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(Review Article)

Leveraging geographic information systems and data analytics for enhanced public sector decision-making and urban planning

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Abstract

Geographic Information Systems (GIS) and data analytics are revolutionizing public sector governance and urban planning by providing innovative tools for data-driven decision-making. This review explores the integration of GIS and data analytics as a means to address complex challenges in resource management, crisis response, environmental sustainability, and urban development. GIS enables spatial data collection, visualization, and analysis, while advanced data analytics, including predictive models and machine learning, enriches decision-making processes by uncovering actionable insights from diverse datasets. Applications in public governance include optimizing resource allocation, enhancing emergency response strategies, and managing environmental impacts. In urban planning, GIS facilitates land use management, infrastructure development, and the creation of smart cities powered by the Internet of Things (IoT). The review highlights successful case studies, showcasing how cities worldwide have leveraged these technologies to achieve sustainable development and improve the quality of life for their residents. Despite their potential, the implementation of GIS and data analytics faces challenges such as data quality issues, financial and technical constraints, privacy concerns, and resistance to change within bureaucratic systems. This review discusses these barriers and offers insights into overcoming them through advancements in technology, collaborative governance models, and increased stakeholder engagement. This concludes by emphasizing the transformative role of GIS and data analytics in fostering more transparent, efficient, and sustainable urban governance. By embracing these tools, public sector entities can better anticipate and address societal needs, paving the way for more resilient and inclusive communities. Future opportunities include leveraging artificial intelligence, expanding GIS use cases, and fostering international collaboration to further enhance public sector and urban planning outcomes.

Keywords: Geographic; Information systems; Data analytics; Urban planning

1. Introduction

Geographic Information Systems (GIS) and data analytics have revolutionized the way governments and organizations address complex urban and administrative challenges (Folorunso, 2024). GIS integrates spatial and non-spatial data to provide visual insights and facilitate spatial analysis, while data analytics involves processing large volumes of data to identify patterns, trends, and actionable insights (Bassey *et al.*, 2024). Together, these technologies enable the systematic analysis of geospatial and administrative data, providing a robust foundation for decision-making (Folorunso *et al.*, 2024). In public sector governance, GIS and data analytics are instrumental in addressing diverse issues such as urban development, disaster management, resource allocation, and infrastructure planning (Ebeh *et al.*, 2024). For urban planning, these tools facilitate informed decisions by visualizing spatial dynamics, enabling predictive

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modeling, and optimizing resource use. For example, mapping population density and transport patterns helps planners design more efficient public transportation systems, while real-time data on environmental conditions supports sustainable city management.

The shift from traditional decision-making, which often relied on intuition or limited data, to data-driven approaches has transformed public administration (Akerele *et al*., 2024). Evidence-based policy-making enhances the precision, efficiency, and inclusivity of governance processes. Governments increasingly rely on data analytics to justify policies, forecast outcomes, and measure the effectiveness of interventions. Geospatial data, in particular, plays a critical role in addressing urban challenges (Crawford *et al*., 2023). Urbanization has led to increased population density, strained infrastructure, and environmental degradation. GIS tools enable the integration of real-time data on traffic, energy consumption, and pollution levels to design responsive and adaptive urban solutions. For instance, governments can use spatial data to predict flooding zones, optimize emergency response routes, or identify underserved areas needing infrastructure investment. In addition, geospatial data supports administrative efficiency by streamlining processes like land management, tax collection, and public service delivery (Umana *et al*., 2024). By providing location-specific insights, GIS facilitates targeted interventions, reducing redundancy and maximizing the impact of governance initiatives (Iwuanyanwu *et al*., 2024).

This review aims to explore the transformative potential of GIS and data analytics in public sector governance and urban planning. By highlighting practical applications of these technologies, it underscores their relevance in addressing contemporary challenges. The primary objectives of this review include. The review examines how GIS and data analytics are applied to critical areas such as infrastructure development, resource management, and environmental monitoring. It also discusses the integration of these technologies into urban systems to promote smart cities and sustainable development. The benefits of GIS and data analytics include improved decision-making, cost efficiency, and enhanced public services. However, the review also addresses challenges such as data privacy concerns, interoperability issues, and the need for specialized skills (Uzoka *et al*., 2024). Understanding these challenges is essential for effective implementation. Real-world examples of successful GIS and data analytics implementations are presented to illustrate their impact. These case studies highlight best practices and provide insights into overcoming barriers to adoption. By achieving these objectives, the review seeks to demonstrate the critical role of GIS and data analytics in modern governance and urban planning (Garba *et al*., 2024). These tools not only enhance efficiency and effectiveness but also pave the way for more sustainable and equitable urban environments.

2. Understanding GIS and Data Analytics

Geographic Information Systems (GIS) are sophisticated tools for collecting, managing, analyzing, and visualizing spatial data. At its core, GIS integrates various types of geographic and non-geographic data to provide meaningful insights into patterns, relationships, and trends across physical spaces (Umana *et al*., 2024). This capability makes GIS invaluable for applications ranging from urban planning to disaster management. Modern GIS platforms are equipped with advanced features that streamline spatial data processing. Key functionalities include. Using remote sensing, GPS, drones, and IoT devices to gather precise geographic information. Employing robust databases to store, retrieve, and organize spatial datasets. Supporting advanced geospatial analysis techniques such as proximity analysis, network modeling, and surface interpolation. Offering intuitive maps, 3D models, and dashboards that enable policymakers and stakeholders to interpret data effectively. Technologies underpinning GIS platforms include cloud computing for scalability, real-time data integration for dynamic insights, and machine learning for predictive mapping (Audu and Umana, 2024). These features ensure that GIS remains at the forefront of technological innovation, providing users with unparalleled capabilities to understand and influence the physical world.

Data analytics involves processing and interpreting large datasets to derive actionable insights. In the public sector, it plays a transformative role by enabling evidence-based policy-making and optimizing the delivery of services (Folorunso *et al*., 2024). Key components include. Public sector data is vast, encompassing information on demographics, infrastructure, transportation, and more. Big data techniques allow for the extraction of patterns and trends from these datasets. By applying statistical models and machine learning, governments can forecast outcomes such as traffic congestion, disease outbreaks, or economic trends. Artificial intelligence enhances analytics by identifying complex patterns, automating repetitive tasks, and offering real-time decision support. When integrated with GIS, data analytics provides deeper insights into spatial data, allowing public sector organizations to tackle multifaceted challenges (Uzoka *et al*., 2024). For example, using predictive analytics alongside GIS, urban planners can model the impact of new housing developments on transportation networks, ensuring that infrastructure keeps pace with urban growth.

The integration of GIS and data analytics creates a powerful synergy that bridges spatial and non-spatial data, unlocking richer insights for decision-making (Bassey, 2022). While GIS excels in spatial data visualization and geospatial analysis, data analytics focuses on identifying trends, correlations, and causations within large datasets. Together, these tools complement each other in several ways. By combining GIS mapping with data analytics techniques, such as clustering and regression analysis, organizations can better understand spatial disparities and predict future scenarios (Ojukwu *et al*., 2024). Real-time data from sensors, satellites, and IoT devices can be processed through analytics frameworks and visualized on GIS dashboards, providing dynamic support for critical decisions, such as disaster response or resource allocation. The integration enables insights across domains like public health, transportation, and environment. For instance, GIS and data analytics can be used to monitor pollution hotspots, correlate them with health outcomes, and design interventions to improve urban air quality. The synergy between GIS and data analytics represents a paradigm shift in public sector governance, offering tools that are not only reactive but also predictive and proactive. By leveraging this synergy, governments can ensure sustainable development, efficient resource management, and improved quality of life for citizens (Akerele *et al*., 2024). Understanding the individual and combined capabilities of GIS and data analytics is foundational for harnessing their full potential in governance. These technologies, when strategically deployed, serve as the cornerstone of data-driven urban planning and policy-making.

2.1. Applications in Public Sector Governance

Resource allocation is one of the most critical aspects of public sector governance, encompassing the distribution and management of public services such as healthcare, education, utilities, and infrastructure. Geographic Information Systems (GIS) and data analytics have proven indispensable tools in optimizing the management of these resources. GIS enables public sector organizations to monitor the spatial distribution of services, evaluate their accessibility, and identify areas in need of improvement (Umana *et al*., 2024). For instance, in healthcare, GIS can be used to visualize the locations of hospitals, clinics, and healthcare facilities relative to the populations they serve. By analyzing demographic data, officials can identify underserved areas and allocate resources more effectively. Furthermore, GIS-based data analytics helps policymakers assess the availability and proximity of critical infrastructure like schools, water supply systems, and waste management facilities, ensuring that resources are distributed efficiently and equitably across urban and rural areas. In education, GIS allows for the visualization of school attendance zones, student distribution, and the accessibility of educational institutions. Through spatial analysis, educational authorities can determine whether schools are within reasonable distances for students and optimize the placement of new schools based on population growth trends. Additionally, utilities such as electricity, water, and gas can be managed more effectively by using GIS to track infrastructure assets, monitor consumption patterns, and identify areas for improvement or maintenance. The use of geospatial data ensures that resource allocation is data-driven, reducing inefficiencies and promoting more targeted and responsive public services.

In times of crisis, such as natural disasters, public health emergencies, or civil unrest, the ability to act quickly and efficiently is paramount (Folorunso *et al*., 2024). GIS and data analytics are critical in enhancing disaster preparedness and response strategies. By integrating real-time data and predictive modeling, authorities can make informed decisions and mitigate the impacts of crises. Disaster management begins with preparation. GIS allows governments to create detailed maps of vulnerable areas, including flood-prone regions, earthquake fault lines, and hurricane evacuation routes (Audu and Umana, 2024). This spatial information is essential in formulating emergency plans, constructing resilient infrastructure, and deploying resources to high-risk areas. In addition, predictive analytics based on historical data can help to model the potential impact of natural disasters, such as predicting the severity of a storm or the spread of a wildfire, enabling authorities to take proactive measures in advance. During an emergency, real-time geospatial analytics become even more vital. GPS-enabled devices, sensors, and social media data can be used to monitor conditions on the ground and track the movement of people and resources. GIS helps to create dynamic maps that highlight areas of immediate need, such as evacuation routes, shelters, medical facilities, and distribution points for relief supplies. For example, during a flood, GIS can pinpoint flooded areas, identify population clusters, and optimize rescue operations by mapping the shortest routes for emergency vehicles. In public health crises like the COVID-19 pandemic, GIS has been used to track infection rates, model disease spread, and allocate medical resources effectively. Interactive dashboards display real-time data on infection hotspots, enabling policymakers to adjust strategies dynamically and direct interventions where they are needed most (Ojukwu *et al*., 2024). Through these tools, GIS and data analytics significantly improve the efficiency and effectiveness of crisis response efforts.

Environmental sustainability and climate governance are key areas where GIS and data analytics play a pivotal role. As climate change accelerates, governments are increasingly tasked with monitoring environmental changes and implementing policies to mitigate environmental damage. GIS provides the tools necessary to track environmental indicators such as deforestation, air quality, water quality, and land use changes (Bello *et al*., 2022). In the context of deforestation, GIS allows for the continuous monitoring of forest cover using satellite imagery. Through spatial analysis, it is possible to detect changes in forest cover over time, identify illegal logging activities, and measure the success of conservation programs. Similarly, GIS enables the monitoring of urban sprawl, helping cities understand how rapidly they are expanding and which natural areas are at risk. This geospatial data can guide zoning laws, land-use planning, and the establishment of green spaces to maintain ecological balance. Pollution management is another critical area where GIS and data analytics have proven effective. Through the integration of air and water quality data with GIS, environmental authorities can track pollution levels across regions. This information is essential in enforcing environmental regulations and in designing policies aimed at reducing emissions. Additionally, GIS can be used to identify pollution hotspots and visualize trends over time, helping to target mitigation efforts in areas with the most significant environmental impacts (Akerele *et al.*, 2024). Sustainability initiatives also benefit from the integration of GIS and data analytics. For instance, in planning renewable energy projects such as wind farms or solar installations, GIS helps identify optimal locations based on factors such as wind patterns, sunlight exposure, and proximity to infrastructure. Similarly, sustainable agriculture practices can be enhanced by GIS, as it allows for precise mapping of agricultural land, helping to optimize water use, crop rotation, and pesticide application. The integration of GIS and data analytics into environmental and climate governance facilitates smarter, data-driven policy decisions that help protect natural resources, reduce pollution, and support long-term sustainability goals.

GIS and data analytics offer powerful tools for improving public sector governance across multiple domains. From optimizing resource allocation to enhancing crisis management and fostering sustainability, these technologies provide governments with the insights needed to address the challenges of the modern world (Bassey, 2023). By incorporating geospatial and data-driven approaches into policy-making, governments can better manage resources, respond to crises, and safeguard the environment for future generations.

2.2. Applications in Urban Planning

Effective urban planning relies heavily on the strategic allocation and management of land. Geographic Information Systems (GIS) play a vital role in urban land use and zoning by enabling planners to visualize, analyze, and manage the spatial distribution of land resources. GIS provides the necessary tools to assess current land use, create zoning maps, and model future land use scenarios. By integrating geospatial data with demographic, economic, and environmental information, GIS allows urban planners to design cities that are both functional and sustainable (Umana *et al.*, 2024). GIS helps in evaluating the best uses for land parcels, considering factors such as proximity to transportation, residential needs, and environmental protection. For instance, residential, commercial, and industrial zones can be mapped and adjusted to balance development with environmental conservation and accessibility. In addition to mapping, GIS aids in zoning regulations by providing spatial analysis to enforce land use policies. Planners can identify areas that are at risk of zoning violations and quickly propose corrective actions. For example, GIS can highlight areas where residential buildings are encroaching on industrial zones or where commercial areas are expanding into environmentally protected regions. Predictive models are another essential application of GIS in urban planning. Using historical data, GIS can generate forecasts for future urban growth, helping cities to anticipate infrastructure needs and avoid over-expansion. By analyzing population trends, migration patterns, and economic development, planners can predict the spatial growth of urban areas and optimize land allocation for future housing, commercial development, and green spaces (Audu *et al.*, 2024).

Infrastructure development and maintenance are critical components of urban planning, with GIS providing essential insights to optimize these processes. GIS allows city planners to analyze traffic patterns, public transit routes, utility distribution, and more, ensuring that infrastructure development aligns with current and future needs (Iwuanyanwu *et al.*, 2024). In traffic and transportation planning, GIS is used to analyze traffic congestion, accident hotspots, and the overall efficiency of road networks. By mapping traffic data, planners can identify bottlenecks and areas where congestion is likely to increase, enabling them to design road improvements, new transportation links, or alternative routes. Additionally, GIS is used to analyze public transit routes, helping urban planners optimize bus and rail networks based on population density, demand, and accessibility (Ebeh *et al.*, 2024). Utilities, such as water, electricity, and sewage systems, also benefit from GIS-based analysis. Urban planners use GIS to map infrastructure systems and analyze their condition, allowing for more effective maintenance schedules and targeted investments. By integrating GIS with real-time data from sensors embedded in infrastructure, planners can monitor system performance and detect faults or inefficiencies. For example, GIS can help identify areas with frequent water leaks or power outages, allowing for quicker maintenance responses. By leveraging spatial and demographic data, GIS also helps prioritize investments in infrastructure. Planners can use GIS to assess which neighborhoods have the most pressing infrastructure needs based on factors like population growth, income levels, and environmental risks. This ensures that investments are made where they will have the most significant impact and contribute to equitable urban development.

The concept of smart cities has gained considerable attention in recent years, with GIS playing a crucial role in the development and management of these urban environments. Smart cities rely on the integration of digital technologies to enhance the quality of life for citizens, improve efficiency, and promote sustainability (Uzoka *et al*., 2024). GIS serves as the backbone for many smart city initiatives, enabling the collection, management, and analysis of vast amounts of spatial and non-spatial data. One of the key contributions of GIS in smart cities is its ability to integrate data from various sources, such as sensors, mobile applications, and social media, into a unified system. This integration provides real-time insights into urban processes, including traffic flow, energy usage, air quality, and public safety. For instance, GIS can be used to monitor traffic conditions in real-time, adjust traffic signal timings to reduce congestion, and optimize routes for emergency vehicles. The Internet of Things (IoT) devices play a vital role in enriching GIS datasets in smart cities. IoT devices, such as smart meters, environmental sensors, and traffic cameras, generate vast amounts of real-time data that can be integrated into GIS platforms. These devices enable continuous monitoring of urban systems and infrastructure, providing planners and decision-makers with up-to-date information. For example, IoT-enabled air quality sensors can transmit real-time data to GIS systems, allowing city officials to monitor pollution levels and take immediate action to reduce health risks. Furthermore, the integration of IoT with GIS enables better decision-making by providing dynamic, location-based insights. For instance, smart waste management systems can use IoT sensors to monitor trash levels in public bins and transmit this data to GIS platforms (Bassey, 2023). City planners can then optimize waste collection routes and schedules based on real-time data, reducing costs and improving service efficiency. Similarly, smart energy systems can leverage GIS to monitor energy usage patterns and optimize energy distribution networks, contributing to more sustainable urban environments. GIS and IoT integration is fundamental to the development of smart cities. GIS provides the spatial framework needed to interpret and visualize data from IoT devices, while IoT enriches GIS platforms with real-time, location-based information. Together, these technologies enable the creation of more efficient, sustainable, and livable urban environments. Through the combination of land use planning, infrastructure management, and smart city initiatives, GIS plays a transformative role in shaping the cities of the future (Umana *et al*., 2024).

2.3. Successful GIS Implementation in Urban Planning

Geographic Information Systems (GIS) have become indispensable tools for urban planning, with several cities worldwide harnessing their power to foster sustainable development. A notable example of GIS application in urban planning is the city of Singapore, which has integrated GIS extensively into its Smart Nation initiative. Singapore uses GIS for a range of urban management tasks, including land use planning, traffic management, and environmental sustainability (Akerele *et al*., 2024). The Urban Redevelopment Authority (URA) of Singapore uses GIS to create detailed maps that guide zoning regulations, land allocation, and urban redevelopment projects. GIS helps in identifying suitable sites for new residential, commercial, and industrial developments by analyzing factors such as proximity to transportation networks, environmental impact, and population growth. Additionally, GIS-based models allow urban planners to visualize future urban expansion, enabling more efficient allocation of resources and minimizing urban sprawl. Another area where GIS has proven successful is in the management of green spaces and sustainable development. By mapping and analyzing green spaces, planners can ensure that urban development does not encroach on important ecological zones. GIS helps monitor the health of these green areas, track biodiversity, and manage ecosystem services such as air and water quality, contributing to Singapore's goal of creating a livable, sustainable city.

The integration of data analytics in public sector governance has enhanced decision-making and problem-solving, with real-time analytics playing a pivotal role in improving services and addressing complex challenges (Bassey and Ibegbulam, 2023). A case study of this application is the city of Barcelona, which has adopted real-time data analytics as part of its "Smart City" strategy. Barcelona uses real-time data collected from various IoT devices, such as sensors placed in public spaces, traffic cameras, and energy meters, to monitor and improve municipal services. One of the most successful applications of real-time analytics has been in traffic management. The city uses data analytics to monitor traffic flow, adjust traffic signals dynamically, and optimize public transportation schedules. By analyzing real-time data on traffic congestion and transit demand, Barcelona has significantly reduced traffic bottlenecks and improved the overall efficiency of its public transport system. Additionally, the city has leveraged real-time analytics to improve waste management. Sensors installed in waste bins monitor fill levels and provide real-time data, enabling the city to optimize waste collection routes and schedules (Umana *et al*, 2024). This data-driven approach has reduced operational costs, improved waste collection efficiency, and contributed to a cleaner urban environment.

The global adoption of GIS and data analytics has provided valuable lessons in both successes and challenges that can guide future applications in urban planning and governance (Akerele *et al*., 2024). A comparative analysis of GIS adoption in different countries highlights the variations in implementation strategies and their impact on outcomes. In the United States, GIS has been extensively used for urban planning, disaster management, and environmental monitoring. For example, New York City uses GIS to manage its vast infrastructure, including roads, utilities, and public services. The city's GIS platform allows decision-makers to track infrastructure conditions, prioritize maintenance tasks, and optimize resource distribution. However, challenges such as data integration from various agencies and ensuring data accuracy have posed difficulties. These issues underscore the importance of data standardization and collaboration between government agencies in GIS implementation (Ebeh *et al*., 2024). In contrast, countries like Kenya and Brazil have adopted GIS for more localized urban planning and resource management. In Kenya, GIS has been instrumental in mapping informal settlements, enabling local authorities to plan for infrastructure improvements and disaster risk reduction. In Brazil, GIS is used for monitoring deforestation in the Amazon rainforest and tracking urban sprawl. The adoption of GIS in these countries, however, has faced challenges due to limited access to technology and a lack of technical expertise, which can hinder effective implementation and scalability. The experiences of these countries highlight the importance of contextual factors, such as government readiness, technical capacity, and data availability, in determining the success of GIS applications (Bassey, 2023). Moreover, the integration of GIS with data analytics, IoT devices, and artificial intelligence presents significant opportunities for improving urban planning and governance. However, these technologies also require robust infrastructure, effective governance, and data privacy frameworks to ensure their success and sustainability. The global use of GIS and data analytics in urban planning and public sector governance has yielded valuable insights. Successful implementations, such as those in Singapore and Barcelona, demonstrate the potential of these technologies to drive sustainable development and improve public services. However, the challenges faced in countries like the United States, Kenya, and Brazil remind us that effective GIS adoption requires careful planning, capacity-building, and collaboration across sectors. By learning from these global experiences, cities worldwide can unlock the full potential of GIS and data analytics for better governance and urban management.

2.4. Challenges and Limitations

One of the primary challenges in leveraging Geographic Information Systems (GIS) and data analytics for public sector governance and urban planning is ensuring high-quality and accessible data. GIS systems rely heavily on accurate, up-to-date, and comprehensive geospatial data, yet many regions still face issues with data collection, processing, and standardization. In many parts of the world, especially in developing nations, data is incomplete, fragmented, or inaccurate, making it difficult to derive actionable insights (Bassey, 2024). Moreover, inconsistencies in data formats, lack of interoperability between different GIS platforms, and the absence of universal data standards pose significant barriers to effective data integration. Public sector entities often need to rely on multiple data sources (e.g., governmental databases, satellite imagery, IoT sensor data), each of which may have varying levels of accuracy and reliability (Oyindamola and Esan, 2023). These discrepancies can lead to erroneous conclusions, which, in turn, may negatively impact decision-making and resource allocation. Additionally, data accessibility remains a critical challenge. In many cases, the data collected by governmental or private entities is either not made publicly available or is housed in proprietary systems that limit its access. Without sufficient data-sharing protocols and open-access platforms, the potential for collaborative analysis and decision-making across various sectors is severely constrained.

The implementation of GIS and data analytics in public sector governance often comes with significant financial and technical challenges. First, the costs associated with GIS adoption can be substantial. Acquiring the necessary hardware, software, and data can require significant upfront investment, especially in countries with limited resources (Bassey *et al*., 2024). Additionally, maintaining these systems over time involves recurring expenses for data updates, system upgrades, and infrastructure maintenance. Beyond financial constraints, public sector organizations often face challenges related to technical capacity. Implementing and managing GIS and data analytics platforms requires specialized skills, which may not always be available within the public sector workforce. Government agencies may struggle to recruit or retain professionals with expertise in GIS, data analytics, and related fields such as data science and machine learning. This shortage of skilled personnel can hinder the effectiveness of GIS platforms and delay the realization of their potential benefits. Furthermore, technical challenges such as the integration of GIS systems with existing legacy systems and ensuring the scalability of solutions in large, complex public sector environments can complicate implementation efforts (Agupugo, 2023; Bello *et al*., 2023).

As GIS and data analytics systems increasingly incorporate personal, social, and environmental data, privacy and ethical concerns become more pronounced (Adepoju and Esan, 2023). Geospatial data, in particular, can reveal sensitive information about individuals and communities, such as their daily routines, movements, and interactions with public services. This raises significant privacy concerns, especially when data is collected from citizens without their explicit consent or when anonymization protocols are not properly implemented. The ethical use of data is another critical issue. Geospatial analyses used for urban planning and public service management may unintentionally reinforce biases or lead to inequitable outcomes. For example, certain urban planning decisions may disproportionately impact vulnerable or marginalized communities. If the data used in GIS systems is biased (e.g., underrepresenting low-income neighborhoods or minority groups), the resulting policy decisions may fail to address the needs of these populations adequately. Governments and organizations must therefore prioritize ethical data governance practices. This includes ensuring transparency in data collection methods, providing citizens with the right to opt-in to data collection programs, and establishing strict data protection regulations to safeguard personal information (Folorunso, 2024; Barrie *et al*., 2024).

Another significant barrier to the widespread adoption of GIS and data analytics in public sector governance is resistance to change within bureaucratic systems (Bassey *et al*., 2024). Public sector institutions are often large, hierarchical, and steeped in traditional processes that can be resistant to technological innovation. Public servants and policymakers may be skeptical of new technologies, especially when the benefits of GIS and data analytics are not immediately apparent (Esan, 2023). Moreover, there is often a lack of trust in data-driven decision-making, particularly in environments where decisions have historically been based on personal expertise or political considerations. Implementing GIS and data analytics requires not only a cultural shift in how decisions are made but also changes in workflows, organizational structures, and job roles, which can be met with reluctance and opposition. Resistance to change is also influenced by the lack of understanding of the potential benefits of GIS and data analytics. Policymakers and public administrators may not fully appreciate the power of these technologies to drive more efficient, transparent, and evidence-based decision-making. Overcoming this resistance requires a combination of education, training, and clear communication about the value of GIS and data analytics in improving public sector governance (Agupugo *et al*., 2022).

While GIS and data analytics have the potential to revolutionize public sector governance and urban planning, several challenges must be addressed for these technologies to reach their full potential (Bassey *et al*., 2024). Data quality and accessibility, financial and technical constraints, privacy and ethical concerns, and resistance to change represent significant barriers that must be overcome. Addressing these challenges requires a concerted effort to improve data management practices, invest in technical skills development, and implement robust privacy and ethical guidelines. Overcoming these limitations will enable the effective use of GIS and data analytics to enhance decision-making and promote more sustainable, efficient, and equitable public services.

2.5. Future Directions and Opportunities

The future of Geographic Information Systems (GIS) and data analytics in public sector governance and urban planning will be significantly influenced by ongoing advancements in technologies such as artificial intelligence (AI), machine learning (ML), and cloud computing (Agupugo *et al*., 2024). These innovations are transforming how GIS platforms process and analyze geospatial data, enabling more precise, dynamic, and actionable insights for decision-makers. AI and machine learning algorithms can improve GIS by automating data analysis and pattern recognition, allowing for real-time predictive analytics and scenario modeling. For instance, machine learning can be used to predict urban growth patterns, identify areas at risk of environmental hazards, or optimize traffic management systems based on historical data and real-time inputs. These capabilities not only enhance the accuracy of GIS analyses but also increase the speed and efficiency with which decisions can be made. Cloud computing further extends the power of GIS by enabling scalable and flexible data storage, sharing, and processing. Cloud-based GIS platforms can integrate vast amounts of data from diverse sources, including satellites, sensors, and citizen-generated data, into a unified system accessible to multiple stakeholders (Manuel *et al*., 2024). This flexibility allows governments to overcome hardware limitations and democratizes access to geospatial data, fostering collaboration and informed decision-making across sectors.

Together, AI, machine learning, and cloud computing are unlocking new possibilities for predictive modeling, real-time data processing, and collaborative governance, driving greater efficiency, resilience, and sustainability in public sector operations. As the use of GIS and data analytics expands, collaborative governance models are likely to play a crucial role in their successful implementation (Bassey *et al*., 2024). These models emphasize the importance of partnerships among various stakeholders, including government agencies, private companies, non-governmental organizations (NGOs), academic institutions, and the general public. By working together, these groups can leverage their expertise, resources, and data to develop more holistic and effective solutions to complex urban planning and governance challenges. In the context of GIS, collaborative governance can facilitate data sharing, the co-creation of policies, and the collective use of spatial information to address shared challenges such as environmental sustainability, public health, and disaster management (Agupugo *et al*., 2022; Bello *et al*., 2023). For example, municipalities can partner with technology firms and academic researchers to develop innovative solutions for smart city infrastructure, while local communities can provide critical data on land use, mobility patterns, and public service needs. Additionally, open data initiatives and participatory GIS platforms are empowering citizens to become active contributors to urban planning processes. This democratization of data not only enhances transparency and accountability but also ensures that policies are more inclusive and reflective of the needs of diverse communities (Esan *et al*., 2024).

The potential applications of GIS in governance and urban planning are vast and continue to grow (Bello *et al*., 2023). Emerging areas for GIS application are opening new opportunities for improving decision-making, service delivery, and community well-being. One promising area is the integration of GIS with Internet of Things (IoT) devices, which are becoming increasingly prevalent in smart cities. IoT devices, such as sensors embedded in traffic systems, buildings, and utilities, generate real-time data that, when combined with GIS, can provide insights into urban operations. For example, traffic management systems can be optimized using real-time geospatial data, reducing congestion and improving public transit efficiency (Bassey *et al*., 2024). Similarly, utility management, including the monitoring of water and energy consumption, can be enhanced by combining GIS with smart meters and sensors, enabling more efficient infrastructure planning and resource distribution. Another emerging use case is in the field of climate resilience. GIS is already widely used for environmental monitoring, such as tracking deforestation and pollution, but its role in climate adaptation is expanding. For example, GIS can help identify areas at risk of flooding or heatwaves, allowing governments to prioritize climate resilience projects in vulnerable regions. By combining GIS with climate modeling and predictive analytics, policymakers can create dynamic, data-driven strategies to mitigate the impacts of climate change and enhance the sustainability of urban areas. Moreover, GIS is increasingly being used for social and health equity. Through geospatial data analysis, governments can identify disparities in access to services, such as healthcare, education, and transportation, and develop policies to address these gaps (Esan *et al*., 2024). By mapping socioeconomic factors and correlating them with service availability, GIS can inform targeted interventions to reduce inequalities and promote more inclusive urban development.

The future of GIS and data analytics in public sector governance and urban planning is filled with exciting possibilities (Agupugo and Tochukwu, 2021). Advancements in AI, machine learning, and cloud computing are transforming GIS into a more powerful tool for real-time decision-making and predictive analysis. Collaborative governance models are enhancing the effectiveness of GIS applications by fostering partnerships between stakeholders, while emerging use cases, such as the integration of IoT devices and the application of GIS for climate resilience and social equity, are expanding its potential (Bello *et al*., 2023; Ebeh *et al*., 2024). As these technologies evolve, GIS will continue to play a pivotal role in shaping sustainable, efficient, and equitable urban environments.

3. Conclusion

This review has explored the critical role of Geographic Information Systems (GIS) and data analytics in enhancing public sector decision-making, particularly in the domains of governance and urban planning. Key findings highlight that GIS, combined with advanced data analytics, provides powerful tools for addressing urban challenges, optimizing resource allocation, improving emergency response, and promoting sustainable development. The synergy between spatial data and analytical models has proven invaluable in enabling evidence-based policy-making, ensuring more effective and efficient governance. One of the most significant takeaways is the growing importance of data-driven decision-making in the public sector. The shift from traditional approaches to evidence-based strategies, empowered by GIS and data analytics, allows governments to address complex issues with greater precision and foresight. This is particularly crucial in managing urban growth, infrastructure development, environmental concerns, and public service delivery. GIS offers spatial insights that inform policies, while data analytics provide the analytical rigor necessary for predicting trends and making informed decisions.

However, for these technologies to reach their full potential, there is a need for greater integration of geospatial tools in governance at all levels. This review has underscored the importance of overcoming challenges related to data quality, financial constraints, and resistance to change. Furthermore, it is essential for governments to invest in the technical infrastructure and expertise required to effectively implement GIS and data analytics solutions. Collaborative efforts between public, private, and academic sectors will also be crucial to foster innovation and ensure the successful adoption of these technologies. The integration of GIS and data analytics into public governance is no longer optional but a necessity for building resilient, efficient, and sustainable urban environments. A strategic push towards adopting these technologies will drive the future of smart governance and urban planning, providing the foundation for more informed, equitable, and transparent decision-making.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

References

[1] Adepoju, O.O. and Esan, O., 2023. RISK MANAGEMENT PRACTICES AND WORKERS SAFETY IN UNIVERSITY OF MEDICAL SCIENCES TEACHING HOSPITAL, ONDO STATE NIGERIA. *Open Journal of Management Science (ISSN: 2734-2107)*, *4*(1), pp.1-12.

[2] Agupugo, C. (2023). *Design of A Renewable Energy-Based Microgrid That Comprises Only PV and Battery Storage to Sustain Critical Loads in Nigeria Air Force Base, Kaduna*. ResearchGate.

[3] Agupugo, C. P., Ajayi, A. O., Nwanevu, C., & Oladipo, S. S. (2022); Advancements in Technology for Renewable Energy Microgrids.

[4] Agupugo, C.P. and Tochukwu, M.F.C., 2021. A model to assess the economic viability of renewable energy microgrids: A case study of Imufu Nigeria.

[5] Agupugo, C.P., Ajayi, A.O., Nwanevu, C. and Oladipo, S.S., 2022. Policy and regulatory framework supporting renewable energy microgrids and energy storage systems.

[6] Agupugo, C.P., Kehinde, H.M. & Manuel, H.N.N., 2024. Optimization of microgrid operations using renewable energy sources. Engineering Science & Technology Journal, 5(7), pp.2379-2401.

[7] Akerele, J.I., Uzoka, A., Ojukwu, P.U. and Olamijuwon, O.J. (2024). Minimizing downtime in E-Commerce platforms through containerization and orchestration. International Journal of Multidisciplinary Research Updates, 2024, 08(02), 079–086. https://doi.org/10.53430/ijmru.2024.8.2.0056

[8] Akerele, J.I., Uzoka, A., Ojukwu, P.U. and Olamijuwon, O.J. (2024). Optimizing traffic management for public services during high-demand periods using cloud load balancers. Computer Science & IT Research Journal. P-ISSN: 2709-0043, E-ISSN: 2709-0051 Volume 5, Issue 11, P.2594-2608, November 2024. DOI: 10.51594/csitrj.v5i11.1710: http://www.fepbl.com/index.php/csitrj

[9] Akerele, J.I., Uzoka, A., Ojukwu, P.U. and Olamijuwon, O.J. (2024). Data management solutions for real-time analytics in retail cloud environments. Engineering Science & Technology Journal. P-ISSN: 2708-8944, E-ISSN: 2708-8952 Volume 5, Issue 11, P.3180-3192, November 2024. DOI: 10.51594/estj.v5i11.1706: http://www.fepbl.com/index.php/estj

[10] Akerele, J.I., Uzoka, A., Ojukwu, P.U. and Olamijuwon, O.J. (2024). Improving healthcare application scalability through microservices architecture in the cloud. International Journal of Scientific Research Updates. 2024, 08(02), 100–109. https://doi.org/10.53430/ijsru.2024.8.2.0064

[11] Akerele, J.I., Uzoka, A., Ojukwu, P.U. and Olamijuwon, O.J. (2024). Increasing software deployment speed in agile environments through automated configuration management. International Journal of Engineering Research Updates, 2024, 07(02), 028–035. https://doi.org/10.53430/ijeru.2024.7.2.0047

[12] Audu, A.J. and Umana, A.U., 2024. Advances in environmental compliance monitoring in the oil and gas industry: Challenges and opportunities. International Journal of Scientific Research Updates, 8(2), pp.48-59. doi: 10.53430/ijsru.2024.8.2.0062.

[13] Audu, A.J. and Umana, A.U., 2024. The role of environmental compliance in oil and gas production: A critical assessment of pollution control strategies in the Nigerian petrochemical industry. International Journal of Scientific Research Updates, 8(2), pp.36-47. doi: 10.53430/ijsru.2024.8.2.0061.

[14] Audu, A.J., Umana, A.U. and Garba, B.M.P., 2024. The role of digital tools in enhancing environmental monitoring and business efficiency. International Journal of Multidisciplinary Research Updates, 8(2), pp.39-48. doi: 10.53430/ijmru.2024.8.2.0052.

[15] Barrie, I., Agupugo, C.P., Iguare, H.O. and Folarin, A., 2024. Leveraging machine learning to optimize renewable energy integration in developing economies. *Global Journal of Engineering and Technology Advances*, *20*(03), pp.080-093.

[16] Bassey, K.E. and Ibegbulam, C., 2023. Machine learning for green hydrogen production. *Computer Science & IT Research Journal*, *4*(3), pp.368-385.

[17] Bassey, K.E., 2022. Optimizing wind farm performance using machine learning. *Engineering Science & Technology Journal*, *3*(2), pp.32-44.

[18] Bassey, K.E., 2023. Hybrid renewable energy systems modeling. *Engineering Science & Technology Journal*, *4*(6), pp.571-588.

[19] Bassey, K.E., 2023. Hydrokinetic energy devices: studying devices that generate power from flowing water without dams. *Engineering Science & Technology Journal*, *4*(2), pp.1-17.

[20] Bassey, K.E., 2023. Solar energy forecasting with deep learning technique. *Engineering Science & Technology Journal*, *4*(2), pp.18-32.

[21] Bassey, K.E., 2024. From waste to wonder: Developing engineered nanomaterials for multifaceted applications. *GSC Advanced Research and Reviews*, *20*(3), pp.109-123.

[22] Bassey, K.E., Aigbovbiosa, J. and Agupugo, C., 2024. Risk management strategies in renewable energy investment. *International Journal of Novel Research in Engineering and Science*, *11*(1), pp.138-148.

[23] Bassey, K.E., Aigbovbiosa, J. and Agupugo, C.P., 2024. Risk management strategies in renewable energy investment. *Engineering Science & Technology*, *11*(1), pp.138-148.

[24] Bassey, K.E., Juliet, A.R. and Stephen, A.O., 2024. AI-Enhanced lifecycle assessment of renewable energy systems. *Engineering Science & Technology Journal*, *5*(7), pp.2082-2099.

[25] Bassey, K.E., Opoku-Boateng, J., Antwi, B.O. and Ntiakoh, A., 2024. Economic impact of digital twins on renewable energy investments. *Engineering Science & Technology Journal*, *5*(7), pp.2232-2247.

[26] Bassey, K.E., Opoku-Boateng, J., Antwi, B.O., Ntiakoh, A. and Juliet, A.R., 2024. Digital twin technology for renewable energy microgrids. *Engineering Science & Technology Journal*, *5*(7), pp.2248-2272.

[27] Bassey, K.E., Rajput, S.A., Oladepo, O.O. and Oyewale, K., 2024. Optimizing behavioral and economic strategies for the ubiquitous integration of wireless energy transmission in smart cities.

[28] Bello, O.A., Folorunso, A., Ejiofor, O.E., Budale, F.Z., Adebayo, K. and Babatunde, O.A., 2023. Machine learning approaches for enhancing fraud prevention in financial transactions. International Journal of Management Technology, 10(1), pp.85-108.

[29] Bello, O.A., Folorunso, A., Ogundipe, A., Kazeem, O., Budale, A., Zainab, F. and Ejiofor, O.E., 2022. Enhancing Cyber Financial Fraud Detection Using Deep Learning Techniques: A Study on Neural Networks and Anomaly Detection. *International Journal of Network and Communication Research*, *7*(1), pp.90-113.

[30] Bello, O.A., Folorunso, A., Onwuchekwa, J. and Ejiofor, O.E., 2023. A Comprehensive Framework for Strengthening USA Financial Cybersecurity: Integrating Machine Learning and AI in Fraud Detection Systems. *European Journal of Computer Science and Information Technology*, *11*(6), pp.62-83.

[31] Bello, O.A., Folorunso, A., Onwuchekwa, J., Ejiofor, O.E., Budale, F.Z. and Egwuonwu, M.N., 2023. Analysing the Impact of Advanced Analytics on Fraud Detection: A Machine Learning Perspective. *European Journal of Computer Science and Information Technology*, *11*(6), pp.103-126.

[32] Bello, O.A., Ogundipe, A., Mohammed, D., Adebola, F. and Alonge, O.A., 2023. AI-Driven Approaches for Real-Time Fraud Detection in US Financial Transactions: Challenges and Opportunities. *European Journal of Computer Science and Information Technology*, *11*(6), pp.84-102.

[33] Crawford T., Duong S., Fueston R., Lawani A., Owoade S., Uzoka A., Parizi R. M., & Yazdinejad A. (2023). AI in Software Engineering: A Survey on Project Management Applications. arXiv:2307.15224.

[34] Ebeh, C.O., Okwandu, A.C., Abdulwaheed, S.A. and Iwuanyanwu, O., 2024. Exploration of eco-friendly building materials: Advances and applications. *International Journal of Engineering Research and Development*, *20*(8), pp.333-340.

[35] Ebeh, C.O., Okwandu, A.C., Abdulwaheed, S.A. and Iwuanyanwu, O., 2024. Sustainable project management practices: Tools, techniques, and case studies. *International Journal of Engineering Research and Development*, *20*(8), pp.374-381.

[36] Ebeh, C.O., Okwandu, A.C., Abdulwaheed, S.A. and Iwuanyanwu, O., 2024. Recycling programs in construction: Success stories and lessons learned. *International Journal of Engineering Research and Development*, *20*(8), pp.359-366.

[37] Ebeh, C.O., Okwandu, A.C., Abdulwaheed, S.A. and Iwuanyanwu, O., 2024. Life cycle assessment (LCA) in construction: Methods, applications, and outcomes. *International Journal of Engineering Research and Development*, *20*(8), pp.350-358.

[38] Esan, O., 2023. Addressing Brain Drain in the Health Sector towards Sustainable National Development in Nigeria: Way Forward.

[39] Esan, O., Nwulu, N. and Adepoju, O.O., 2024. A Bibliometric Analysis Assessing the Water-Energy-Food Nexus in South Africa. *Heliyon*.

[40] Esan, O., Nwulu, N.I., David, L.O. and Adepoju, O., 2024. An evaluation of 2013 privatization on Benin Electricity Distribution technical and workforce performance. *International Journal of Energy Sector Management*.

[41] Folorunso, A., 2024. Assessment of Internet Safety, Cybersecurity Awareness and Risks in Technology Environment among College Students. *Cybersecurity Awareness and Risks in Technology Environment among College Students (July 01, 2024)*.

[42] Folorunso, A., 2024. Cybersecurity And Its Global Applicability to Decision Making: A Comprehensive Approach in The University System. *Available at SSRN 4955601*.

[43] Folorunso, A., Adewumi, T., Adewa, A., Okonkwo, R. and Olawumi, T.N., 2024. Impact of AI on cybersecurity and security compliance. *Global Journal of Engineering and Technology Advances*, *21*(01), pp.167-184.

[44] Folorunso, A., Olanipekun, K., Adewumi, T. and Samuel, B., 2024. A policy framework on AI usage in developing countries and its impact. *Global Journal of Engineering and Technology Advances*, *21*(01), pp.154-166.

[45] Folorunso, A., Wada, I., Samuel, B. and Mohammed, V., 2024. Security compliance and its implication for cybersecurity.

[46] Garba, B.M.P., Umar, M.O., Umana, A.U., Olu, J.S. and Ologun, A., 2024. Energy efficiency in public buildings: Evaluating strategies for tropical and temperate climates. World Journal of Advanced Research and Reviews, 23(03), pp.409-421. doi: 10.30574/wjarr.2024.23.3.2702.

[47] Iwuanyanwu, O., Gil-Ozoudeh, I., Okwandu, A.C. and Ike, C.S., 2024. *International Journal of Applied Research in Social Sciences*, 6 (8), pp. 1951-1968.

[48] Iwuanyanwu, O., Gil-Ozoudeh, I., Okwandu, A.C. and Ike, C.S., 2024. The role of green building materials in sustainable architecture: Innovations, challenges, and future trends *International Journal of Applied Research in Social Sciences*, 6(8), pp. 1935-1950

[49] Manuel, H.N.N., Kehinde, H.M., Agupugo, C.P. and Manuel, A.C.N., 2024. The impact of AI on boosting renewable energy utilization and visual power plant efficiency in contemporary construction. *World Journal of Advanced Research and Reviews*, *23*(2), pp.1333-1348.

[50] Ojukwu P. U., Cadet E., Osundare O. S., Fakeyede O. G., Ige A. B., & Uzoka A. (2024). The crucial role of education in fostering sustainability awareness and promoting cybersecurity measures. International Journal of Frontline Research in Science and Technology, 2024, 04(01), 018–034. https://doi.org/10.56355/ijfrst.2024.4.1.0050.

[51] Ojukwu P. U., Cadet E., Osundare O. S., Fakeyede O. G., Ige A. B., & Uzoka A. (2024). Exploring theoretical constructs of blockchain technology in banking: Applications in African and U. S. financial institutions. International Journal of Frontline Research in Science and Technology, 2024, 04(01), 035–042. https://doi.org/10.56355/ijfrst.2024.4.1.005

[52] Oyindamola, A. and Esan, O., 2023. Systematic Review of Human Resource Management Demand in the Fourth Industrial Revolution Era: Implication of Upskilling, Reskilling and Deskilling. *Lead City Journal of the Social Sciences (LCJSS)*, *8*(2), pp.88-114.

[53] Umana, A.U., Garba, B.M.P. and Audu, A.J., 2024. Innovations in process optimization for environmental sustainability in emerging markets. International Journal of Multidisciplinary Research Updates, 8(2), pp.49-63. doi: 10.53430/ijmru.2024.8.2.0053.

[54] Umana, A.U., Garba, B.M.P. and Audu, A.J., 2024. Sustainable business development in resource-intensive industries: Balancing profitability and environmental compliance. International Journal of Multidisciplinary Research Updates, 8(2), pp.64-78. doi: 10.53430/ijmru.2024.8.2.0054.

[55] Umana, A.U., Garba, B.M.P., Ologun, A., Olu, J.S. and Umar, M.O., 2024. The impact of indigenous architectural practices on modern urban housing in Sub-Saharan Africa. World Journal of Advanced Research and Reviews, 23(03), pp.422-433. doi: 10.30574/wjarr.2024.23.3.2703.

[56] Umana, A.U., Garba, B.M.P., Ologun, A., Olu, J.S. and Umar, M.O., 2024. Architectural design for climate resilience: Adapting buildings to Nigeria’s diverse climatic zones. World Journal of Advanced Research and Reviews, 23(03), pp.397-408. doi: 10.30574/wjarr.2024.23.3.2701.

[57] Umana, A.U., Garba, B.M.P., Ologun, A., Olu, J.S. and Umar, M.O., 2024. Innovative design solutions for social housing: Addressing the needs of youth in Urban Nigeria. World Journal of Advanced Research and Reviews, 23(03), pp.383-396. doi: 10.30574/wjarr.2024.23.3.2700.

[58] Umana, A.U., Garba, B.M.P., Ologun, A., Olu, J.S. and Umar, M.O., 2024. The role of government policies in promoting social housing: A comparative study between Nigeria and other developing nations. World Journal of Advanced Research and Reviews, 23(03), pp.371-382. doi: 10.30574/wjarr.2024.23.3.2699.

[59] Uzoka A., Cadet E. and Ojukwu P. U. (2024). Applying artificial intelligence in Cybersecurity to enhance threat detection, response, and risk management. Computer Science & IT Research Journal. P-ISSN: 2709-0043, E-ISSN: 2709-0051 Volume 5, Issue 10, P.2511-2538, October 2024. DOI: 10.51594/csitrj.v5i10.1677: www.fepbl.com/index.php/csitrj

[60] Uzoka A., Cadet E. and Ojukwu P. U. (2024). Leveraging AI-Powered chatbots to enhance customer service efficiency and future opportunities in automated support. Computer Science & IT Research Journal. P-ISSN: 2709-0043, E-ISSN: 2709-0051 Volume 5, Issue 10, P.2485-2510, October 2024. DOI: 10.51594/csitrj.v5i10.1676: www.fepbl.com/index.php/csitrj

[61] Uzoka A., Cadet E. and Ojukwu P. U. (2024). The role of telecommunications in enabling Internet of Things (IoT) connectivity and applications. Comprehensive Research and Reviews in Science and Technology, 2024, 02(02), 055–073. https://doi.org/10.57219/crrst.2024.2.2.0037