

Emerging Trends in Developing Appropriate Data Management Infrastructure for Physical Development Planning in Nigeria

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Abstract. Developing an enduring and sustainable data management infrastructure for physical planning in Nigeria is critical to addressing the numerous problems posed by uncontrolled urbanization, rapid population growth and environmental degradation. The thrust of this paper focuses on the key elements that are important for the creation of a robust and efficient data management infrastructure systems that are data-driven, which aid in making informed decisions in physical planning. The proposed data infrastructure embraced National Spatial Data Infrastructure (NSDI) as the bedrock that ensures the integration of geographic information systems, data mining, knowledge discovery and advanced data analytics, which forms the enabling environment for data collection, storage, analysis of spatial and aspatial data, and visualization. The establishment of NSDI will enable unified data management framework, standardized data format, interoperable systems and a centralized data repository that is accessible to various stakeholders, including government agencies, city planners, and related researchers. Capacity building through training and technical skill education of planners and policy formulators will add value to the successful implementation and utilization of the data management infrastructure systems. Nonetheless, the awareness of Common Data Environments (CDE), International Standard Organization (ISO) protocol, advanced information and communication and groupware technologies are crucial for data management infrastructure for physical development planning in Nigeria.

Keywords: NSDI, Knowledge Discovery, Common Data Environments, International Standard Organizations.

1.0 Introduction

In recent times, electronic data have become pervasive, particularly geospatial, socio-economic, project, and task-related datasets that underpin data management infrastructures for physical development planning in Nigeria (Olowookere & Ayeni, 2023; Al-Yadumi, 2021).

This development draws attention to the critical importance of data quality in supporting physical development planning and other governmental applications. Across the globe, data quality is recognized as a key performance issue influencing the effectiveness of physical development planning processes, and it remains a major challenge in the design and implementation of data management infrastructures.

This relates to specialized systems and processes that enable the processing, manipulation, and analysis of geospatial and socio-economic data underpinning spatial planning, urban development, infrastructure projects, and land-use management (Batty, 2021; Boland et al., 2021).

This infrastructure is crucial for effective and sustainable planning, decision making, and implementation of projects aimed at improving spatial planning. However, Soyinka (2023), drawing on Majone's (2002) definition, adopts an integrated perspective that combines both

data-oriented and user-oriented objectives. From this viewpoint, an *infrastructure for spatial information* comprises metadata, spatial datasets, spatial data services, network services and technologies, as well as agreements governing data sharing, access, and use. It also includes coordination and monitoring mechanisms and processes established, operated, or made available in line with the INSPIRE Directive, with the aim of supporting policy formulation for activities and policies that may directly or indirectly affect the environment.

Kolade, Hanien and Beinisch (2023) and Ponjavic et al. (2019) argue that the growing online availability and accessibility of geodata and various electronic data types to both expert and non-expert users has transformed the context in which geospatial and electronic data are generated, accessed, and applied, especially in physical development planning.

In this digital era, communication technology has become the backbone for physical planning applications as it provides a channel for applications to transfer data seamlessly. To this extent, Nigeria no doubt is facing a pragmatic herculean task of having appropriate data management infrastructure for physical development planning.

2.0 Assessment of Current Infrastructure

The term “infrastructure” brings to mind public facilities such as telecommunication, roads, railway lines, electric lines, airports, geodetic control framework and the likes for the access of data management infrastructure in relation to physical development planning. Therefore, data management infrastructure centres on spatial information infrastructure which is an institutional concept that has been advanced to respond to the various needs regarding spatially referenced information with respect to various problems relating to physical development planning. The ability of government to make information available in the form of raw data to citizens, scientists, stakeholders, and the governmental agencies in the area of physical planning as at when needed is important and obviously a constitutional role of any responsive and sensitive government. Digital infrastructure unquestionably provides the foundational framework upon which physical development can be effectively promoted and sustained (Geertman & Stillwell, 2020). Through the National Geospatial Data Infrastructure (NGDI), digital infrastructure plays a vital role in development planning by improving the performance and integration of key sectors such as education, healthcare, commerce, and governance (Deren, 2016). The critical goals of NGDI according to (ADB, 2020) are:

To improve quality, and reduce costs related to spatial information;

Reduced duplication of efforts among agencies;

Increase the benefit of using available data; and

Establish key partners with local governments, states, academia, and the private sector to increase data availability.

The Importance of NGDI

Despite the establishment of NGDI in Nigeria, the value of its existence is yet to be appreciated among the stakeholders both internally and externally. Though the NGDI Bill has been passed by the Senate, there are still problems with the policy implementation. The basic infrastructure to make NGDI effective and enduring with respect to land related activities are poorly maintained if at all they are in existence. Besides, the role of NGDI is not pronounced compared to the advanced world such as the United States of America and Europe generally. NGDI obviously provides a solid base of practices and foster symbiotic relationships among geodata producers and users that facilitate data sharing and use with regards to land related activities.

The land-related activities focus on networks, survey coordinates, waterways, and railway networks, electricity supply, communication facilities, farming, fishing, tourism, forestry, transport, just to mention a few. The roles of NGDI with respect to land related activities are (AFC 2024; Ali and Imran, 2021).: Provision of necessary framework for mapping and environment monitoring;

Reduction in the risk of loss of life, cargo and other properties and environmental damages in the ocean, sea and rivers;

- Provision of the necessary framework for improved response to marine spills of oil and hazardous wastes;
- Provision of the necessary support for the use of space-based techniques;
- Provision the necessary solid foundation upon which more detailed and/or sophisticated datasets and related applications are used;
- Functions as the basic building blocks upon which all other applications are dependent;
- They are of critical importance in the design and delivery of essential public services and benefits;
- They are of critical importance in facilitating national innovation and economic opportunities;
- Their availability and accessibility assist in avoiding duplication of efforts by different organizations / Agencies and end users in providing the same datasets;
- Provision of the necessary standards for integration of another similar network

3.0 Stakeholders Engagement in developing data management Infrastructure

As noted by Shahat and Elragal (2021), urban problems are highly interconnected and collectively form what is described as a “mess.” Once such a complex set of interrelated challenges emerges, it necessitates the engagement of multiple stakeholders to develop sustainable and long-term solutions. This collaborative approach is commonly referred to as inclusiveness in contemporary planning practice. Figure 1 illustrates an example of such a complex of urban problems. Data management for physical planning needs the involvement of all stakeholders to minimize this mess. Planning without data – that is, quality data, leads to practical failure in managing data infrastructure for physical development planning. Planning without facts and figures have been the major problems facing physical planning in Nigeria. The emergence of this problem can be attributed to degraded, inadequate, or poorly implemented data management infrastructure. However, advancements in technology are gradually transforming the data management ecosystem, enabling more robust systems that can integrate diverse inputs from multiple stakeholders, improve accessibility, and support collaborative decision-making (Geertman and Stillwell, 2020). There is improvement in the telecommunication sectors, internet access is gradually improving while trained manpower is disproportionate to the required standard based on the United Nations standard.

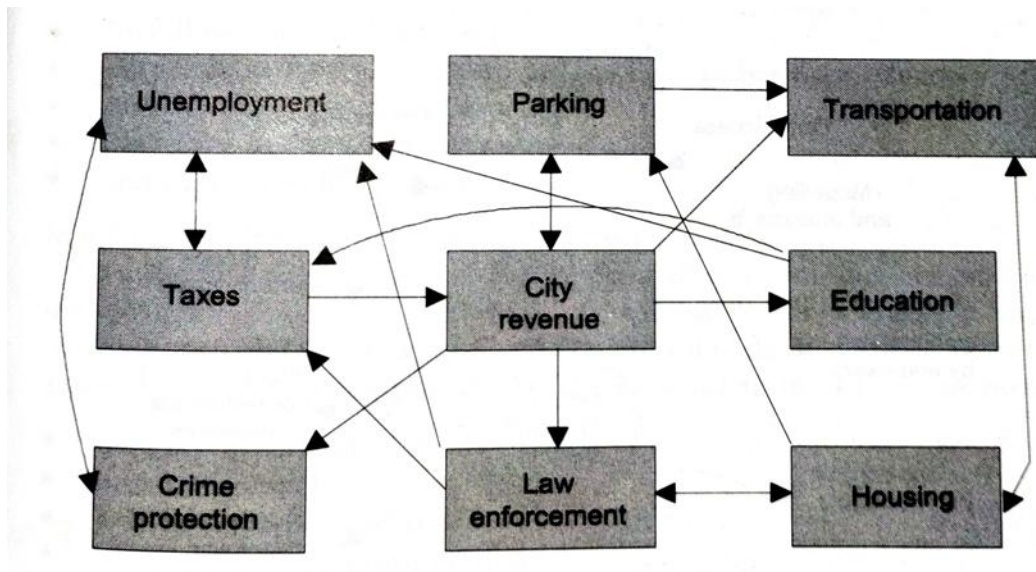


Figure 1: A mess of urban problems

In this regard, the issue of stakeholder's involvement is still an issue in data management infrastructure for physical planning. The stakeholders that are germane to the success of data management infrastructure for physical planning are: Government agencies, local governments, Private sector, Academia and research institutions, civil society and non-governmental organizations, community members, and international organizations such as UN-Habitat, World Bank, European Union, and African Union and Economic Community of West African States (ECOWAS) that generate, operate and utilize planning related data. All these various stakeholders are very important in the actualization of data management infrastructure for physical development with respect to this digital era. Their involvement will no doubt range in the areas of technical and financial involvement, training of manpower to handle and manipulate data that lead to better-informed decision – making that will have positive effect on physical planning outcomes for Nigeria.

4.0 Data Storage and Management in Nigeria

In this era of advanced and sophisticated technology, data proliferation has become the order of the day both in the government institutions and private sector. Hence data “obesity” can be a serious problem if not properly managed. The existing infrastructure in Nigeria cannot cope with the data obesity situation; hence, centralized data repositories in the form of National Databases, and Cloud – based solutions are needed. Besides, data warehousing enables aggregate data from various sources that will enhance comprehensive analysis and on the spot reporting (Ogunleye, 2021). Promoting open data initiatives will encourage transparency and public access to planning data. There is undoubtedly a great value in opening up urban data as a means to increase transparency and enable new uses and applications for the data (Oracle, 2024)

Awareness of Common Data Environments

At present, many urban planners lack familiarity with the concept and practical use of a Common Data Environment (CDE), largely due to limited training and awareness of digital

collaborative platforms that support shared data workflows in planning and related disciplines. (Abma, Nastiti, & Ramadhani, 2025). For example, linking project data and task data may be a difficult task for planners in the Built Environment if they fail to acquire knowledge of data terminologies and training (Credence Research, 2024). Project data encompasses all information related to the planning, execution, monitoring to the planning, or execution, monitoring and completion of an entire project; while task data is the information about the individual tasks or activities that need to be completed as part of a project. Modern planners with advanced digital knowledge, must be aware of fair knowledge of CDE which encompasses document data, operational data, communication data, compliance and regulatory data, photographic data, monitoring and sensor data, historical data, metadata, security and access control data, analysis and reporting data. All these different datasets might be structured or unstructured, hence modern planners must acquire skills in this area so that data management infrastructure could be successfully implemented. This notwithstanding, in the geomatic environment, different types of data are used to capture, store, analyze, and manage spatial and geographic information which directly relates to modern urban planning or urban analytics. The various types of data that will facilitate data management infrastructure are spatial data, which encompasses raster and vector data; attribute data, topological data, temporal data, remote sensing data, surveying data, geostatistical data, and metadata. All these different datasets have relationship with physical planning which enhances the sustainability of data management and infrastructure development (Scholten *et al.*, 2011)

Data sharing is making data accessible by other stakeholders without difficulties. While interoperability means that any computer could use data located on any other computer site using software located on another computer through the power of internet. With the advancement in computer architecture for physical planning, effective data sharing enables various stakeholders, such as government agencies, private sector, community-based organizations (CBO), academic institutions just to mention a few to access and use data from other dependable sources for informed decision – making. However, there are some technical problems data sharing and interoperability is currently facing in Nigeria. The practical problems are that the computer operating systems have different functionalities and structures within the various organizations holding different types of data. For example, the database management systems (DBMS), the Object-Oriented Database Systems (ODBMS) and the Geodata systems usually or can have different structures within each organization dealing with data related to physical planning. These peculiarities will no doubt make interoperability difficult within the various systems because of standard and quality. It is based on this premise that President Bill Clinton of the United States of America, signed the ‘Executive Order 12906, for the coordination of Geographic Data Acquisition and Access (Olowookere & Olayinka, 2023). This executive order instructs Federal agencies to document new geospatial data using the metadata under development by the Federal Geographic Data Committee (FGDC), and to make these metadata available to the public through the National Geospatial Clearing House (World Bank, 2021). A lot of different metadata formats and information systems are emerging all over Africa and particularly in Nigeria. Hence there is the need for a universally accepted standard that will make data sharing and interoperability effective. With the advancement in scientific knowledge, the International Standard Organization (ISO) proposed a standard for quality and metadata including the following elements (Source??):

Identification information: Language of dataset code, dataset character code set, abstract, purpose, Supplemental information, Dataset environment, dataset credit, Identification citation, Initiative identification information, Image identification, status, dataset extent, resolution level code, category, primary point of contact, Browse graphic, Dataset association, Dataset constraints

Data quality information: Data quality

Lineage Information: Usage, Lineage

Spatial data representation information: Spatial representation type code, vector spatial representation information, Raster spatial representation information, Image spatial representation

Reference system information: Temporal reference system information, spatial reference information

Feature catalogue information: External feature catalogue, Internal feature catalogue,

Distribution information: Distributor information, distribution format information

Metadata reference information: Metadata file identifier, Metadata parent identifier, Dataset application scheme name, Metadata date information, Metadata contact, Metadata standard information, metadata extension information, Metadata ancillary information, Metadata constraints, and Metadata security constraints.

Groupware in data management infrastructure for physical planning

Physical planning is a task that involves various actors to collaborate in order to design a plan including maps and documented or written statements. Al-Yadumi, Xion, Wei, & Boursier (2021) and Laurini (2018), asserted that with the advancement in technology coupled with the availability of Internet, computer-supported co-operative works (CSCW) can allow several actors or persons, located in different places, to work together seamlessly. This technique is called groupware. Groupware is a technology that supports person-to-person collaboration. This mutual collaboration could be achieved through email, webinar, video conferencing to electronic meeting systems to workflow. As defined by Olowookere & Olayinka (2023), groupware is a technology that makes group to collaborate and further make them efficient and productive. In addition, groupware radically changes the dynamics of group interactions by supporting access to information, improving communications, and by structuring and focusing on problem – solving efforts. From the above definition, appropriate data management for physical planning cannot be devoid of groupware which ultimately improves productivity, enhances co-operative information systems and improves geoprocessing.

5.0 Conclusion

An enduring and effective data management infrastructure is crucial for enhancing physical development planning in Nigeria. Proper management of this infrastructure revolves around a robust centralized and interoperable data system that facilitates the collection, storage, real time analysis, and dissemination of spatial and socio-economic data. It should involve the use of geographic information systems (GIS), remote sensing technology, data mining, knowledge discovery and other technologies that enable real-time data access, analysis and decision making. A well-structured data management system is essential for addressing the humongous data challenges facing physical planning in Nigeria. Capacity building for planners and other related professionals in the Built environment in the area of ICT and CDE coupled with modern computing as applied to data and database technologies is important for the sustainability of data management infrastructure. Furthermore, mutual collaboration between government agencies, the private sector, community base organizations and international organizations is undoubtedly important for developing a unified framework for data management. With the establishment of NGDI and backed up with political will, priority investment in digital infrastructure is long overdue for data management infrastructure with regards to physical

planning in the country. By strengthening data management infrastructure, the country can enhance its physical planning processes, leading to more organized urban growth, improved service delivery, and better quality of life for the citizens.

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