Carnegie Mellon University Africa

AI's Impact on African Urban Development

A Vision for Smart Cities

Contents

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Introduction

As global urbanization rapidly intensifies, cities are grappling with complex challenges, such as population growth, infrastructure strain, and resource management. The inevitably increasing complexities of urban management have compelled local governments to seek innovative technologies to enhance urban and regional performance. As part of this effort, governments and related stakeholders have adopted the concept of the "smart city" as a guiding principle for developing more efficient and suitable urban planning policies and practices.

However, a significant challenge remains: how to effectively contextualize this global concept, which has yet to be fully embraced by African cities that aspire to be recognized as "smart." In the African context, where infrastructure gaps have hindered the region's pursuit of economic transformation, artificial intelligence (AI)-driven smart cities hold the potential to revolutionize public services, urban mobility, energy management, and public safety. As emphasized in Agenda 2063's Sustainable Urbanization for Africa's Transformation, harnessing technology and innovation is crucial for developing smart cities that enhance governance, service delivery, support communities, and quality of life while promoting sustainability, efficiency, and transparency.[1]

As such, there is a need to scrutinize the potential of AI to address Africa's urban challenges. This will involve exploring how AI can enhance public infrastructure, bridge the digital divide, and create a human-centered focus on inclusivity to ensure that no one is left behind in the continent's smart city revolution.

AI and Smart Cities: An Overview

Connectivity as a Driving Component: The Network Nervous System

The journey toward smart cities in Africa is not without hurdles. Connectivity is the cornerstone of any smart city, yet it remains a significant barrier, with only 28.5% of individuals in Sub-Saharan Africa living in households with internet access.[2] Moreover, the continent displays the largest coverage and usage gaps in comparison to all other regions.[3]

Ready access to data is central to the realization of smart cities in Africa. It is indispensable to empowering agility and decision-making capacities among diverse stakeholders. As enterprises increasingly rely on data, pervasive broadband infrastructure can support the digital transformation of businesses and power a wide range of connected devices.

Much like nerve cells transmit signals to coordinate bodily functions, network connectivity enables the flow of data between various devices and systems in a smart city. This reliable network connectivity becomes the smart city's "nervous system," supporting essential functions, such as real-time monitoring, operational efficiency, and citizen-focused services, to enhance overall urban management and well-being.[4]

However, smart cities depend on network connectivity not only to enhance operational efficiency but also to foster economically sustainable urban environments. These networks form the data pipeline between information-collecting endpoints and the cloud, where data is processed and decisions are made.

As further explored in the sections to follow, from smart transportation systems that alleviate congestion to energy-efficient buildings that optimize resource use, connectivity facilitates the seamless integration of various systems. It is this integration that then improves residents' quality of life and supports sustainable urban development. Accordingly, it is crucial for stakeholders to understand when and where different connectivity networks offer specific advantages.

Connectivity Options for Smart Cities[5]

Mobile Connectivity (4G and 5G)

Mobile networks, including 4G and 5G, are transforming the way smart cities operate by providing fast, reliable connectivity. LTE offers extensive coverage and high-speed data transmission, supporting a wide range of applications, such as mobile internet, environmental monitoring, and smart mobility services. It also serves as a bridge to 5G, ensuring robust mobile connectivity during the transition.

5G builds on this by delivering ultra-low latency and faster speeds, enabling real-time data processing crucial for autonomous vehicles, smart traffic management, and public safety systems. The high capacity of 5G networks supports a larger density of IoT devices, ensuring seamless communication across city infrastructure. Together, LTE and 5G form a powerful foundation for enabling smart city applications, from mobility services to emergency response systems.

Fiber Connectivity

Fiber-optic networks form the backbone of smart city infrastructure, providing high bandwidth and low latency. Fiber is essential for managing the vast amounts of data generated by IoT devices, supporting real-time applications like video monitoring, smart grids, and transportation systems. Its durability, immunity to electromagnetic interference, and scalability make fiber a long-term, cost-effective solution. Fiber networks can be upgraded without replacing physical infrastructure, making them ideal for future-proofing smart city systems.

Wireless Connectivity (Wi-Fi)

Wi-Fi is a key technology for local, high-speed data transmission in smart cities. Its low-cost short-range capabilities make it ideal for areas such as public hotspots, residential networks, and commercial buildings. Wi-Fi provides affordability and flexibility for connecting consumer devices and services, like smart home systems, public Wi-Fi zones, and city kiosks. As Wi-Fi networks are easy to deploy and scale, they are well-suited for densely populated urban environments, ensuring reliable, localized access to digital services.

Network Convergence

Network convergence integrates multiple network types (fiber, mobile (4G and 5G), and wireless (Wi-Fi) into a single, unified system. This convergence allows smart cities to take advantage of the strengths of each technology: fiber for high-capacity data transport, mobile networks for real-time communication and wide coverage, and Wi-Fi for flexible local connectivity. The integration reduces the need for separate infrastructures, optimizing resource use and improving scalability.

By converging these networks, cities can ensure seamless, high-speed connectivity across various smart city applications, from energy management to public safety. This approach also supports the adoption of emerging technologies like AI, IoT, and edge computing, making smart cities more efficient, sustainable, and capable of meeting growing bandwidth demands.

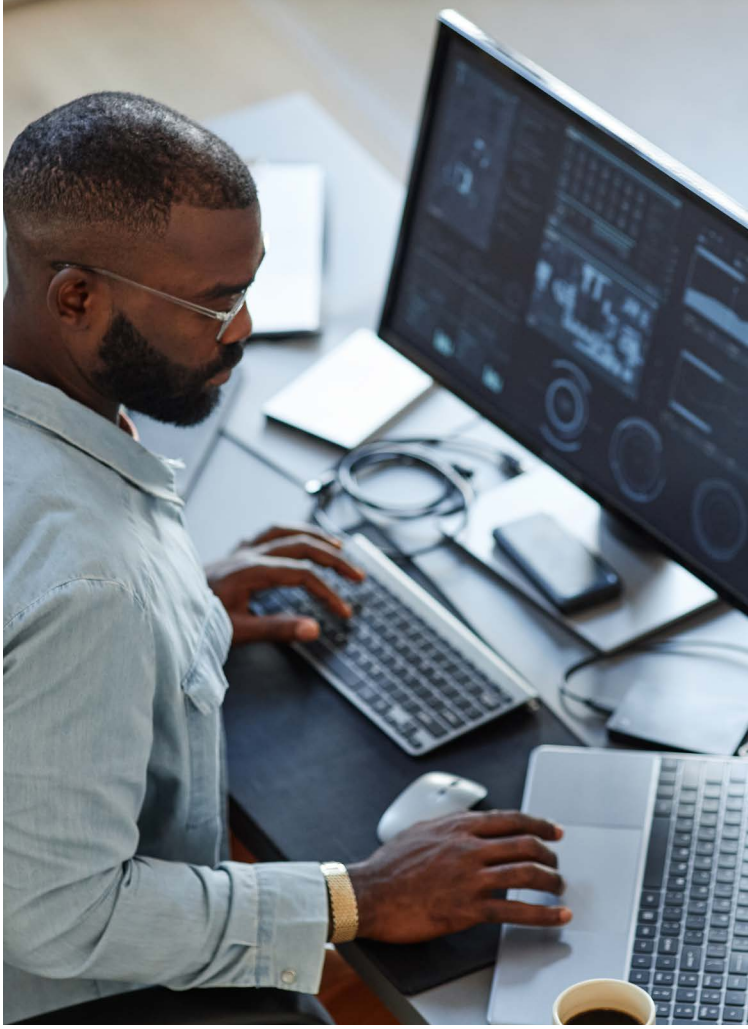
Smart cities of the future will rely on the convergence of technologies like 5G, fiber, AI, and IoT to build interconnected, data-driven ecosystems. Whether it's improving security through automated monitoring systems, enhancing emergency response, or optimizing energy and transportation networks, next-generation connectivity will enable smarter, safer urban environments.

5G provides ultra-fast, low-latency wireless communication, ensuring real-time data transmission essential for IoT devices, autonomous vehicles, and responsive city services. Fiber complements this by acting as the backbone, offering the bandwidth and reliability required to handle massive data traffic generated by smart systems. AI plays a critical role in processing and analyzing this data, transforming raw information into actionable insights, while a multitude of connected IoT devices, ranging from sensors in waste bins and streetlights to home automation systems and industrial machinery, creates a network of constantly communicating endpoints.

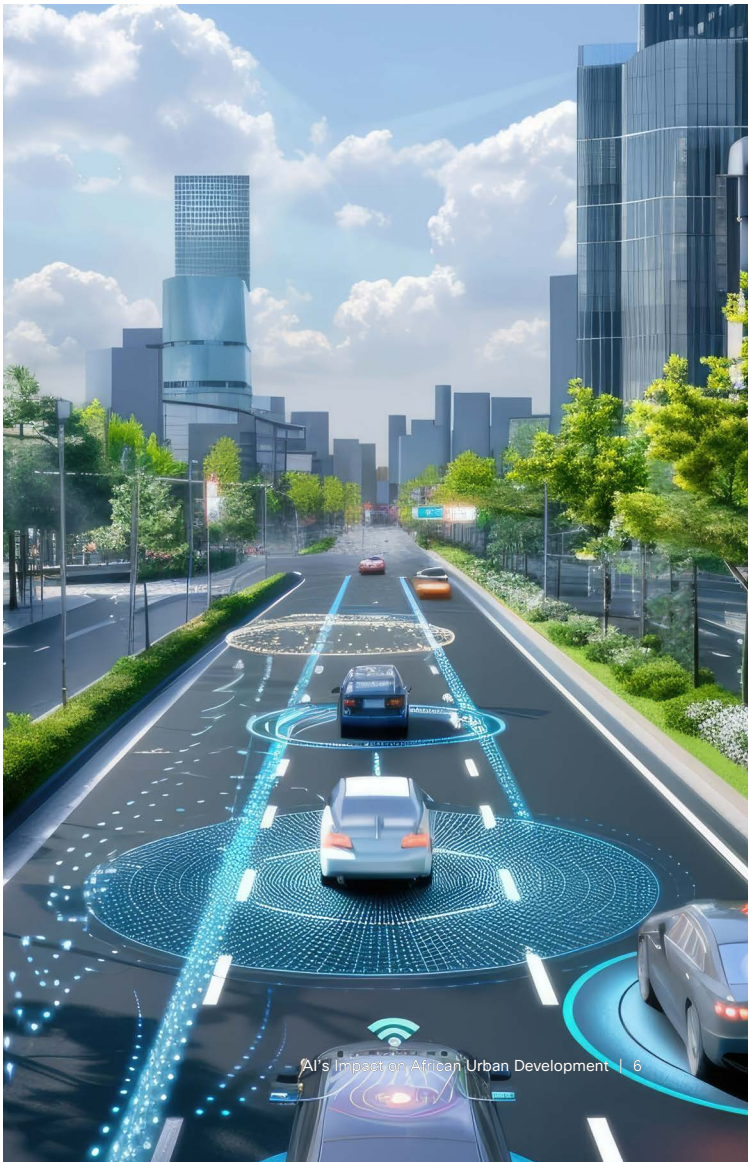
Together, these technologies power use cases like adaptive traffic management, where sensors and cameras provide real-time traffic flow data to AI systems that dynamically adjust signal timings to reduce congestion. They enable predictive maintenance for public infrastructure, where IoT devices monitor wear and tear and AI predicts failures before they occur. In energy management, smart grids use IoT to track consumption patterns, while AI optimizes energy distribution, integrating renewable sources more effectively. Emergency services benefit from real-time communication and predictive analytics, allowing faster and more precise responses to incidents. This convergence creates a city that is not only interconnected but also intelligent, learning from data patterns to continually improve efficiency, sustainability, and quality of life for its inhabitants. It exemplifies a future where technological synergies redefine urban living, with adaptability and scalability at its core.

The Allure of Smart Cities: Smart Lessons for Africa from a Global Lens

In an era where digital transformation holds a multiplier of socioeconomic value, governments are increasingly establishing smart city offices and directorates, complete with dedicated staff, resources, and budgets, to support the development of urban innovation. Those looking to capitalize on the innovation headwind have already launched smart city challenges to encourage ideation and provide funding for scaling projects. Notable examples include the US Department of Transportation (USDOT) Smart City Challenge,[6] which promotes technology-driven transportation solutions, the European Union's Intelligent City Challenge,[7] and India's Smart City Mission,[8] all designed to push forward smart city development. In some cases, a city may appoint a dedicated smart city director or manager, while others collaborate with corporate partners to drive innovation and implement projects.



Progress can be seen through individual city achievements, with Barcelona and Hong Kong standing out as leaders. Barcelona, for instance, has become a model for integrating IoT with public services, such as waste management, parking, and street lighting. Hong Kong has excelled in using AI and data analytics to optimize public transport systems, improve urban planning, and ensure public safety.[9] While public safety remains the key policy driver, sustainability benefits have drawn the most interest from countries prone to the damaging effects of extreme weather events. Natural disasters annually cost Portugal 0.4% of its GDP and affect 60 per 100,000 inhabitants. In response, Lisbon has started using digital twins to model and prepare for the increasing flooding events.[10]



Global Case Studies

Smart Mobility

- In the US, Dallas is at the forefront of testing next-generation autonomous vehicles. Self-driving lorries equipped with Copilot4D, a generative AI system, are being trialed between Dallas and Houston. These vehicles use lidar sensors to create 3D maps of their surroundings and predict events up to 10 seconds in the future, allowing them to avoid potential hazards. This AI-first approach helps address issues such as supply chain delays, carbon emissions, and labor shortages, demonstrating the transformative potential of autonomous transportation powered by AI.[11]

- London is also leveraging AI and connectivity through its Connected London program, which aims to deliver full-fiber connectivity across the city. The integration of smart sensors into urban infrastructure, such as streetlights and bus stops, along with the deployment of 5G transmitters, is designed to improve citywide connectivity. This infrastructure supports not only smarter transportation systems but also a wide range of AI-driven applications, from smart parking zones to intelligent traffic management, enabling a more connected and efficient urban environment.[12]

- Dubai International Airport (DXB), the world's busiest airport, has harnessed advanced sensor technology and AI-driven analytics to expand capacity without the need for additional terminal space, infrastructure, or runways. The baggage system, spanning 150km, handles over 150 million bags annually. Each bag generates more than 200 data points, all monitored using Splunk technology to ensure accurate routing. By embedding IoT sensors across the airport, real-time data on passenger movement, baggage handling, and security processes is collected and analyzed. This enables precise resource allocation and predictive planning, resulting in key improvements, such as reducing security wait times to under five minutes and accurately forecasting baggage loads for greater operational efficiency. Through these innovations, DXB has not only optimized its infrastructure but also enhanced traveler experiences, solidifying its status as a global aviation leader.[13]

Digital Twins

- The University of the Bundeswehr Munich in Germany, in partnership with Cisco, has developed an intelligent digital twin for bridges, transforming traditional approaches to infrastructure management. Traditionally, the impact of commuters on bridges was assessed using projections based on historical engineering practices, rather than real-time data. This innovative, repeatable model integrates sensors embedded in the bridge to deliver real-time telemetry and a detailed historical record of its performance and condition. By using actual data to schedule maintenance, rather than relying on forecasted usage, the model reduces maintenance costs, optimizes the design of new bridges, and minimizes unnecessary construction projects. This approach not only extends the lifespan of bridges but also significantly lowers CO2e emissions by ensuring construction occurs only when truly necessary. Ultimately, this solution revolutionizes bridge maintenance while advancing global sustainability goals by reducing the environmental footprint of infrastructure projects.[14]

- Singapore became the world's first nation to create a digital twin, a virtual model of the city-state. Building on this achievement, Singapore launched a government initiative that has resulted in the development of over 100 generative AI solutions. These innovations include tools for educational staff to quickly create new course content and a chatbot designed to assist community centers. While many governments worldwide are cautious about AI, Singapore has taken an ambitious approach, revising its National AI Strategy in late 2023 to focus on integrating the technology into the economy, encouraging businesses and public institutions to embrace its transformative potential.[15]

AI and Sustainability

- Oslo has emerged as a leader in using AI and smart technologies to tackle climate change. The city has implemented widespread use of sensors to control lighting, heating, and cooling systems, significantly optimizing energy consumption in public and private spaces. Oslo's goal is to cut emissions by 95% by 2030, an ambitious target that aligns with its broader sustainability agenda. In addition, the city is developing a smart grid that incorporates AI to manage energy distribution more efficiently while also expanding its electric vehicle (EV) charging infrastructure. By integrating AI into its climate strategy, Oslo has set a benchmark for cities aiming to achieve large-scale emissions reductions and energy efficiency.[16] In Greece, the municipal water supply and sewage utility, DEYAL, has partnered with technology companies IoTECH and Cisco to pilot smart water meters, aiming to transform water management through digitization. By automating the collection of water meter readings, this initiative not only saves time for DEYAL staff but also provides real-time insights into water usage patterns, enabling quicker detection of leaks and inefficiencies. This proactive approach helps optimize water conservation and ensures more sustainable management of resources. As water becomes an increasingly precious commodity, Greece's adoption of smart technologies highlights the potential for digital innovation to protect vital resources and create a model for sustainable urban infrastructure.[17]

Key Takeaways for Africa's Policymakers

Large cities in developing nations, particularly in Africa, will account for over 90% of future population growth. With an average annual urban growth rate of 3.5% over the past 20 years, Africa has experienced the fastest urbanization among developing regions, a trend expected to continue through 2050. This means well-considered and forward-looking urban planning cannot be a mere luxury on Africa's policy agenda.

To this end, key initiatives driving smart city development in Africa include Rwanda's Smart City Masterplan,[18] Nigeria's Smart City Initiative,[19] and Ethiopia's Smart Parking Initiatives.[20] Other noteworthy endeavors include Morocco's Digital Project for the City of Casablanca[21] and Mauritius' Moka Smart City.[22] While the number of smart cities on the continent is currently limited, the transformative potential of these concepts for urban planning, management, and governance in African cities remains significant, such as Oslo, Singapore, and Greece, in how they have utilized national policy frameworks to spur research and partnerships in tailoring smart solutions. In fact, several iterations of the policies, such as Singapore's National AI Strategy, were developed as countries revised their approaches to meet technological advancements.

Where policymakers face uncertainty concerning how to regulate technological advancements, the implementation of regulatory sandboxes is gaining traction across the continent. These sandboxes allow for the controlled testing and development of new technologies and services, helping to clarify regulatory pathways. As of 2024, over 10 African nations have implemented sandboxes, reflecting a growing recognition of their potential to stimulate innovation in various vectors[23] – this should include smart city technologies as well.

By integrating regulatory sandboxes into their smart city strategies, African nations can create an enabling environment that encourages experimentation while ensuring consumer protection and market integrity. These sandboxes can be particularly beneficial for testing emerging ICT products and services related to smart city development, such as innovative telecommunication solutions, IoT devices, cybersecurity tools, and smart city solutions for urban planning and management. This approach allows African cities to adapt global smart city concepts to their specific contexts, fostering local innovation and ensuring that smart city solutions are tailored to the unique challenges and opportunities of the continent.

1 Supporting Connectivity Initiatives

Africa faces a formidable connectivity challenge that threatens to impede the integration of AI in smart city initiatives. With internet penetration at just 43%, well below the global average of 66%, many citizens remain excluded from the digital revolution that underpins smart city technologies.[24] This gap is further exacerbated by the high cost of mobile data. Without addressing these disparities, the transformative potential of AI in urban management, transportation, and public services risks being unevenly distributed, leaving marginalized communities behind and limiting the overall impact of these innovations.

To bridge these gaps, Africa can draw valuable lessons from global efforts to improve digital access. Behind the successful case studies described above in Germany and London, smart city technologies are equally pioneering programs such as WiFi4EU[25] and the Gigabit Broadband Voucher Scheme,[26] illustrating how targeted investments in connectivity infrastructure can significantly expand access. Policies aimed at reducing the cost of devices and data, coupled with investments in digital literacy programs, can bring more citizens online, ensuring that smart city technologies reach underserved communities. Addressing these issues holistically will create a solid foundation for AI integration across African cities.

Moreover, addressing the gender digital divide is crucial for inclusive progress. Women in Sub-Saharan Africa are 37% less likely to use mobile internet than men, highlighting a significant barrier to equitable access.[27] African nations can learn from global initiatives that promote gender parity in digital access by prioritizing policies that target women and other marginalized groups. By fostering a more inclusive digital environment, Africa can ensure that AI-driven smart city initiatives benefit all citizens. These efforts, combined with strategies to improve affordability and infrastructure, can enable African cities to fully harness AI and digital technologies, driving sustainable and equitable urban transformation.

2 Actualizing the Value of Data

In his State of the Nation Address, South African President Cyril Ramaphosa highlighted the need to improve operational efficiencies at the country's ports. Commenting on this, Donald Baan, Director at Portbase (a body that represents the interests of South Africa's port community), opined that ports like Durban could learn much from Port Rotterdam's use of smart technology to achieve maximum efficiency.

This underscores two key considerations. First is the immense knowledge and value that the private sector can provide. The Port of Rotterdam, Europe's largest port and the world's largest container port outside East Asia, has worked with Cisco to become one of the world's most advanced and innovative ports. Second, Baan stated that the technological revolution is not about what ports do but how well they do it. He emphasized, "An important part is that data is needed to optimize space and infrastructure utilization and enable transport optimization."[28] Although Baan's comments focused specifically on smart technologies at ports, the broader implication is clear: the real value of smart technologies lies in the data they generate, which can be leveraged for continuous improvement and scalability.

Therefore, as connectivity improves, it is essential to adopt frameworks like the ITU principles to ensure that AI-driven initiatives align with local laws, secure citizens' data, and promote inclusivity.[29] Moreover, as the foundation of modern infrastructure, the success of smart cities in Africa depends on public trust in the networks that support them – emphasizing the need for availability, integrity, confidentiality, and accountability. These four data principles are essential to create a transparent and secure environment, where real-time data can be collected, analyzed, and used for decision-making, ensuring smart cities run smoothly and deliver on their promise of a higher quality of life:

- Availability is crucial for providing real-time data access, enabling cities to make informed decisions by collecting, analyzing, and sharing information at high speeds.
- Maintaining data integrity is essential, as accurate and reliable data is the foundation for smooth smart city operations.
- Confidentiality safeguards citizens' personal information, ensuring that data is protected from unauthorized access, and where appropriate, anonymized.
- Accountability ensures that system administrators and users are held responsible for their actions, maintaining transparency across all layers of the smart city network.

Beyond these principles, the infrastructure must also be scalable and flexible to accommodate future growth, interoperable to allow seamless integration of various devices and services, and resilient to ensure continuous operation, even during failures or disruptions.[30]

Potential for AI in Managing Public Infrastructure in Africa

Africa is vast and diverse, so socioeconomic priorities and challenges vary considerably across different countries. However, there are some sectors that the entire continent is focused on: transportation, energy, water, and sanitation, as well as public health.

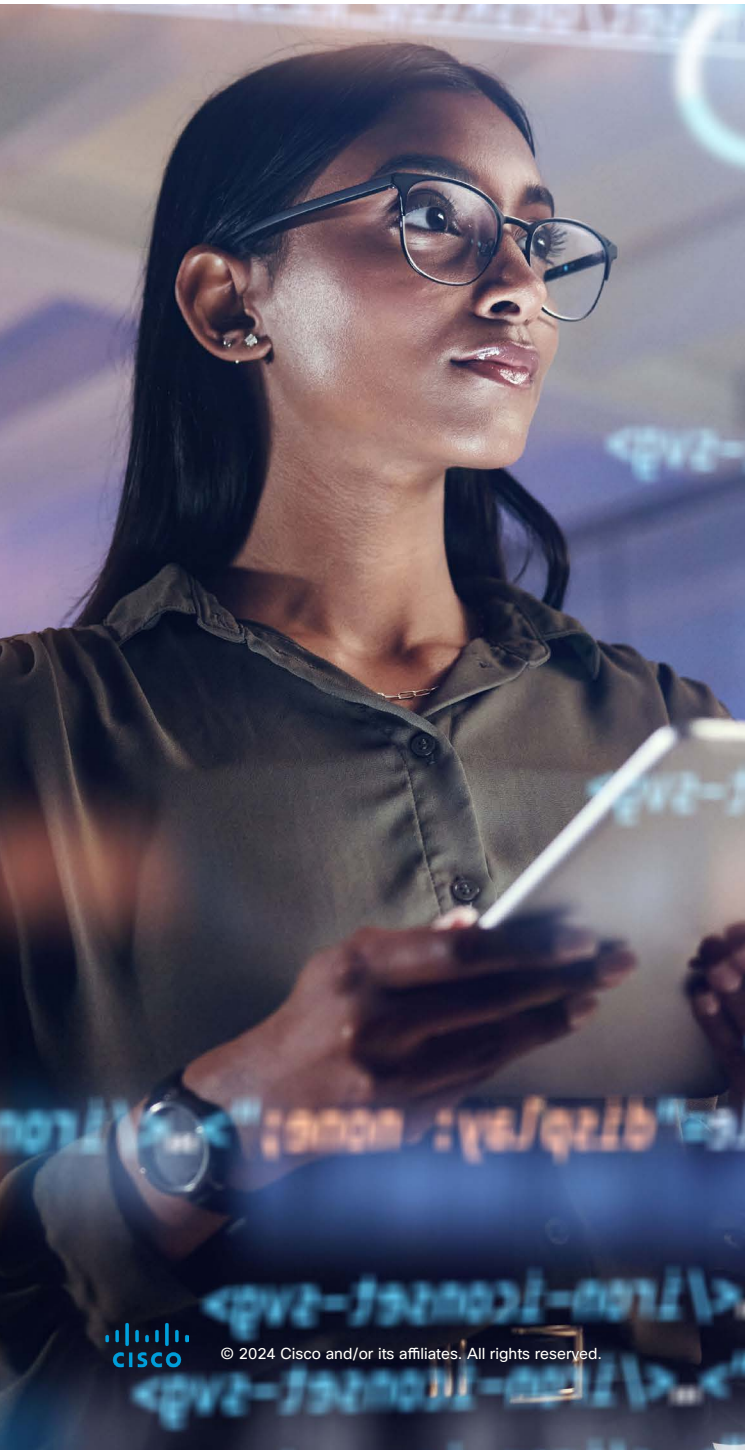
Perhaps the most critical single domain that impacts all of the above is digital infrastructure. In Côte d'Ivoire, 28% of the population lives in areas without mobile broadband coverage, representing a digital infrastructure gap affecting over 7 million people.[31] In Ethiopia, approximately 80.6% of the population remained offline at the start of 2024, leaving 103.3 million people without internet access.[32] There is a consensus that a connectivity gap exists, with a critical need for innovative solutions that transcend geographical barriers and deliver connectivity where it is needed most.

The effective design, maintenance, and monitoring of digital infrastructure (such as fiber-optic networks and data centers) can prevent outages, reduce downtime, and ensure consistent service delivery. More broadly, by wisely using scarce resources, African countries can expand internet access and digital services to economic hubs and underserved areas. AI can be used to accelerate this process and magnify its impact. By analyzing data traffic patterns and predicting network congestion, network resources can be dynamically adjusted to enhance connectivity. Furthermore, by monitoring network performance and taking steps to prevent failures, service providers can improve service reliability.

Among the different ways to apply AI for public infrastructure management, four stand out. These are data analytics for resource optimization, infrastructure monitoring and maintenance, traffic and transportation management, and environmental monitoring.

Data Analytics for Resource Optimization

enhancing efficiency, reducing waste, and promoting sustainability. While decision-makers typically focus on human and financial resources, others, such as energy and communication networks, should also be considered as they impact so many other activities.



Successful Examples

Cape Town, South Africa - Water Management: Cape Town has adopted AI technologies for water management in response to its severe droughts. The AI systems analyze data from various sources to predict water demand and optimize distribution, ensuring efficient use of water resources. By detecting anomalies in the water flow, leaks can be identified early thus reducing wastage.[33]

Kenya Power's Smart Grid Initiative: Kenya Power, the main electricity distribution company in Kenya, is implementing a smart grid initiative that leverages AI to enhance the efficiency and reliability of electricity distribution.[34]

Implementation

Smart meters are being installed across the network to gather real-time data on electricity usage and grid performance. These meters provide detailed insights into energy consumption and help detect anomalies. AI will also help in managing the integration of renewable energy sources, such as solar and wind, by predicting their output and adjusting the grid operations accordingly.

Impact

The smart grid initiative will reduce the frequency and duration of power outages. By optimizing the distribution of electricity and reducing losses, the initiative will improve overall energy efficiency. The reduction in outages and energy losses will lead to substantial cost savings for both Kenya Power and its customers.

Infrastructure Monitoring and Maintenance

Data-driven infrastructure monitoring and maintenance can help ensure the longevity, efficiency, and reliability of critical infrastructure and allow for informed decision-making. This can facilitate sustained economic growth and resilience against environmental and operational challenges.

Traffic and Transportation Management

Traffic and transportation management is crucial for the future of the African continent due to its potential to boost mobility, reduce congestion, and enhance safety, all of which contribute to economic growth across the continent. In particular, the availability of effective and efficient public transportation enables ordinary citizens to reach employment opportunities that might otherwise be inaccessible and helps increase access to essential services like education and healthcare.

AI has been used to address many transportation-related issues, and the lessons learned elsewhere stand to help deliver better outcomes in Africa.[35] For example, public transportation schedules can be optimized by analyzing passenger demand and travel patterns. This ensures that buses, trains, and other forms of public transport run more efficiently, reducing waiting times and improving service reliability.[36]

Successful Examples

Rabat, Morocco:
An AI-based solution is being used for monitoring a major bridge and connected civil infrastructure. By analyzing data from multimodal sensors embedded in bridges and roads under the Digital Twin model, AI algorithms predict when maintenance is needed, prevent costly damage and extend the lifespan of infrastructure.[37]

Case Study: AI-Powered Traffic Flow Prediction in Johannesburg, South Africa

Researchers in Johannesburg developed an AI-based model to optimize traffic flow at key intersections, addressing congestion challenges linked to urban expansion and rising vehicle numbers.[38]

Implementation
The researchers used an Artificial Neural Network (ANN) model to predict traffic flow. The model was trained using traffic data collected from seven road intersections connected to the N1 Allandale interchange, one of the busiest roads in South Africa. Traffic data was gathered using inductive loop detectors, video cameras, and geographical positioning equipment. The data included variables such as vehicle speed, traffic density, time, and traffic volume. The model achieved high accuracy in predicting traffic flow.

Impact
The AI model helped optimize traffic signal timings, reduce congestion and improve traffic flow at the intersections. By predicting traffic patterns, the system also anticipated maintenance needs, helping to prevent breakdowns and improve road safety. The project has the potential for scaling AI-based traffic management systems to other parts of the city and beyond.

Environmental Monitoring

Air and Water Quality

AI can enhance air quality monitoring by processing data from sensors measuring pollutants such as particulate matter, nitrogen dioxide, and ozone. Algorithms identify pollution sources, predict trends, and support mitigation efforts. Similarly, AI can assess water quality by analyzing sensor data for pH levels, turbidity, and other metrics, detecting anomalies and predicting contamination for timely intervention. The real-time monitoring of pollution levels can yield immediate insights into environmental conditions. This allows for quick responses to pollution spikes and allows for implementing effective mitigation strategies.

Waste Management

AI can help optimize waste collection routes by analyzing data on waste generation patterns. This ensures that collection trucks operate more efficiently, reducing fuel consumption and operational costs. AI-powered systems can improve the sorting of recyclable materials. Using computer vision and machine learning, these systems can accurately identify and separate different types of waste, enhancing the efficiency of recycling processes. AI can also be used to develop strategies to reduce waste generation. By analyzing consumption patterns and waste data, AI can provide insights into areas where waste can be minimized, promoting more sustainable practices.[39]

Successful Examples

The United Nations Environment Program (UNEP) and IQAir's GEMS Air Pollution Monitoring platform operates as the largest global air quality network. Data from over 25,000 air quality monitoring stations in more than 140 countries are aggregated and then processed by AI algorithms to offer insights into the impact of real-time air quality on populations. These insights help inform health protection measures.[40]

Governance and Regulatory Requirements

Data Protection Policy and Regulatory Frameworks

Current Landscape

Before implementing AI solutions, cities must address key challenges such as AI and data governance and ensure that city employees have the necessary data literacy to manage AI systems effectively. These considerations are critical for building a robust, long-term AI strategy that can transform urban environments. However, only 65% of African countries even have a data protection framework.[41]

That said, the African data protection landscape is quickly evolving, with the number of countries with data protection laws having more than doubled in the past decade.[42] A key indicator of this advancement is the upcoming Network of African Data Protection Authorities Conference, scheduled for May 2025 in Nigeria.[43] This conference, following its predecessor held in Nairobi in May 2024, serves as a crucial platform for regulators across the continent to engage in important conversations about data protection frameworks and their implementation. These gatherings are instrumental in fostering collaboration and knowledge sharing among African nations, potentially accelerating the adoption of comprehensive data protection policies across the continent.

Furthermore, international partnerships are playing an increasingly important role in shaping Africa's data protection and AI landscape. A notable example is the joint statement signed by the US Department of Commerce and Nigeria's Ministry of Communications, Innovation and Digital Economy in July 2024, focusing on data protection, data transfers, AI, and digital upskilling.[44] This collaboration demonstrates the growing recognition of the importance of cross-border cooperation in addressing the challenges and opportunities presented by AI and data governance. Such partnerships facilitate knowledge transfer and help align African data protection frameworks with global standards, potentially enhancing the continent's readiness for AI-driven smart city initiatives. More of these types of partnerships and collaborations would be a positive step forward.

Regional Level

African Union (AU)	Malabo Convention on Cyber Security and Personal Data Protection (Malabo Convention)[45]
African Continental Free Trade Area (AfCFTA) governments	AfCFTA Digital Trade Protocol (data governance and data protection are key provisions)[46]
East Africa	East African data protection laws are set to strengthen after various stakeholders met at the East African Exchange on Data Protection in Uganda in March 2024, which recognized the need to promote privacy rights in the region.[47]

National Level

Algeria	Law No. 18-07 Relating to the Protection of Individuals in the Processing of Personal Data[48]
Angola	Law 22/11 on the Protection of Personal Data (2011)[49]
Benin	Law No. 2009-09 on the Protection of Personal Data (2009)[50]
Botswana	Data Protection Act, No. 32 of 2018[51]
Burkina Faso	Act No. 001-2021/AN on the Protection of Personal Data (2021)[52]
Burundi	No data protection regulation
Cape Verde	Law 133-V-2001 on the Protection of Personal Data[53]
Cameroon	No data protection regulation
Central African Republic	No data protection regulation
Chad	Law No. 007/PR/2015 on the Protection of Personal Data (2015)[54]
Comoros	No data protection regulation
Cote d'Ivoire	Law No. 2013-450 on the Protection of Personal Data (2013)[55]
Democratic Republic of Congo	No data protection regulation
Djibouti	No data protection regulation
Egypt	Personal Data Protection Law No. 151 of 2020[56]
Ethiopia	Personal Data Protection Proclamation No. 1321/2024[57]
Equatorial Guinea	Law No. 1/2016 on the Protection of Personal Data[58]
Eritrea	No data protection regulation
Eswatini	Data Protection Act (2022)[59]
Gabon	Personal Data Law No. 025/2023[60]
Ghana	Data Protection Act (2021)[61]
Kenya	Data Protection Act (2019)[62]
Lesotho	Data Protection Act of 2013[63]
Madagascar	Law No. 2014-038 relating to protection of personal data (2017)[64]
Malawi	Draft Data Protection Bill 2023 introduced in Parliament[65]
Mauritius	Data Protection Act (2017)[66]
Morocco	Law No. 09-08 on the Protection of Personal Data (2009)[67]
Namibia	Draft Data Protection Bill (as of 2024)[68]
Niger	Data Protection Act (2023)[69]
Nigeria	Nigeria Data Protection Act (NDPR) (2023)[70]
Republic of Congo	Law No. 29-2019 on the Protection of Personal Data (2019)[71]
Rwanda	Law No. 058/2021 on the Protection of Personal Data and Privacy[72]
Sahrawi Arab Democratic Republic	No data protection regulation
Sao Tome & Principe	Law No. 03/2016 on the Protection of Personal Data[73]
Senegal	Law No. 2008-12 on the Protection of Personal Data (2008)[74]
Seychelles	Data Protection Bill 2023[75]
Somalia	Data Protection Act No. 005 of 2023[76]
South Africa	Protection of Personal Information Act (2013)[77]
South Sudan	Draft Data Protection Bill
Tanzania	Personal Data Protection Act 11 of 2022[78]
The Gambia	Gambia Data Protection Bill (2020)[79]
Togolese Republic	Law No. 2019-014 on the Protection of Personal Data (2019)[80]
Tunisia	Law No. 2004-63 on the Protection of Personal Data
Uganda	Data Protection and Privacy Act (2019)[81]
Zambia	Data Protection Act (2021)[82]
Zimbabwe	Cyber and Data Protection Act No. 5/2021[83]

Implementation Challenges

There is a recognition across the continent that data protection is important, evidenced by the number of countries that have adopted data privacy legislation (as per the text box above). While this is great progress, there are issues related to resources and implementation that continue to be discussed and examined. This is an ongoing process and the more the data protection framework is built out across the continent, the easier it will be to foster an environment that will support the growth of smart cities.

Many nations around the world face limited institutional capacity, making it hard to enfocet data laws. For instance, the Nigeria Data Protection Regulation (NDPR), overseen by the National Information Technology Development Agency (NITDA), has faced criticism for inadequate enforcement mechanisms and resource constraints that leave data protection gaps vulnerable to exploitation.[84] Similarly, Kenya's Data Protection Act of 2019, hailed as a significant step toward comprehensive data regulation, has struggled with implementation setbacks due to insufficient funding and a lack of technical expertise within regulatory bodies.[85] This challenge, however, is not unique to Kenya or the African continent. Globally, regulators struggle with the resource and talent gaps necessary for effectively enforcing complex data protection laws. The rapid evolution of technology often outpaces the capacity of enforcement agencies to keep up, creating a universal challenge in aligning regulatory frameworks with technological advancements.

In Kenya and other similar contexts, these difficulties are further compounded by systemic issues such as limited public awareness, competing governance priorities, and uneven digital infrastructure. These factors exacerbate the challenge of building robust regulatory systems capable of enforcing data protection laws. As such, Kenya's experience underscores a broader, global struggle where resource constraints and systemic barriers hinder the effective implementation of even the most well-intentioned regulations.

The fragmented nature of regulations across the continent further complicates data governance. For example, South Africa's Protection of Personal Information Act (POPIA) stands as one of the most comprehensive frameworks, aligning with global standards like the EU's GDPR.[86] However, its strict mandates differ significantly from those of neighboring countries with more lenient or outdated policies. This divergence complicates cross-border data collaboration, creating friction that undermines regional integration and smart city scalability.

Public awareness of data rights also remains limited, diminishing accountability. In Ghana, despite the presence of the Data Protection Act of 2012, studies indicate that only a small fraction of citizens are aware of their rights under the law, which hinders public pressure for compliance and better practices. Promoting data literacy is essential to empower citizens and strengthen the push for robust data governance.[87]

Balancing data-driven innovation with privacy protection presents another challenge. Rwanda's tech-forward initiatives, such as its use of data for public health monitoring through its smart city blueprint, showcase

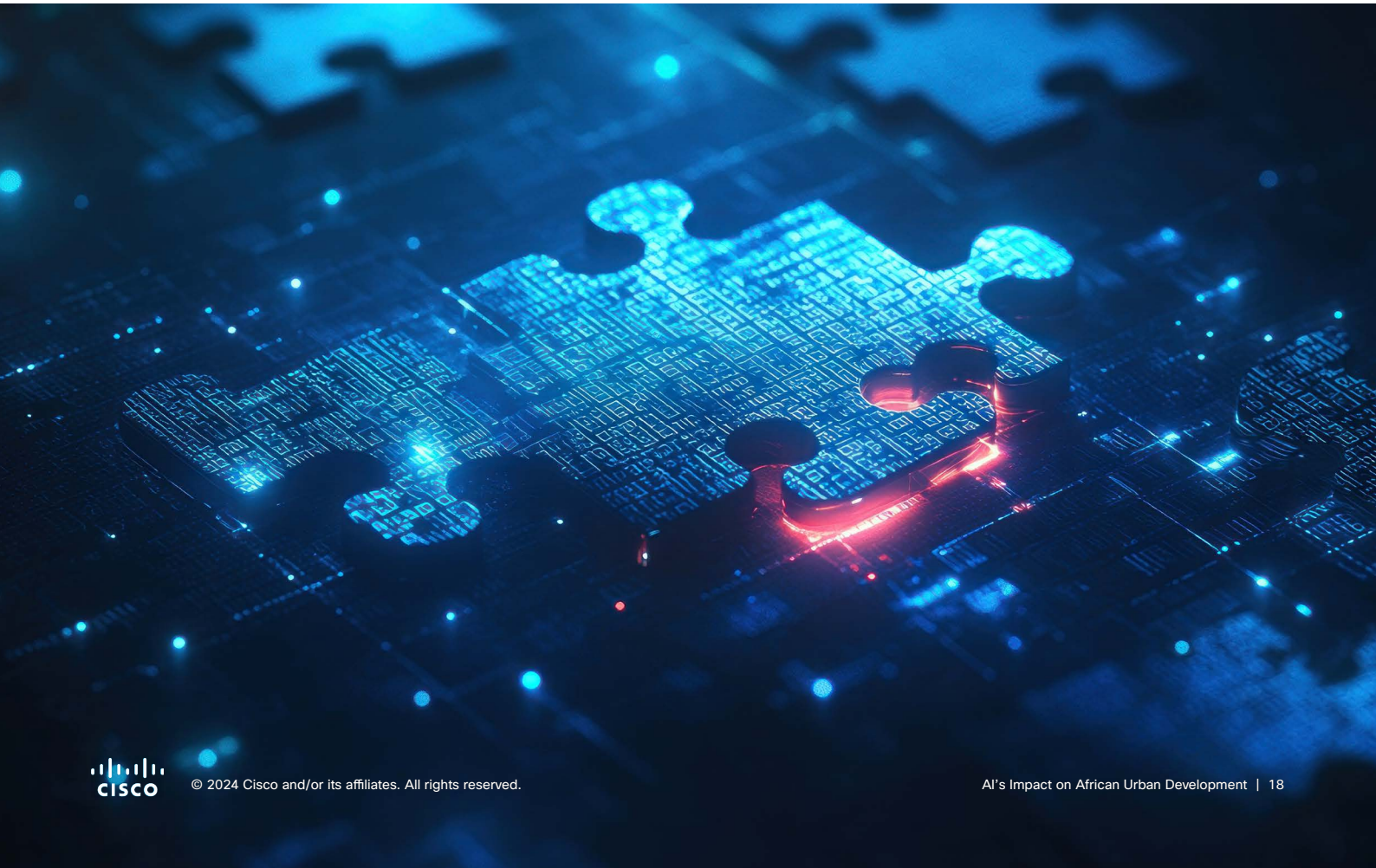
both opportunities and risks. While these programs offer models for innovation, they also highlight the urgent need for clear ethical guidelines to prevent potential misuse of data and build public trust.[88]

The continued development of data protection frameworks in Africa would be a positive step toward facilitating a number of tech innovations, including smart cities. However, it is important to note that the lack of personal data laws is not the only challenge. Equally crucial is the absence of frameworks that facilitate the collection and sharing of data across various sectors and government agencies.

Many African countries lack comprehensive data governance frameworks that would enable efficient data sharing while maintaining privacy and security.[89] These frameworks are essential for creating interoperable systems that can power smart city initiatives, allowing for the integration of diverse data sources to drive informed decision-making and improve urban services.

Finally, as smart cities rely heavily on interconnected systems and vast amounts of data, robust cybersecurity measures are critical. To address these challenges, cities should adopt international standards that provide comprehensive frameworks for network security and data protection. Organizations such as the International Organization for Standardization and International Electrotechnical Commission (ISO/IEC), the Institute of Electrical and Electronics Engineers (IEEE), and the Internet Engineering Task Force (IETF) have developed standards that address various aspects of network architecture, security, and protocols (more details on these under Section 5).

These standards collectively facilitate interoperability between diverse hardware and software, establish security benchmarks, define performance criteria, and foster innovation in network technologies. By implementing these internationally-recognized standards, African cities can build a strong foundation for addressing emerging challenges in network communications and data protection, crucial for the successful development and operation of smart cities.



The Cisco Approach to Data Protection

At Cisco, privacy is respected as a fundamental human right and operationalized as a business imperative – it is much more than just a compliance exercise. Privacy is core to our commitment to earning and maintaining trust. We strive to responsibly manage personal data and embed privacy in our products, services, and operations. Privacy strengthens customer relationships, supports responsible innovation, and aligns with our values by safeguarding individuals' rights. Against this backdrop, we propose three policy points of action to help address some of these considerations. As we navigate the era of enhanced data access and management, the policy implications in addressing how data are used and shared, at both local and national levels, are pivotal. Accordingly, Cisco recommends the following steps to enhance data protection on the continent:

1. **Capacity-building:** Investing in capacity-building initiatives at the local level is crucial to enhancing data literacy and analytical skills among urban planning professionals. This investment will ensure that the implications of data choices and their inherent imperfections are better understood and managed. By implementing targeted training programs and educational initiatives, local governments can be empowered to harness the full potential of data-driven decision-making. Moreover, these local entities are uniquely positioned to provide invaluable ground-truth validation of data, given their intimate knowledge of local contexts and conditions. This dual role of data consumers and validators makes local governments essential actors in the smart city ecosystem, capable of both leveraging data effectively and ensuring its accuracy and relevance to local realities.

   Through programs such as the Cisco Networking Academy, we are committed to building local capacity in cybersecurity and data governance.[90] In fiscal year 2023, we trained over 20.5 million learners in 190 countries, equipping them with the skills needed to implement and manage data protection systems.[91]

2. **Implementation Roadmaps:** Developing clear, phased implementation roadmaps that account for varying levels of technological readiness across different regions is essential. Cisco's Smart City solutions can be tailored to support each phase of this journey.[92]

3. **Data Exchange Regimes:** Implementing regulatory frameworks that facilitate secure and efficient exchange of data between different entities and across borders will also be key. These regimes should prioritize interoperability and standardization to enhance collaboration and innovation in smart city initiatives.

   Cisco supports frameworks that facilitate secure cross-border data flows, crucial for the development of a pan-African digital economy. Several African countries, including Mauritius, have been active in the Global Cross Border Privacy Rules (CBPR) Forum. The Global CBPR Forum enables trusted data flows globally through international data protection and privacy certifications – the Global Cross Border Privacy Rules System and the Global Privacy Recognition for Processors System.

   Cisco's solutions, such as Cisco Secure Network Analytics, enable organizations to monitor and secure data transfers across borders while maintaining compliance with local regulations.[93]

The most immediate success is obtainable through collaboration between industry stakeholders and policymakers to develop people-centric, responsible, and safe AI and smart city governance. Where industry players drive innovation and know-how to apply it to the best advantage, policymakers frame and set the terms for implementation and enforcement. By partnering with Cisco, African cities can leverage our expertise and ethical AI framework to build a data ecosystem that is technologically advanced, trustworthy, and inclusive.

Baseline Recommendations

Building a robust network for smart city development requires strong collaboration among stakeholders, including government, private companies, and citizens. Partnerships are essential for providing the expertise and resources needed to design, deploy, and maintain effective networks. As these partnerships develop, we recommend that African cities focus on the below priorities, incrementally:

Phase 1: Immediate Actions (Laying the Foundations)

Focus on the essential, foundational elements required to enable smart city development and ensure a secure, inclusive, and prepared ecosystem.

1. Strengthening Data Privacy and Security

As smart cities and AI heavily rely on data collection, ensuring robust privacy protections is critical. Cities should adopt Privacy by Design principles, including anonymization and data minimization, to protect citizens' personal information. Proactive measures, such as security audits and continuous monitoring of AI systems, can help mitigate cyber threats and maintain data integrity.

Moreover, as African cities digitize public infrastructure, they must recognize that this expansion increases the attack surface, making robust cybersecurity measures a key enabler of successful smart city implementations.

To address these challenges, cities should adopt internationally-recognized standards, such as the ISO/IEC 27033 series, which provides a comprehensive framework for network security, covering risk assessment and architecture design.[94] Additionally, implementing IEEE 802 standards for local and metropolitan area networks, including the ubiquitous Ethernet and Wi-Fi protocols, can enhance the security and reliability of smart city communication systems.[95] Regular security assessments, penetration testing, and adherence to evolving cybersecurity best practices are essential to protect against emerging threats and ensure the resilience of smart city infrastructure.

Lastly, digital resilience (the ability to prevent, respond, and quickly recover from events that have the potential to disrupt key business processes, service delivery, and access to technology[96]) is crucial for maintaining the integrity and continuity of smart city operations.

This involves implementing robust strategies for auditing unsupported devices, developing effective plans for regular upgrades and patching, and ensuring rapid recovery from potential cyber incidents. By prioritizing digital resilience, African cities can enhance their ability to withstand, respond to, and quickly recover from cyber threats, maintaining the trust and reliability of smart city services.[97]

Splunk can play a crucial role in enhancing digital resilience by providing a platform that offers end-to-end visibility across a city's digital footprint. This allows cities to identify risks, detect threats early, and prioritize alerts effectively, ensuring that potential issues are addressed before they impact critical services. With Splunk's capabilities, cities can prevent major issues, absorb shocks, and restore services swiftly, ultimately minimizing the impact of outages and breaches on urban operations.[98]

2. Fostering Inclusivity and Equity

Smart cities must bridge the digital divide by ensuring that all citizens, regardless of socioeconomic status, have access to the benefits of AI and IoT infrastructure. Strategies include expanding affordable high-speed connectivity and creating digital literacy programs that equip marginalized populations with the skills needed to interact with smart city systems. Additionally, governments should prioritize inclusive AI datasets to avoid bias and ensure fairness across diverse populations.

3. Investing in Workforce Training

Investing in workforce training is crucial for the successful implementation and utilization of AI-driven smart city initiatives. As highlighted earlier, the effectiveness of these technologies hinges on the ability of city officials and workers to properly analyze data and maintain cybersecurity. To address this need, cities should prioritize comprehensive training programs that equip their workforce with essential data analytics and cybersecurity skills.

Cisco's Networking Academy serves as a model for such initiatives. By implementing our programs, with curricula covering areas such as cybersecurity, AI, IT, and data science, African cities can ensure their workforce is capable of interacting with AI-enabled systems and adept at leveraging the vast amounts of data generated by smart city technologies.

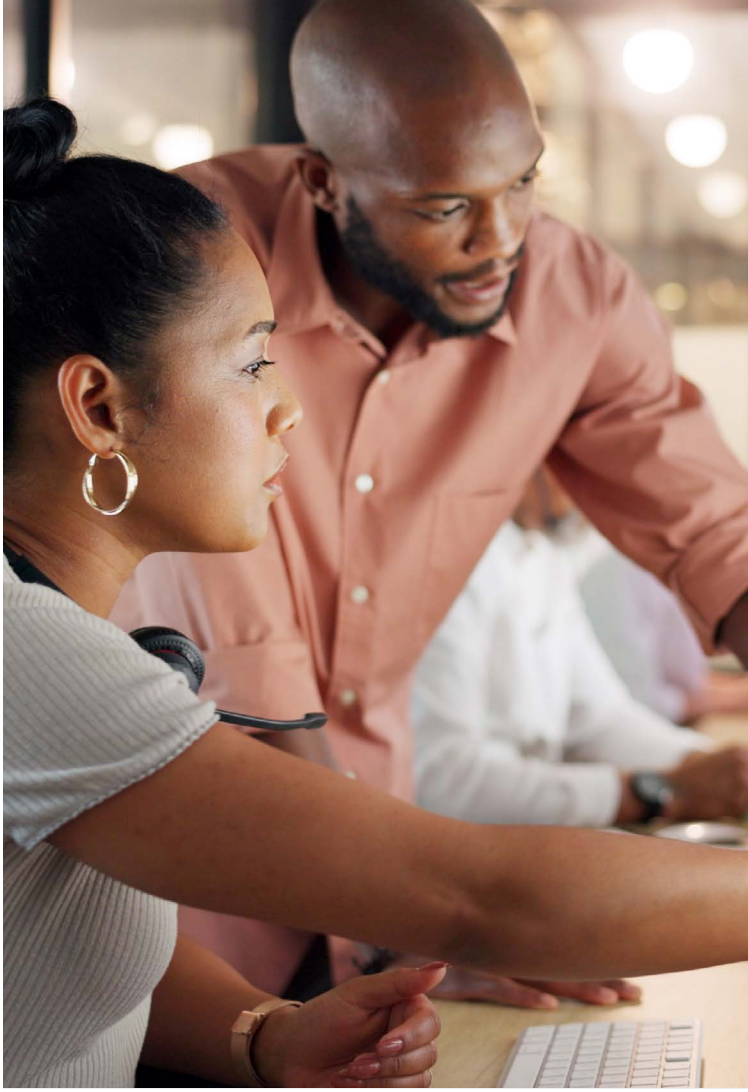
Importantly, as AI becomes more integrated into urban systems, a broader range of job positions will require familiarity with these technologies. This means that AI-related skills will no longer be limited to specialized roles but will become essential across various job functions in the smart city ecosystem. This digital upskilling approach enables cities to maximize the benefits of their smart infrastructure investments, enhance decision-making processes, and ultimately improve residents' quality of life.

Phase 2: Medium-Term Goals (Scaling and Enhancing Capabilities)

Once the foundational aspects are addressed, African cities can scale operations, leverage data, and ensure transparency for greater public trust and efficiency.

4. Gaining Value and Harnessing All Data

To harness the full potential of smart city initiatives, governments must recognize and leverage the vast amounts of structured and unstructured data generated by connected devices and infrastructure. Many governments are unaware of the value hidden within this data, particularly "dark data" – information that is collected but not effectively utilized. According to Splunk's "The



State of Dark Data" report, 55% of organizations' data remain dark, despite 81% of respondents acknowledging data as extremely or very valuable to their organization's success.[99]

For African cities embarking on smart city projects, this presents both a challenge and an opportunity. By assessing and harnessing data already being generated by existing infrastructure and devices, cities can unlock valuable insights to drive innovation, improve efficiency, and enhance service delivery. However, this requires a concerted effort to improve data literacy among government officials and invest in the necessary tools and expertise to analyze and interpret this wealth of information.

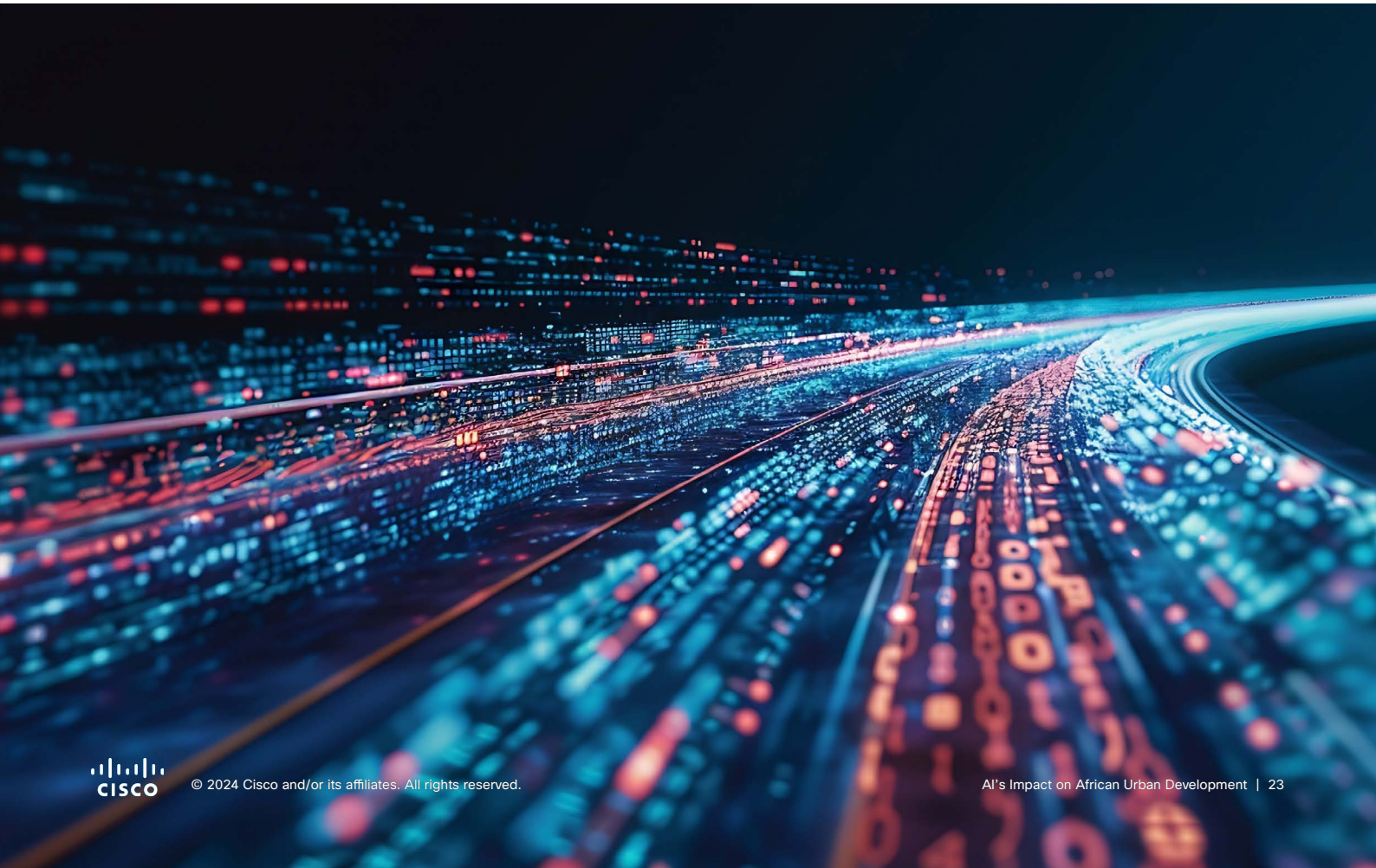
5. Enhancing Transparency and Public Trust

To address concerns about surveillance and AI decision-making, cities should embrace transparency with open data portals and public AI registers. These tools allow citizens to understand how their data is being used and enable public participation in urban planning. Engaging communities early and often, especially in the deployment of surveillance technologies, can build trust and foster a collaborative environment.

To support this process, Cisco's Networking Academy offers comprehensive courses on IoT, digital transformation, and networking, providing foundational skills crucial for working with smart city technologies. Additionally, cities can follow the example set in Colombia, where Cisco partnered with the municipality of Bogota in 2023 to develop cybersecurity skills for public sector staff, enhancing their ability to protect and manage smart city infrastructure and equipping them with new skills to reduce the level of cyber-attacks on the city through the CISCO Cybersecurity Route program.

6. Developing Scalable and Interoperable Networks

Sustainable smart city infrastructure requires scalable and interoperable systems. Cities should facilitate network convergence by integrating multiple network types, including fiber, 4G, 5G, and Wi-Fi, into a unified network to ensure seamless connectivity and futureproofing. Complementary deployment of fiber, cellular, and Wi-Fi networks will ensure a diversity of means to allow everyone to stay connected. Moreover, AI and IoT applications should be designed to support evolving technologies like edge computing and cloud-based solutions.



Phase 3: Long-Term Strategies (Sustaining and Innovating)

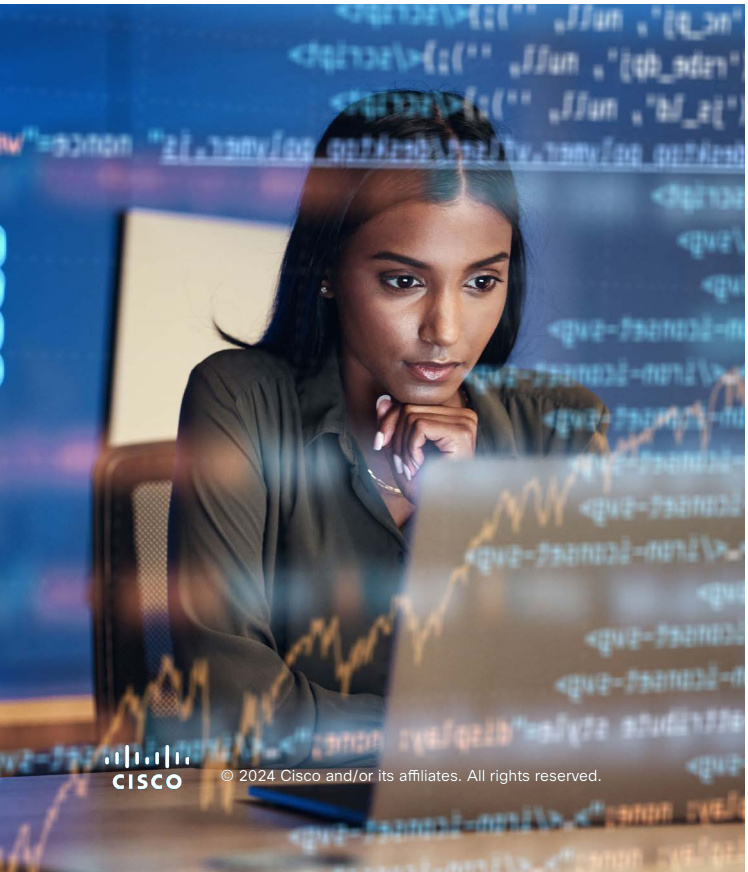
In the long term, the focus should be on strategic partnerships, cutting-edge technologies, and ethical governance to maintain and expand smart city initiatives.

7. Promoting Ethical AI Governance

Ethical considerations must guide AI deployment in smart cities. African governments should establish AI governance frameworks based on globally recognized approaches. These frameworks should emphasize accountability, fairness, and transparency, with mechanisms to ensure human oversight of AI systems. Advisory boards, ethical assessments, and regular audits will help ensure that AI is implemented responsibly and sustainably.

8. Prioritizing Public-Private Partnerships (PPPs)

Smart city initiatives require collaboration between governments and the private sector to share expertise and resources. PPPs can accelerate the deployment of AI and IoT solutions, with cities benefiting from the innovation and investment capacity of private companies. Public and private entities should work together to co-create AI strategies that align with local urban goals and regulatory frameworks.



9. Leveraging Digital Twins for Urban Planning

Digital twins offer a powerful tool for city planning and infrastructure management. African cities should explore using digital twins to simulate urban scenarios, such as flood risks, transportation efficiency, and energy usage. This technology allows cities to model future developments, improve resource management, and enhance resilience to climate change.

By following these headline recommendations, African cities can develop smart city initiatives that are sustainable, inclusive, and secure, leveraging AI to improve public services, optimize resources, and enhance residents' quality of life while addressing key risks and ethical concerns.

At Cisco, we believe smart city technologies must be secure, scalable, and interoperable – not just to meet today's needs but also to enable cities to undergo a sustainable journey towards digital transformation. This means strategically planning African cities' communications networks and adopting next-generation capabilities, as embodied in Cisco's Connected Communities Infrastructure (CCI). It also means leveraging industry standards and interoperability across a partner ecosystem. Security, scalability, and interoperability can also be extended to African cities' data with the Cisco Kinetic for Cities platform. Based on this approach, below are some high-level recommended practices for cities looking to accelerate their digital transformation:

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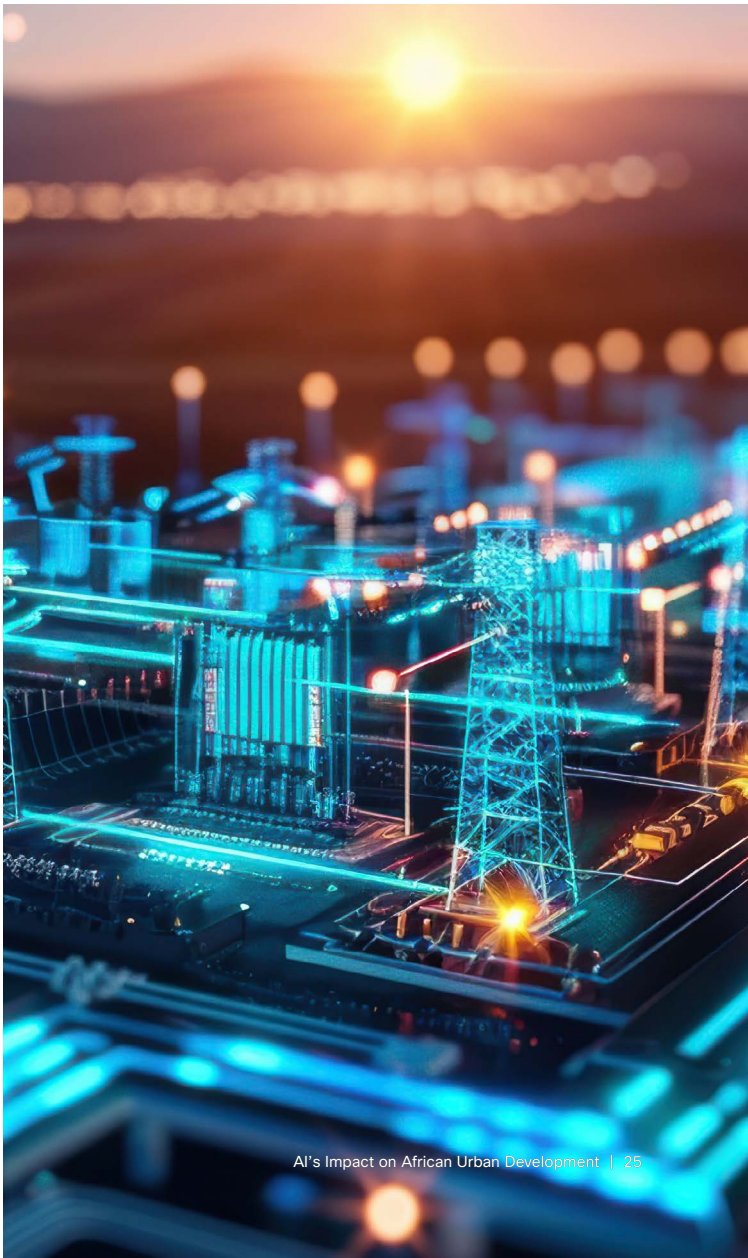
1. Adopt a comprehensive multi-service IoT network and security architecture to avoid siloed deployments, such as the CCI.
2. Implement a smart city platform, such as Cisco Kinetic for Cities, that can aggregate and normalize data from multiple use cases and integrate with various sensors and applications.
3. Utilize modular architecture, as embodied in CCI, that allows for flexibility in choosing communication technologies (e.g., fiber or Wi-Fi).
4. Focus on interoperability to ensure data from various IoT services can be accessed and utilized effectively.
5. Prioritize cybersecurity, secure data management, and regulatory compliance in all smart city initiatives.[100]

Case Study

In India in 2019, Cisco partnered with the Ministry of Housing and Urban Affairs to launch an Urban Observatory Room, showcasing the potential of data-driven urban management. This initiative aimed to improve city productivity by leveraging real-time data analytics across various urban systems to enhance urban management.

The observatory enables city administrators to make informed decisions on urban planning, infrastructure development, and service delivery.[101] The initiative led to significant improvements in urban management through the integration and analysis of diverse data sources. Cities saw their livability index rise as data-driven insights helped optimize resources and services. New monetization models emerged, leveraging data insights to create economic opportunities.



Conclusion

AI's potential to reshape Africa's urban future is both vast and inspiring. By integrating AI into public infrastructure, African cities can unlock new efficiencies in transportation, energy management, and public services while addressing long-standing challenges, such as congestion, pollution, security and uneven service delivery. However, the journey will require a concerted effort across all sectors – government, private enterprise, and civil society – to ensure that the implementation of AI technologies is inclusive, secure, and sustainable.

Looking ahead, it is crucial that African governments adopt forward-thinking policies that support AI innovation while safeguarding citizens' rights. As cities across the continent strive to become smarter, collaboration between local authorities and technology providers will be essential in addressing the continent's connectivity gap and ensuring the equitable distribution of AI's benefits. Public engagement, transparency, and robust data protection frameworks will be key to building public trust in AI technologies as concerns over privacy and surveillance remain pertinent. Ultimately, the future of AI-powered smart cities in Africa hinges on their ability to balance technological innovation with human-centered governance. By fostering partnerships, investing in digital skills, and creating scalable infrastructures, African cities can position themselves at the forefront of global smart city initiatives. This report envisions a future where AI not only improves the efficiency and sustainability of cities but also enhances the well-being of all residents, ensuring that the African cities of tomorrow are more connected, inclusive, and resilient.

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