach grounded in the continent's socioeconomic realities, urban histories, and cultural complexity (Frankema *et al.*, 2023; Kamana, Radoine, and Nyasulu, 2023). Historically, many African cities evolved without structured planning, producing informal settlements, inadequate infrastructure, and overstretched public services (UN-Habitat, 2020). At the same time, the core of the global smart-city transformation, data-driven decision-making enabled by sensors, analytics, and the Internet of Things (Ishaq and Farooq, 2023), depends on exactly the kind of robust geospatial and institutional data infrastructure that is least developed in the traditional and informal urban systems that characterise much of urban Africa. This mismatch between the data and governance assumptions embedded in global smart-city models and the lived conditions of African cities is the central problem this review addresses. This paper critically reviews the conceptual foundations, theoretical perspectives, methodological approaches, and geospatial applications underpinning smart and sustainable urban development in traditional African cities.

It synthesises recent interdisciplinary literature to identify dominant trends and persistent research gaps, with particular attention to contextual adaptability, citizen participation, data governance, and informal urban dynamics.

2. Conceptual and Theoretical Framework

2.1 Sustainable Development

Sustainable development is commonly defined as development that meets the needs of the present without compromising the ability of future generations to meet their own needs (World Commission on Environment and Development, 1987, as discussed in Strange and Bayley, 2008). It is best understood as both a goal and an approach rather than a fixed set of mandates, seeking a balance between human needs and natural resources that respects cultural diversity and ecological integrity. The concept gained wide currency after the publication of *Our Common Future* in the late 1980s, and while the Brundtland definition remains widely cited, contemporary scholarship has emphasised operationalising it through integrated environmental, social, and economic goals (Sachs, 2015). The United Nations Sustainable Development Goals provide the principal contemporary framework for this operationalisation, particularly in the Global South, where urbanisation pressures are most acute (United Nations, 2015).

Sustainable development is generally understood to rest on interdependent components: *social equity*, or access to the basic necessities of life, including food, healthcare, education, and protection from violence; *environmental protection*, or the maintenance of ecological integrity; *economic growth*, or the expansion of access to goods, services, and income; *citizen participation*, or the meaningful involvement of citizens in decision-making; *gender equality*, ensuring full participation by both women and men; and *institutional strengthening*, or the capacity of governments and institutions to create an enabling policy environment. African cities, confronting rapid population growth and environmental pressure, require models that address informal settlements, infrastructure deficits, and governance inefficiencies while expanding inclusive economic opportunity across all six dimensions (Elmqvist *et al.*, 2018; Simon *et al.*, 2016).

2.2 Smart Cities versus Traditional African Cities in Historical Context

The smart-city concept has gained global traction as a response to urbanisation pressures, using technology and data analytics to improve urban efficiency, resilience, and quality of life (Batty *et al.*, 2012). Smart cities are characterised by interconnected systems in transportation, energy, governance, and citizen services, enabled by ICT and data-integration platforms (Angelidou, 2017), and typically comprise intelligent transportation systems, renewable-energy networks and smart grids, e-governance services, and participatory platforms for citizen feedback (Anthopoulos, 2017). Their benefits include enhanced service delivery, optimised resource use, increased public participation, and more data-informed decision-making (Ahvenniemi *et al.*, 2017). The transition toward smart cities is not merely a technological upgrade; it represents a shift in how urban space is designed, managed, and experienced, requiring a holistic approach that recognises the interconnectedness of urban systems and the active participation of citizens, businesses, and government (Ahvenniemi *et al.*, 2017; Angelidou, 2017; Yigitcanlar *et al.*, 2018). In the African context, cities such as Kigali, Cape Town, and Nairobi are experimenting with smart-city projects, and pilot initiatives such as Nairobi's Konza Technopolis illustrate emerging possibilities, but integration of smart-city components across the continent remains uneven, constrained by infrastructural deficits, digital divides, and limited governance capacity

(Odendaal, 2015; Ojo, Curry, and Janowski, 2017).

Although African societies have been predominantly rural for most of their history, urban settlement in Africa has existed for centuries and forms an important part of the continent's history. The earliest known African cities emerged around the Nile Valley, most famously Alexandria in Egypt; the kingdoms of highland Ethiopia organised themselves around towns two thousand years ago; and, in West Africa, the trans-Saharan trading town of Timbuktu, in present-day Mali, developed into an intellectual and spiritual centre and a hub for the spread of Islam across the continent from the fifteenth century (UN-Habitat, 2022). Contemporary African urban form nonetheless bears the further, more recent imprint of colonial and imperial planning, which shaped city growth in ways that continue to structure infrastructure distribution, land tenure, and socio-spatial inequality today.

2.3 Geospatial Technology

Geospatial technology encompasses Geographic Information Systems (GIS), remote sensing, the Global Positioning System (GPS), and spatial-analysis methodologies that together enable the collection, management, visualisation, and analysis of spatial data (Li, Dragicevic, and Anton, 2016). These tools have transformed urban planning and environmental monitoring by generating spatial insight into land use, infrastructure distribution, socioeconomic patterns, and environmental risk (Kuffer *et al.*, 2020). Geospatial applications allow urban managers to map infrastructure, monitor land-use change, analyse the spatial patterning of poverty and resource distribution, and support evidence-based decision-making (Yeboah, Codjoe, and Forkuo, 2021); GIS dashboards and remote-sensing imagery, in particular, allow planners to detect informal settlements, forecast traffic flows, and assess environmental risk (Ahmed, Achieng, and Otieno, 2021). In Africa, the growing availability of open-source spatial data and cloud-based geospatial platforms has expanded opportunities for integrating geospatial intelligence into urban management and policy-making, although this integration remains nascent (Abdullahi and Pradhan, 2018; Ouma, Tateishi, and Murayama, 2022).

2.4 Theoretical Perspectives smart and sustainable urban development

The review draws on four clusters of theory that together frame the analysis of smart and sustainable urban development in African cities.

a. Urban form and growth theories. *Smart Growth Theory* (Smart Growth Network, International City/County Management Association, and US Environmental Protection Agency, 2002) promotes efficient land use, environmental conservation, and community well-being through compact, walkable development, diverse housing, and the preservation of natural resources. *Transit-Oriented Development* (Calthorpe, 1993) proposes compact, mixed-use communities organised around public-transport hubs to reduce congestion and emissions while improving accessibility. *Sustainable Urbanism* (Owens, 1990; Farr, 2007) emphasises green space, renewable energy, and reduced carbon emissions within self-contained, nature-integrated communities, while *New Urbanism* (Duany, Plater-Zyberk, and Speck, 2001) focuses on human-scale design, walkability, and community-oriented space.

b. Sustainability and resource-management theories. The *Extinction Avoidance* or conservation-biology perspective (Soulé, 1985) prioritises the preservation of biodiversity and ecosystem function, while *Collective Stewardship Theory* (Ostrom, 1990) emphasises shared

responsibility among individuals, organisations, and governments for the sustainable management of common resources.

c. Geospatial theories. *GIS Theory* (Goodchild, 1987) treats spatial analysis as the analytical core of geographic information systems and underpins the use of GIS for land-use planning, zoning, and urban-growth modelling. *Remote Sensing Theory* (Jensen, 2005) establishes remote sensing as a cost-effective source of land-use, land-cover, and infrastructure data for monitoring urban sprawl. *Spatial Analysis Theory* (Haggett, 1965; Tobler, 1970) provides the conceptual basis for examining relationships between urban features, such as transport networks, land use, and population density, that underlie the identification of congestion, density, and environmental degradation.

d. Theories of African urban structure. *Central Place Theory* (Christaller, 1933) explains the spatial distribution of settlements and economic activity around central places, a pattern traditional African city have long exhibited as providers of goods and services to surrounding regions. *Urban Primacy Theory* (Jefferson, 1931; Davis, 1968) accounts for the dominance of a single large city, such as Cairo, Lagos, or Johannesburg, within a country's urban hierarchy. *Dependency Theory* (Frank, 1967) frames the growth of cities in peripheral regions, including many in Africa, as conditioned by external factors such as foreign investment and global market trends, a dynamic reinforced by the colonial and imperial shaping of African urban form noted in Section 2.4.

2.5 Interrelationships between Geospatial Technology, Smart Cities, and Sustainability

Geospatial technology is the connective tissue linking sustainability and smart-city objectives in African urban development. For sustainability, geospatial tools enable data-driven environmental management, infrastructure optimisation, and socioeconomic analysis (Abdullahi and Pradhan, 2018): remote sensing has been used across African cities to monitor deforestation, flood risk, and urban sprawl (Nyarko, Boateng, and Osei, 2020), while GIS-based vulnerability mapping supports disaster-risk management and service-delivery planning in ways that strengthen both resilience and social equity (Ahmed, Achieng, and Otieno, 2021).

For smart-city planning, spatial data underpins infrastructure monitoring, transportation management, energy optimisation, and citizen services (Yigitcanlar *et al.*, 2018), supporting the design of intelligent transport systems, the optimisation of emergency-response routing, and the shaping of urban policy (Angelidou, 2017). Pilot projects in Cape Town and Nairobi illustrate the growing integration of geospatial applications into African urban planning, although scalability remains a persistent constraint (Ojo, Curry, and Janowski, 2017).

Finally, geospatial technology extends the reach of citizen participation itself, through platforms for spatial-data visualisation, community mapping, and participatory planning (Ouma, Tateishi, and Murayama, 2022). Mobile-based GIS applications and open-source mapping tools allow residents to report infrastructural problems, environmental hazards, and service-delivery gaps, fostering more inclusive governance (Bwalya and Mutula, 2015); such initiatives have shown particular promise in informal settlements in Nairobi and Accra, where top-down planning has often marginalised residents (Myers, 2016). Taken together, these three strands suggest that geospatial technology is not a peripheral tool within African smart-and-sustainable-city development but a precondition for it: without robust, locally grounded spatial data, neither the environmental-management ambitions of sustainability nor the service-optimisation ambitions of

smart-city planning can be realised in contexts where a large share of the built environment remains unmapped or informally structured.

3. Contemporary Methodological Approaches and Empirical Trends

Urban settlements worldwide have been the subject of extensive geospatial research, and recent studies illustrate both the methodological diversity of the field and the specific issues that arise when its tools are applied to African cities.

3.1 Methodological Diversity in the Broader Literature

Outside Africa, recent studies have combined GIS with a widening range of analytical techniques. Cardone and Di Martino (2023) developed a GIS-based framework using systems of fuzzy relation equations that outperformed earlier fuzzy-relation frameworks in the accuracy and granularity of urban-area characterisation, addressing the difficulty of classifying heterogeneous urban areas and the uncertainty inherent in planning decisions. Zhao *et al.* (2023) analysed the spatiotemporal evolution of impervious surfaces in China's Central Plains Urban Agglomeration between 2000 and 2018, linking urban expansion to heat-island effects and waterlogging and highlighting the continuing lack of predictive models that integrate socioeconomic and environmental drivers of land-cover change. Mhana *et al.* (2024) reviewed 370 papers published between 2010 and 2022 on road-network analysis and land-use and land-cover (LULC) change, drawing on techniques such as kernel density estimation, supervised and unsupervised LULC classification (including Random Forest, Artificial Neural Networks, and Support Vector Machines), and land-change prediction models such as Markov chains, cellular automata, and MOLUSCE/LCM. Wang and Ding (2024) applied social network analysis together with quadratic assignment procedure regression to examine economic, informational, and population flows within the Chengdu–Chongqing urban agglomeration. Liu *et al.* (2024) conducted a systematic review of 175 references on the evolution of land-use planning tools between 2004 and 2023, distinguishing foundational, computerised, internet-technology, and smart-tool epochs, while Tyris *et al.* (2024) used geocoding and GIS platforms such as ArcGIS and GeoDa, combined with spatial clustering and distance analysis, to study health inequities and resource distribution.

3.2 Methodological Approaches in African-Focused Studies

Within Africa, Kamana, Radoine, and Nyasulu (2023) conducted a systematic literature review identifying seventeen persistent urban challenges, including informal housing, infrastructure deficits, pollution, rapid population growth, slum proliferation, and climate risk, alongside sixteen applied strategies such as strategic spatial planning and resilience-based models. Their review found that localised approaches such as smart and green city models are gaining traction, and that Northern and Southern African cities are, on the whole, further advanced in adopting integrated urban strategies than cities in West and Central Africa. Toku *et al.* (2024) combined quantitative surveys, qualitative interviews, and observation across 225 respondents with remote sensing, using ERDAS Imaging and Landsat imagery, to analyse land-use and livelihood transformation in peri-urban Northern Ghana between 2000 and 2019. Enwin, Ikiriko, and Peter (2024) conducted a comparative review of GIS applications in architecture and urban planning, critically evaluating the technology's role in spatial decision-making and sustainability. As a comparative benchmark outside Africa, Jiménez-Espada, Martínez García, and González-Escobar (2023) used sustainability indicators and GIS to assess Cáceres, Spain, finding strong

performance on green space and cultural heritage but weaker outcomes on compactness and waste management, illustrating how GIS-based indicator frameworks can identify actionable areas for policy intervention, an approach with clear relevance for African cities.

3.3 Cross-Cutting Methodological Issues

Across this literature, Mortaheb and Jankowski (2023) argue that smart-city models remain overly techno-centric, marginalising the human-centred dimensions of urban planning, and call for the integration of human rights, inclusivity, ethics, and democratic governance into smart-city frameworks even as GeoAI, the integration of big-data analytics, machine learning, and GIS, offers powerful new tools for service optimisation through digital twins, real-time GIS, and participatory mapping. Okonta and Vukovic (2024), through a systematic review of fifteen smart-city software applications and a thematic analysis of thirty case studies, mapped their findings to six action areas, governance, mobility, economy, environment, living, and people, and found that rapid urbanisation produces multifaceted challenges spanning traffic congestion, disaster management, environmental degradation, community engagement, and economic disparity. No single methodology dominates this body of work: GIS-based frameworks, multi-temporal remote sensing, systematic and thematic literature reviews, case-study research, and AI/machine-learning-integrated geospatial models each appear, reflecting a still-diversifying methodological landscape in smart and sustainable urban research.

4. Research Gaps

Synthesising the studies reviewed above, five interlocking gaps recur across the literature on smart and sustainable urban development, with particular consequences for traditional African cities.

a. **Contextual and methodological limitations.** Prior studies of GIS-based multicriteria decision-making frequently excludes integrated sustainability criteria, spanning social, economic, and environmental dimensions, from land-use optimisation (Rahman and Szabó, 2022), and connections between GIS applications and participatory planning remain underdeveloped in the wider literature on GIS and sustainability. Ali *et al.* (2025), studying urban expansion in Sahiwal, Punjab, similarly identify a shortage of predictive models and call for more proactive, eco-friendly land-use planning in rapidly urbanising regions of the Global South.

b. **Data governance, ethics, and security.** Biu, Oliha, and Obi (2024) highlight the need for frameworks that balance data governance, ethics, and security in geospatial intelligence, noting limited empirical research on AI-enhanced geospatial intelligence in African urban contexts and on its long-term implications for community resilience. This concern echoes Mortaheb and Jankowski's (2023) broader caution about data bias and ethical risk in AI-driven city management.

c. **Post-implementation and longitudinal evidence.** Islam, Vishakha, and Vikram (2024) note the scarcity of longitudinal studies on the outcomes of smart-city implementation, insufficient frameworks for integrating legacy infrastructure, and limited models addressing urban inequality within smart-city contexts, all of which point to a need for adaptive, locally tailored governance frameworks. Akinyemi *et al.* (2025) similarly identify a lack of integrated

models combining terrain, socioeconomic, and policy factors, and note that GIS-based terrain analysis remains only sparsely applied in developing-country contexts.

d. Socio-cultural and informal-sector adaptability. Costa *et al.* (2024) find that frameworks for socio-culturally adaptive smart services remain limited, as do scalable models suited to small and mid-sized cities in developing countries, methods for aligning geospatial innovation comprehensively with the Sustainable Development Goals, and strategies for integrating informal local data sources, an especially significant gap given the scale of informality in African urban systems. Benabdallah, Munyaka, and Chenal (2025) add that insufficient data connects urban design and planning with migration management in Moroccan cities, and recommend the localisation of global intercultural-city frameworks rather than their direct transfer.

e. Africa-specific structural gaps. Taken together, these studies point to a broader structural absence: the insufficiency of context-specific frameworks for African urban environments, the inadequate use of integrated, real-time geospatial and Internet-of-Things data for decision-making, and the limited application of smart-city models to traditional African cities with substantial informal settlement. Closing these gaps requires inclusive, community-centred, and participatory geospatial planning models developed specifically for, rather than adapted after the fact to, African urban conditions.

4. Discussion of findings

The reviewed conceptual framework and empirical evidence point to a consistent tension. Global smart-and-sustainable-city models assume a baseline of structured spatial data, stable institutions, and formal infrastructure that many traditional African cities do not possess, while the geospatial technologies capable of supplying that missing data, GIS, remote sensing, and increasingly GeoAI, are themselves under-applied in African contexts because of resource constraints, fragmented data systems, and institutional silos (Owolabi *et al.*, 2020). This is not simply a matter of adoption lag. Kamana, Radoine, and Nyasulu's (2023) finding that Northern and Southern African cities are further ahead in adopting integrated urban strategies than cities in West and Central Africa suggests that geography, colonial planning legacy, and institutional capacity interact to produce highly uneven readiness for smart-and-sustainable transformation across the continent, a pattern that a single continent-wide framework is unlikely to accommodate.

The evidence also suggests that the risk identified by Mortaheb and Jankowski (2023), that techno-centric smart-city models marginalise equity, privacy, and participatory governance, is heightened rather than reduced in African contexts, because the same data infrastructure gaps that constrain formal smart-city planning also make informal settlements systematically under-represented in the spatial datasets on which such planning depends. Mobile-based GIS and participatory-mapping initiatives in Nairobi and Accra (Bwalya and Mutula, 2015; Myers, 2016) indicate that this exclusion is not inevitable, but scaling such initiatives beyond pilot projects will require the kind of adaptive, locally tailored governance frameworks that Islam, Vishakha, and Vikram (2024) find largely absent from the current literature.

These observations support the paper's central argument: that context-sensitive, community-centred, and geospatially enabled frameworks, rather than the direct transfer of Western- or Asian-designed smart-city models, offer the more viable route to inclusive and resilient urban

transformation in traditional African cities. Such frameworks would need to integrate informal settlement data explicitly, build data-governance safeguards into geospatial intelligence systems from the outset, and treat citizen participation as a design principle for spatial-data infrastructure rather than an add-on feature.

5. Conclusion and Directions for Future Research

This review has examined the conceptual, theoretical, methodological, and geospatial foundations of smart and sustainable urban development in traditional African cities. It finds that although the global smart-and-sustainable-city literature is methodologically diverse and technologically sophisticated, it remains only partially adapted to African urban conditions, particularly with respect to informal settlements, fragmented geospatial data infrastructure, and participatory governance. Closing these gaps will require research that treats African cities as a distinct empirical and theoretical context rather than a late-adopting variant of models developed elsewhere. Building on the gaps identified in Section 4, future research would usefully pursue geospatially integrated, predictive approaches to urban growth modelling that combine remote sensing, GIS, and machine-learning techniques with locally sourced and informal spatial data, applied at the scale of individual metropolitan regions where such integration can be evaluated in depth. Medium-sized and rapidly urbanising African metropolises, such as Ibadan in Oyo State, Nigeria, offer a particularly instructive setting for this kind of study, since they combine significant informal settlement with the kind of institutional capacity needed to trial new data-governance and participatory-mapping approaches, without the scale constraints that complicate implementation in Africa's largest primate cities. More broadly, the field would benefit from longitudinal, post-implementation studies of existing African smart-city pilots; from frameworks that formally integrate informal-sector data into geospatial planning systems; and from governance models that build ethical and participatory safeguards into geospatial intelligence systems at the design stage rather than retrofitting them after deployment.

References

Abdullahi, S., and Pradhan, B. (2018). Sustainable brownfield redevelopment using GIS-based multicriteria decision analysis. *Land Use Policy*, 73, 29–40. https://doi.org/10.1016/j.landusepol.2018.01.032

Ahmed, A., Achieng, L., and Otieno, J. (2021). Urban spatial data infrastructure for sustainable development in Kenya. *GeoJournal*, 86(4), 1615–1630. https://doi.org/10.1007/s10708-019-10104-7

Ahvenniemi, H., Huovila, A., Pinto-Seppä, I., and Airaksinen, M. (2017). What are the differences between sustainable and smart cities? *Cities*, 60, 234–245. https://doi.org/10.1016/j.cities.2016.09.009

Akinyemi, A. D., Egogo-Stanley, A. O., Ibrahim, O. M., and Ezeamii, G. C. (2025). Assessing the role of topographical analysis in sustainable urban development: Insights from GIS-driven terrain studies. *EPRA International Journal of Economic Growth and Environmental Issues*, 13(2), 9–20. https://doi.org/10.36713/epra20127

Ali, K., Shah, J. A., Ullah, S., and Raza, S. T. (2025). Quantifying sustainable urbanization by predictive modeling for better agricultural management: A case study in the South Asiatic Region. *Heliyon*, 11, e40978. https://doi.org/10.1016/j.heliyon.2024.e40978

Ali, M., Naeem, F., Adam, N., Kaddoum, G., Huda, N. ul, Adnan, M., and Tariq, M. (2023). Integration of data-driven technologies in smart grids for resilient and sustainable smart cities: A comprehensive review. *arXiv*. https://arxiv.org/abs/2301.08814

Angelidou, M. (2017). The role of smart city characteristics in the plans of fifteen cities. *Journal of Urban Technology*, 24(4), 3–28. https://doi.org/10.1080/10630732.2017.1348880

Anthopoulos, L. (2017). *Understanding smart cities: A tool for smart government or an industrial trick?* Springer.

Batty, M., Axhausen, K. W., Giannotti, F., Pozdnoukhov, A., Bazzani, A., Wachowicz, M., and Portugali, Y. (2012). Smart cities of the future. *The European Physical Journal Special Topics*, 214(1), 481–518. https://doi.org/10.1140/epjst/e2012-01703-3

Benabdallah, N., Munyaka, J.-C. B., and Chenal, J. (2025). Public spaces and urban integration of migrants in Morocco: Challenges and opportunities for inclusive cities. *African Cities Journal*, 5(1), 23–46. https://doi.org/10.34915/acj.v5i1.180

Biu, P. W., Oliha, J. S., and Obi, O. C. (2024). The evolving role of geospatial intelligence in enhancing urban security: A review of applications and outcomes. *Engineering Science and Technology Journal*, 5(2), 483–495. https://doi.org/10.51594/estj/v5i2.826

Bwalya, K. J., and Mutula, S. M. (2015). *E-Government: Implementation, adoption and synthesis in developing countries*. De Gruyter.

Calthorpe, P. (1993). *The next American metropolis: Ecology, community, and the American dream*. Princeton Architectural Press.

Cardone, B., and Di Martino, F. (2023). A GIS-based framework using fuzzy relation equation system solutions in urban planning. *Journal of Ambient Intelligence and Humanized Computing*, 14, 12159–12178. https://doi.org/10.1007/s12652-022-03762-8

Christaller, W. (1933). *Die zentralen Orte in Süddeutschland* [Central places in southern Germany]. Gustav Fischer.

Costa, D. G., Bittencourt, J. C. N., Oliveira, F., Peixoto, J. P. J., and Jesus, T. C. (2024). Achieving sustainable smart cities through geospatial data-driven approaches. *Sustainability*, 16, 640. https://doi.org/10.3390/su16020640

Davis, K. (1968). The urbanization of the human population. *Scientific American*, 218(3), 82–90.

Duany, A., Plater-Zyberk, E., and Speck, J. (2001). *Suburban nation: The rise of sprawl and the decline of the American dream*. North Point Press.

Elmqvist, T., Bai, X., Frantzeskaki, N., Griffith, C., Maddox, D., McPhearson, T., and Watkins, M. (2018). *Urban planet: Knowledge towards sustainable cities*. Cambridge University Press.

Enwin, A. D., Ikiriko, T. D., and Peter, V. K. (2024). Using geographic information systems as methodologies in architecture and urban planning research. *International Journal of Research Publication and Reviews*, 5(8), 4064–4082.

Farr, D. (2007). *Sustainable urbanism: Urban design with nature*. Wiley.

Frank, A. G. (1967). *Capitalism and underdevelopment in Latin America: Historical studies of Chile and Brazil*. Monthly Review Press.

Frankema, E., Hillbom, E., Kufakurinani, U., and Meier zu Selhausen, F. (Eds.). (2023). *The history of African development: A textbook for a new generation of African students and teachers*. African Economic History Network. https://doi.org/10.18174/590864

Goodchild, M. F. (1987). A spatial analytical perspective on geographical information systems. *International Journal of Geographical Information Systems*, 1(4), 327–334.

Haggett, P. (1965). *Locational analysis in human geography*. Arnold.

Ishaq, K., and Farooq, S. S. (2023). Exploring IoT in smart cities: Practices, challenges and way forward. *arXiv*. https://arxiv.org/abs/2309.12344

Islam, I., Vishakha, and Vikram, A. (2024). Smart cities and civil engineering: Integrating technology for urban development. *International Journal of Civil Engineering and Technology*, 15(1), 13–26.

Jefferson, M. (1931). The law of the primate city. *Geographical Review*, 29(2), 226–232.

Jensen, J. R. (2005). *Introductory digital image processing: A remote sensing perspective* (3rd ed.). Prentice Hall.

Jiménez-Espada, M., Martínez García, F. M., and González-Escobar, R. (2023). Sustainability indicators and GIS as land-use planning instrument tools for urban model assessment. *ISPRS International Journal of Geo-Information*, 12(2), 42. https://doi.org/10.3390/ijgi12020042

Kamana, A. A., Radoine, H., and Nyasulu, C. (2023). Urban challenges and strategies in African cities: A systematic literature review. *City and Environment Interactions*, 21, 100132. https://doi.org/10.1016/j.cacint.2023.100132

Kuffer, M., Barros, J., Sliuzas, R., and Van Maarseveen, M. (2020). Geospatial analysis of slum growth in Sub-Saharan Africa. *Remote Sensing*, 12(4), 694. https://doi.org/10.3390/rs12040694

Li, S., Dragicevic, S., Anton, F., et al. (2016). Geospatial big data handling theory and methods: A review and research challenges. *ISPRS Journal of Photogrammetry and Remote Sensing*, 115, 119–133. https://doi.org/10.1016/j.isprsjprs.2015.10.012

Liu, Y., de Vries, W. T., Zhang, G., and Cui, X. (2024). From tradition to smart: A comprehensive review of the evolution and prospects of land use planning tools. *Heliyon*, 10, e40857. https://doi.org/10.1016/j.heliyon.2024.e40857

Mhana, K. H., Norhisham, S. B., Katman, H. Y. B., and Yaseen, Z. M. (2024). Road urban planning sustainability based on remote sensing and satellite dataset: A review. *Heliyon*, 10, e39567. https://doi.org/10.1016/j.heliyon.2024.e39567

Mortaheb, R., and Jankowski, P. (2023). Smart city re-imagined: City planning and GeoAI in the age of big data. *Journal of Urban Management*, 12(1), 4–15.

https://doi.org/10.1016/j.jum.2022.08.001

Myers, G. A. (2016). *Urban environments in Africa: A critical analysis of environmental politics*. Policy Press.

Nyarko, B. K., Boateng, I. A., and Osei, J. (2020). Geospatial techniques for environmental management in Africa. *Journal of Environmental Management*, 265, 110556. https://doi.org/10.1016/j.jenvman.2020.110556

Odendaal, N. (2015). Africa's urban revolution: Smart city ambitions and the resilience imperative. *Local Economy*, 30(7), 718–730. https://doi.org/10.1177/0269094215604785

OECD. (2008). *Sustainable development: Linking economy, society, environment*. OECD Insights. https://www.oecd.org/insights/2074770.pdf

Ojo, A., Curry, E., and Janowski, T. (2017). Designing next-generation smart city initiatives: Highlights from Cape Town. *Journal of Urban Technology*, 24(4), 7–28. https://doi.org/10.1080/10630732.2017.1348893

Okonta, D. E., and Vukovic, V. (2024). Smart cities software applications for sustainability and resilience. *Heliyon*, 10, e32654. https://doi.org/10.1016/j.heliyon.2024.e32654

Ostrom, E. (1990). *Governing the commons: The evolution of institutions for collective action*. Cambridge University Press.

Ouma, Y., Tateishi, R., and Murayama, Y. (2022). Geospatial information science in Africa: Trends, opportunities, and challenges. *GeoJournal*, 87, 2435–2451. https://doi.org/10.1007/s10708-020-10322-w

Owens, S. (1990). Sustainable urban development: Making space for nature. In *Proceedings of the international conference on sustainability*. Cambridge University.

Owolabi, O., et al. (2020). Institutional and data silos in African urban planning systems. *[full source details to be supplied]*.

Rahman, M. M., and Szabó, G. (2022). Sustainable urban land-use optimization using GIS-based multicriteria decision-making (GIS-MCDM) approach. *ISPRS International Journal of Geo-Information*, 11(5), 313. https://doi.org/10.3390/ijgi11050313

Sachs, J. (2015). *The age of sustainable development*. Columbia University Press.

Simon, D., Arfvidsson, H., Anand, N., Bazaaz, A., Fenna, O., and Foster, J. (2016). Developing and testing the urban sustainable development goal's targets and indicators: A five-city study. *Environment and Urbanization*, 28(1), 49–63. https://doi.org/10.1177/0956247815619865

Smart Growth Network, International City/County Management Association, and US Environmental Protection Agency. (2002). *Getting to smart growth: 100 policies for implementation*. Smart Growth Network.

Soulé, M. E. (1985). What is conservation biology? *BioScience*, 35(11), 727–734.

Strange, T., and Bayley, A. (2008). *Sustainable development: Linking economy, society, environment*. OECD.

Tobler, W. (1970). A computer movie simulating urban growth in the Detroit region. *Economic Geography*, 46(2), 234–240.

Toku, A., Amoah, S. T., N-yanbini, N. N., Sarfo, A. K., and Tornyeviadzi, P. (2024). Analysis of land-use and livelihood transformations in peri-urban areas: Insights from North-Western Ghana. *Heliyon*, 10, e38467. https://doi.org/10.1016/j.heliyon.2024.e38467

Tyris, J., Dwyer, G., Parikh, K., Gourishankar, A., and Patel, S. (2024). Geocoding and geospatial analysis: Transforming addresses to understand communities and health. *Hospital Pediatrics*, 14(6), e292–e298. https://doi.org/10.1542/hpeds.2023-007383

UN-Habitat. (2020). *World cities report 2020: The value of sustainable urbanization*. United Nations Human Settlements Programme. https://unhabitat.org/wcr/

United Nations Human Settlements Programme (UN-Habitat). (2022). *Growing cities: Urbanization in Africa*. UN-Habitat.

United Nations. (2015). *Transforming our world: The 2030 agenda for sustainable development*. https://sdgs.un.org/2030agenda

United Nations. (2018). *World urbanization prospects: The 2018 revision*. https://population.un.org/wup/

United Nations Economic Commission for Africa (UNECA). (2017). *Economic report on Africa 2017: Urbanization and industrialization for Africa's transformation*. UNECA. https://hdl.handle.net/10855/23936

Wang, X., and Ding, Z. (2024). Analysis of network patterns and its influencing factors in Chengdu-Chongqing urban agglomeration based on multi-flow. *Heliyon*, 10, e30375. https://doi.org/10.1016/j.heliyon.2024.e30375

World Commission on Environment and Development. (1987). *Our common future*. Oxford University Press.

Wright, G., Shea, S., and Burns, E. (2025). What is a smart city? *TechTarget*. https://www.techtarget.com/iotagenda/definition/smart-city

Yeboah, G., Codjoe, S., and Forkuo, E. (2021). GIS-based assessment of urban growth impacts in Accra. *Land Use Policy*, 103, 105301. https://doi.org/10.1016/j.landusepol.2021.105301

Yigitcanlar, T., et al. (2018). Smart cities and data-driven urbanism: 21st-century urban development. *Cities*, 81, 145–159. https://doi.org/10.1016/j.cities.2018.04.013

Zhao, C., Zhang, H., Wang, H., and Zhao, J. (2023). Analysis of changes in the spatiotemporal characteristics of impervious surfaces and their influencing factors in the Central Plains Urban Agglomeration of China from 2000 to 2018. *Heliyon*, 9, e18849. https://doi.org/10.1016/j.heliyon.2023.e18849