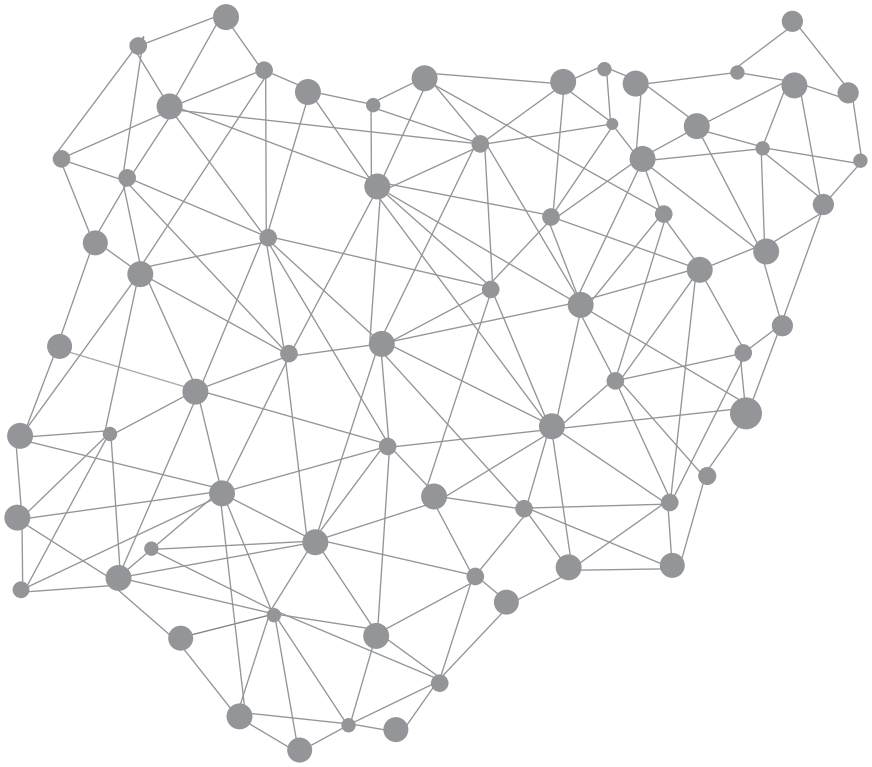
NIGERIA'S GEOSPATIAL VALUE PIPELINE LANDSCAPE REPORT



BILL & MELINDA GATES foundation

Dev-Afrique

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2. Acronyms

Below are the acronyms used in this document and their accompanying meanings

AFRIGIST	Africa Regional Institute for Geospatial Information Science and Technology
ARCSSTE-E	African Regional Centre for Space, Science and Technology Education-English
AfrIPI	Africa Intellectual Property Rights and Innovation Project
BMGF	The Bill & Melinda Gates Foundation
CHAI	Clinton Health Access Initiative
CODI-GEO	Committee on Development Information, Geo-information Sub-committee
CRS	Coordinate Reference System
DSN	Data Scientists Network
EOC	Emergency Operation Centre
FCDO	Foreign, Commonwealth, and Development Office
GEOSON	Geoinformation Society of Nigeria
GIS	Geographic Information System
GRID3	Geo-Referenced Infrastructure and Demographic Data for Development
IGIF	Integrated geospatial information framework
INEC	Independent National Electoral Commission
KDBS	Kaduna Bureau of Statistics
LAMATA	Lagos Metropolitan Area Transport Authority
LBS	Lagos Bureau of Statistics
NASRDA	National Space Research and Development Agency
NBC	National Boundary Commission
NBS	National Bureau of Statistics
NGDI	National Geospatial Data Infrastructure
NGF	Nigeria Governor's Forum
NIMC	National Identity Management Commission
NOEC	Nigerian Oncho Elimination Committee
NPHCDA	National Primary Health Care Development Agency
NPoPC	National Population Commission
NSC	National Steering Committee
NTC	National Technical Committee
OAU	Obafemi Awolowo University
OSGOF	Office of the Surveyor-General of the Federation
POI	Points of Interests
UBEC	Universal Basic Education Commission
UNECA	United Nations Economic Commission for Africa
UNFPA	United Nations Population Fund
UNICEF	United Nations International Children's Emergency Fund
USAID	United States Agency for International Development
WHO	World Health Organization

A digital geospatial map of a local government in the Federal Capital Territory (FCT) *(Source: GRID3)*

3. Executive Summary

The geospatial ecosystem in Nigeria is relatively one of the more matured ecosystems in Africa. Despite this relative maturity, the ecosystem of Nigeria remains far behind countries with advanced geospatial technology. With the support of the Bill and Melinda Gates Foundation, Dev-Afrique Development Advisors conducted an end-to-end assessment of the geospatial data ecosystem to understand the gap within the ecosystem, identify opportunity areas within the ecosystem, and plan a stakeholder validation forum to forge the next steps in the geospatial development path in Nigeria.

Dev-Afrique analyzed Nigeria's geospatial ecosystem using the value pipeline framework, which helped assessing the ecosystem using three comprehensive pillars – generation of the data; analysis of the data; and operationalization of the data. The value pipeline framework also embedded key sub-pillars including capacity building, governance, and stakeholder coordination. In a bid to comprehensively understand the entire ecosystem, Dev-Afrique evaluated the geospatial ecosystem using nine evaluation metrics: the current landscape, the prominent stakeholders within the ecosystem, the ecosystem at various levels of government, sectors, funding structure, sustainability, successes, the existing challenges, and the opportunities within the ecosystem.

Geospatial data generation

Dev-Afrique's assessment showed that the generation pillar of the geospatial ecosystem in Nigeria is dominated by relatively diverse forms of geospatial data - the population characteristics form

of data, settlements, boundaries, and infrastructure and building footprints - collected across sectors and government levels in the country. In addition, the generation of the geospatial ecosystem in Nigeria is dominated by relatively small circles of actors operating across various levels and in various sectors.

The major actors are the government, non-profit, or private sector. Non-profits exert a major influence on the generation of geospatial data in Nigeria. Within the government, the generation of geospatial data is domiciled with several institutions. The National Space Research and Development Agency (NASRDA), Office of the Surveyor-General of the Federation (OSGOF), National Bureau of Statistics, National Population Commission, and the National Boundary Commissions generate their own geospatial datasets, and all laid claims to the overall responsibility for geospatial data in Nigeria.

Across various levels of geospatial data generation, the relationship between national actors and state actors on geospatial data is not fully linear. In certain cases, there are well-structured geospatial generation and coordination efforts between the federal, state, and even the local actors while in others, state and federal have worked independently.

The generation pillar of the geospatial ecosystem has been fairly funded by three main actors: government, donor partners, and private sector. The Nigerian government has a budgetary provision for geospatial activities domiciled under the recognized institutions (NASRDA, National Boundary Commission, National Population Commission, and OSGOF), however, the value pipeline assessment showed that funding remains insufficient to drive geospatial data generation.

Geospatial Data Analysis

Within the analysis pillar of Nigeria's geospatial ecosystem, several data processing tools have emerged, and in this their applications have become prominent with increasing stakeholders now offering GIS software training for data processing and analysis.

The focus area of an organization, the skills level of the workforce, and the technical capability of the geospatial data users influence the choice of the analytic tool(s) and process. Many national government agencies lack the technical expertise and infrastructure to undertake advanced data analysis, hence they rely on the support and services provided by their partners, the technical capability at Nigeria's national level on geospatial data analysis exceeds the capacities in states and local governments.

This remains true at the state level especially in low-income states. However, Kaduna and Lagos states stand out as frontier states in the development of geospatial data analysis.

No special funding is dedicated to geospatial analysis within the ecosystem despite expensive cost associated with software procurement and subscription. As a result, more actors within the ecosystem are now turning to open-source software despite the ecosystem's perceived risks of security or reliability. The sustainability of geospatial analysis within the value chain ties to data generation, capacity building, and capacity retention.

Geospatial Data Operationalization

Geospatial data use cases in Nigeria cut across different sectors including health, environment, education, utility, financial services, telecommunication, and government planning spanning the federal, state, and local levels. The health sector has the most use cases in the country. This can be traced to the long history of applying geospatial data to polio eradication efforts. These government-led multi-stakeholder efforts happened over eight years (2012-2020) and involved actors such as NPHCDA, BMGF, eHealth Africa, and GRID3. Currently, geospatial data supports the health sector's microplanning, immunization campaigns (polio, measles, and NTDs (neglected tropical

diseases)), and vaccine delivery. In the environmental sector, use cases include flood prediction and vulnerability mapping, deforestation studies, pollution mapping, risk, and vulnerability assessment of lakes, amongst others.

The use-case demand generation process differs from sector to sector. Our interviews revealed that use-case generation is mostly demand-driven in the public sector, however, there are instances of supply-driven use cases within the public sector.

Communication in the geospatial ecosystem in Nigeria focuses on two main themes – use cases and available datasets. Information about geospatial datasets is often disseminated through in-person channels, especially workshops. These workshops are organized by data-generating organizations such as GRID3 and non-profit organizations like Data Scientist Network (DSN).

Across government levels, use cases that originate at the federal level may involve actors at the state and local levels. However, the use-cases generated at the state level are only applied within the state and local governments. In addition, funding for geospatial data operationalization focuses on use cases and where it is provided, funding is embedded within projects as opposed to a standalone investment. However, sources of project funding differ from sector to sector. Projects and organizations in the health sector have significantly benefited from donor funding compared to other sectors like agriculture, forestry, etc. On the contrary, other sectors have predominantly depended on meagre government and donor funding, and the proportion varies across projects.

Overall, the geospatial ecosystem in Nigeria has seen organic growth, including the development of governance and policy structures. One of the core policy structures for the geospatial ecosystem was development of the National Geospatial Data Infrastructure (NGDI) bill – pending legislative approval –, which aims to establish frameworks for geospatial data and usage.

A local government health worker describing a digital geospatial map used for COVID-19 vaccine distribution in Niger state.
(Source: GRID3)

Challenges within the ecosystem

Despite the development within the geospatial ecosystem in Nigeria, Dev-Afrique's assessment showed significant challenges within the geospatial ecosystem in Nigeria as summarized in Table 1

Table 1. Generation pillar: Challenges and context

Generation Pillar	
Challenges from Assessment	**Context**
Geospatial data collection efforts are not harmonized and standardized among stakeholders	Nigeria's geospatial data ecosystem has no universally accepted data generation standards to guide stakeholders on how to generate different forms of data – leading to the generation of data forms with different standards and metrics and non-interoperable data.
Limited geospatial data sharing and access among stakeholders at all levels of the value chain	While there are open geospatial data portals like GRID3, many geospatial data generation efforts are linked to projects and treated as proprietary to other actors. Government-generated geospatial data can be difficult to access due to complex bureaucracies. As a result, data generation efforts are repetitive with incomplete highly disaggregated data. Accessing geospatial data is a challenge due to the lack of data repository and proprietary rights.
Inaccurate, incomplete, and out of date geodata	Secondary geospatial data sources have incomplete and missing data due to inconsistencies in data generation and aggregation of data. Data sources are not comprehensive enough to cover all sectors and project needs.
High data generation costs; low funding	Most data-generating actors highlighted funding as the bedrock for exploring new data forms. However, owing to inadequate funding different actors are unable to build data generation capacity and validate data, hence do not have consistent data available for decision-making.
Limited human capital and skills for data generation among stakeholders within the Ecosystem	Insights from the landscape assessment showed that there are few staff with geospatial data generation skills. Some stakeholders noted that even a basic skill such as the interpretation of maps is still a challenge, which is further exacerbated due to lack of sustained capacity-building interventions. This challenge hinders the exploration of new geospatial data forms within the ecosystem.
Need for more disaggregated and higher spatial resolution data	Stakeholders highlighted the need for the collection of geospatial data that is disaggregated to the lowest level for more insightful analyses.
Lack of a centralized geospatial data repository for all stakeholders within the ecosystem	Nigeria currently has no centralized geospatial data repository that all stakeholders can utilize causing duplication of efforts, increased costs of generating already existing data, and difficulties with data access.
No incentives for private sector to share their data	With no incentives to share privately funded generated data, private sector stakeholders are hesitant to share data within their repositories. Beyond this, there is no established process for sharing independently generated data with government actors.
Analysis Pillar	
Limited funding for geospatial data analysis: Cost of geospatial analysis software are exorbitant; increasing need to move from physical to cloud servers.	Funding is opportunistic and mostly driven by the project needs. The limited option for funding negatively impacts the sustainability of geospatial analysis outputs. High cost of proprietary geospatial tools limits the scope and sustainability of geospatial analysis conducted by several actors within a value chain. Excessive cost of software has triggered increased move to open-source tools which have limitations around security and technical features. The assessment also showed funding as a limitation for the transition from physical to cloud servers.
Multiple analyses, no insight	Despite the prevalence of various geospatial analysis outputs, including dashboards and maps, stakeholders noted that these do not necessarily translate to insights. There is a need to establish a connection between analysis and development objectives.
Limited infrastructure	Infrastructural challenges – such as internet, electricity/power, high processing computers, and proprietary software licenses - limit the analysis and utilization of analysis outputs by end users.
Limited use of advanced geospatial data analysis e.g., Artificial intelligence (AI) and Machine learning (ML)	There is a dearth of more advanced geospatial analysis within the Nigerian geospatial ecosystem such as web-based computing and deep learning tools. Geospatial analyses have been limited to basic GIS analysis with limited utilization of advanced geospatial techniques or tools like machine learning or artificial intelligence.
Poor data quality for analysis	A lot of substandard data exists, caused by limited expertise in how to collect and process data or simply human error under the data generation pillar. Lack of standardization plays a large part in this as stakeholders reported that it caused analysts to miss critical details in geospatial analysis. Other inaccuracies in geocoding and digitizing physical places and features can cause a cascade of inconsistencies in their geographic representation
Unavailability and inaccessibility of geospatial data for analysis	Data sharing and data improvement are major challenges within Nigeria's geospatial ecosystem. Many agencies have geospatial data within their repositories but refuse to share – with significant number of actors not even aware that such datasets exist within their organizations. In addition, there is no open-source algorithm to localize and exchange analytics code.

Operationalization Pillar	
Duplication of use cases amidst lack of coordination.	The lack of donor coordination often encourages competition and duplication of use cases among end users. Donor activity unintentionally leads to the fragmentation of geospatial data operationalization.
Limited capacity at the state and local levels limits localization of use cases	Despite the extensive geospatial use cases that abound in the country, the localization of the use cases (such as microplanning maps) at the last mile is limited due to low level of capacity at the local government and ward levels. Limited capacity at the last mile also limits the input of local actors in use cases design.
Lack of a central repository for use cases	The Nigeria ecosystem lacks a centralized use case repository. Non-government organizations and some government agencies share their use cases on their individual websites. Aside from these, others hardly share their use cases. There is no community of practice for shared learning around geospatial applications.
Low levels of awareness of the benefits of geo-data	Despite the wide array of use cases that exist, the country still has low levels of awareness of geospatial data and its benefits. This is primarily because information about geospatial data is not widely communicated.
Hesitancy to adopt geospatial data	Low levels of advocacy and lack of stakeholder coordination limits political buy-in, government funding and wider adoption of geospatial data in Nigeria.
No dedicated platform for cross-learning of use cases	Post evaluation learnings from projects and use cases across sectors are not shared due to the ad-hoc approach to use case development. For instance, learnings from use cases in the government sector are not shared with the private sector and vice versa. Also, there is a little communication of use cases, data, best practices, and insights between experts in the private and public sectors, and academia to drive research products for public use.
Cross-cutting Challenges- Governance, Stakeholder Coordination and Capacity	
Governance	
Lack of national geospatial policy	The lack of a national policy to delineate responsibilities and provide guidelines for data democratization, ownership, and integration. Although there is a bill developed to address this, yet it has experienced a delay in implementation.
Lack of delineated mandates among agencies within the ecosystem	Currently, there are several government agencies with overlapping mandates on geospatial data generation (OSGOF, NASRDA, NBS, and NPC), leading to mandate conflict and institutional rivalry.
Lack of standards for data harmonization and interoperability	The generation of geospatial data in the country is being conducted by different organizations, each using its internal standards.
Duplication of Efforts by Stakeholders	The lack of a policy to delineate the roles of stakeholders in the ecosystem has led to multiple stakeholders performing the same tasks such as collecting the same set of data or the same type of analysis.
Stakeholder Coordination	
No designated lead agency	Lack of a clearly designated lead agency in the ecosystem has made stakeholder coordination difficult for stakeholders within the ecosystem to lean to a particular government agency for coordination.
Limited collaboration among geospatial stakeholders	Limited collaboration among stakeholders in the ecosystem cuts across different sectors. In the government sector, for instance, mandate conflict has limited collaboration among relevant agencies. However, non-profit organizations have multiple coordination mechanisms that are either based on projects or thematic areas.
Lack of Incentives for Continued Participation	Assessment revealed that another challenge came from lack of incentives to drive continued participation. In Kaduna, the GIS Development Committee has not been convened from a long time because of the busy schedules of its representatives.
Capacity Building	
Limited funding for capacity development	Lack of funding affects the ability of actors to generate data for student practice, get licensing for data analysis software, and support student internships.
Inadequate enabling technology for capacity building	Absence of the required technology for capacity building including power, software, hardware, and instruments, is a major limitation to capacity building.
Limited capacity of advanced geospatial analytics	Existing geospatial institutions do not have capacity for advanced geospatial analytics and training.
Capacity building programs are not aligned to needs of stakeholders	Most capacity building programs in the ecosystem are foundational and very generic and do not meet the specific needs of the organizations they target.

Capacity Building	
Obsolete/rigid curriculum	Curricula used in many of the training are obsolete and do not reflect the advancement in technology. More so, they are structured with little flexibility, which makes it difficult for working professionals to enroll.
No coordination around capacity-building systems	Conflict exists among government agencies regarding what agency leads geospatial interventions in the country and the roles of relevant agencies. Lack of coordination on capacity building within the geospatial ecosystem leads to the replication of training and disparity in the depth and scale of training conducted by actors within and outside the government.
Capacity-building initiatives neither have sustainability plan nor monitored	Most capacity-building activities are tied to projects and are mostly driven by non-government actors. This makes capacity-building initiatives limited to a project time-lines with minimal institutionalization. Further, there is no adequate monitoring of the several capacity-building activities, except those offered by universities and specialized institutions.
Low capacity building and resource pooling	The capacity for geospatial data analysis is limited, especially in government organizations. The available training institutions (both academic and non-academic) are not sufficient to meet the skills gap and do not have state-of-the-art technology. There is especially limited capacity around advanced analytics like Artificial Intelligence/Machine Learning (AI/ML) methods and tools.
High turnover of GIS-trained government workers	The landscape assessment also found that there is a high staff turnover of trained geospatial data experts from government agencies to the private sector or NGOs. This is mainly due to better conditions of service offered by the NGOs and private sector.

4. Background

Local government health workers in Niger state reading a digital geospatial map. *(Source: GRID3)*

This report summarizes findings from the assessment of Nigeria's geospatial landscape conducted between April and October 2022 by Dev-Afrique Development Advisors, with support from the Bill & Melinda Gates Foundation (BMGF).

For context, BMGF partnered with Dev-Afrique Development Advisors and its partner organization, DevIndia, to conduct an end-to-end assessment of the geospatial landscape to determine the gaps and the needs of governments and geospatial organizations working within the health sector in Africa and Southeast Asia.

Nigeria is the first country in the series of focus countries including Burkina Faso, Democratic Republic of Congo, and India. This assessment explored the current geospatial landscape in Nigeria, identified gaps within the value pipeline, and showcased potential geospatial investment opportunities to enable the BMGF's investment strategy in Africa.

Through the adoption of a human-centered design approach, the geospatial value pipeline assessment scoped key stakeholders - government actors (national and selected state and local end-users), private and non-profit organizations, academic institutions, multilateral organizations, and donor agencies – to provide visibility into the needs of local stakeholders across the geospatial value chain in Nigeria.

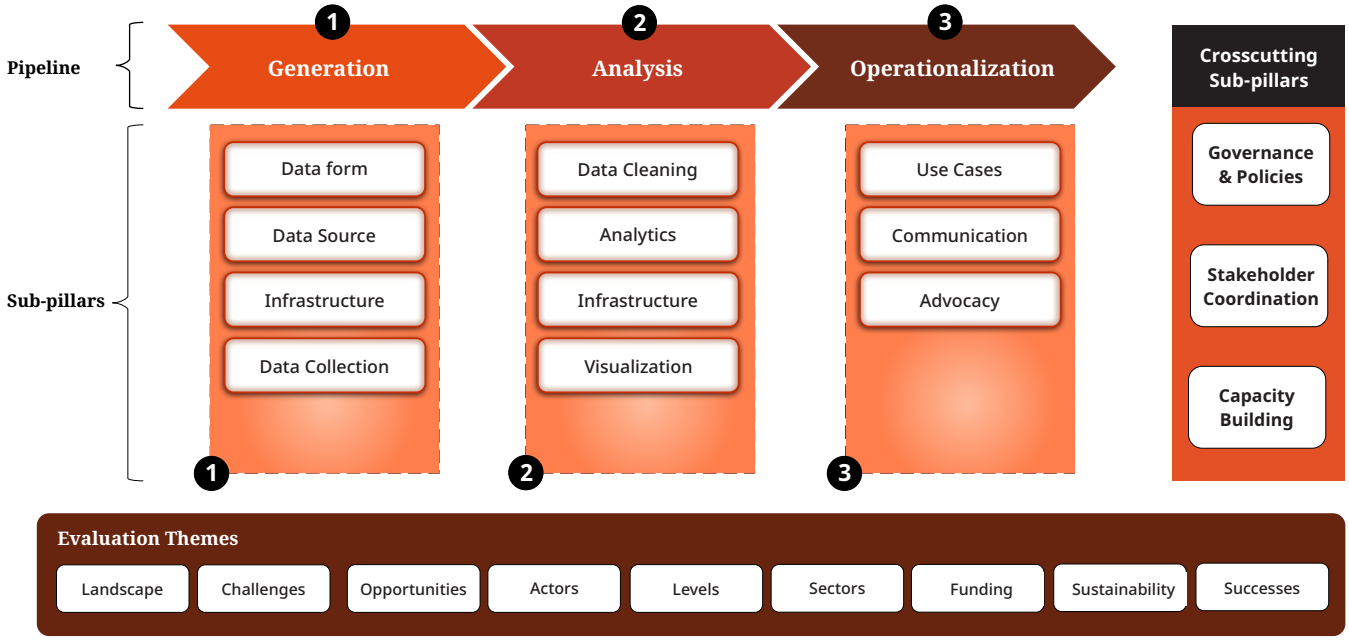
This report outlines the current capacity of organizations, the available geospatial interventions, and current funders, the successful geospatial use cases in the targeted geographies, the gaps between their current level and advanced use of geospatial technology, and their readiness and interest to expand their geospatial capabilities in Nigeria.

Methodology

In a bid to comprehensively assess Nigeria's geospatial ecosystem, we conducted a qualitative case study that included three main phases: development and validation of the evaluation framework; desk-based review, and interviews with stakeholders within Nigeria's geospatial ecosystem (see Annexure 6 for the list of sampled stakeholders).

Development and validation of the research framework

In the first phase of the assessment, a research framework was developed to model the critical elements of a geospatial ecosystem. Development of the framework included brainstorming sessions with Gates Foundation, DevGlobal, WHO Afro GIS Center, World Bank, GRID3, and NASRDA to identify key elements that summarize a geospatial ecosystem. This assessment reviewed several globally acceptable geospatial value chain frameworks – including the integrated geospatial information framework (IGIF) – to design a comprehensive and acceptable landscape assessment framework (Figure 1).



Evaluation themes were used to analyse each pillar of the value pipeline.

Figure 1: Geospatial landscape assessment research framework

The final framework – termed the value pipeline framework – summarized the ecosystem end-to-end using three comprehensive pillars –generation, analysis, and operationalization. In a bid to showcase the granularity and interactions of the various pillars, the three overarching pillars were further disaggregated into sub-pillars – which are a critical bedrock of the geospatial pillars. The value pipeline framework also acknowledged that some pillars –capacity building, governance, and stakeholder coordination – may feature across the three pillars. As a result, Dev-Afrique categorized these recurring sub-pillars as cross-cutting sub-pillars. A visual representation of the value pipeline framework is given in Figure 2.

[1] Nigeria's geospatial ecosystem refers to the set of activities, interactions, and interconnectedness of stakeholders working with geographic information systems in Nigeria.

Narrative of the Geospatial Landscape Assessment Framework (Figure 1)

The Geospatial Landscape Assessment Research Framework summarizes Nigeria's geospatial ecosystem end-to-end – i.e., from generation to operationalization of data. The framework is split into three main components namely – pipeline, sub-pillars, and crosscutting sub-pillars.

Pipeline

The pipeline describes the main pathway of geospatial data from generation to operationalization. It has three main pillars which anchor the whole ecosystem – Generation, Analysis, and Operationalization.

Sub-pillars

The sub-pillars summarize the critical elements that must be covered for geospatial data to go through each of the pillars defined in the pathway.

Crosscutting Sub-pillars

The crosscutting sub-pillars include all enabling factors that exist across the three pillars of the framework. These include governance and policies, stakeholder coordination, and workforce (capacity building).

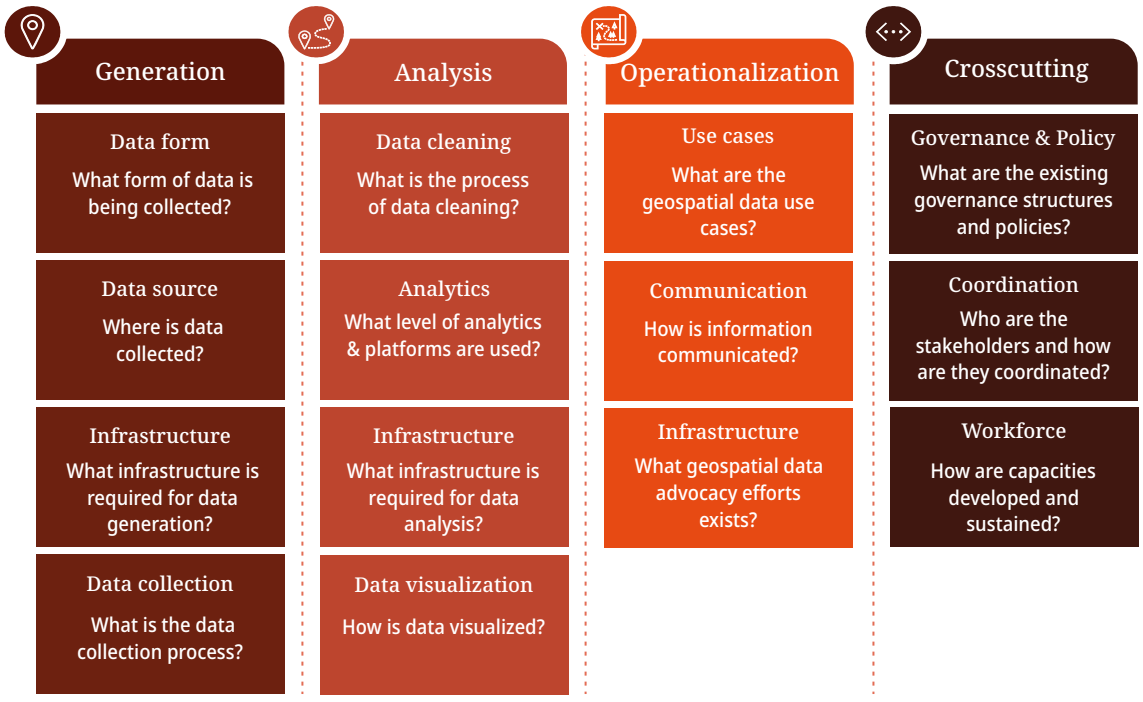


Figure 2: Geospatial research framework sub-pillars and their overarching research questions

As a guide to comprehensively assess the geospatial value pipeline, the assessment adopted nine evaluation themes. Each evaluation theme contained several probing questions which were applied to the sub-pillars of the research framework. Visit this link for a summary of the probing questions generated for each sub-pillar using the evaluation themes.

Table 1: Evaluation themes and definitions

Evaluation Theme	Definition
Landscape	Overview of what is currently happening within the ecosystem – i.e., what are the activities?
Challenges	Key challenges encountered within the ecosystem
Opportunities	Overview of initiatives and collaborations that could lead to more effective and efficient work within the ecosystem
Actors	Main stakeholders working within the geospatial ecosystem
Levels	Description of the geospatial ecosystem at the federal, state, and local levels
Sectors	Description of geospatial ecosystem based on different sectors e.g., health, agriculture, education
Funding	Overview of the funding structure within the geospatial ecosystem
Sustainability	Description of geospatial initiatives that are mainstreamed into government systems post donor support. This theme also captures all initiatives private or government that have shown resilience and are continuously supported by local actors.
Successes	Geospatial initiatives implemented within the ecosystem that have shown some impact. There are currently no rigorous impact evaluations within Nigeria's geospatial ecosystem.

Desk Based Review

A preliminary desk-based review of online articles, conference proceedings, reports, and organizational websites related to GIS in Nigeria, was conducted. The relevance of the reviewed literature was based on their country of focus (Nigeria), focus on GIS, year of publication, and reliability of information source.

The desk-based review provided initial responses to the questions in a research framework, while the stakeholder interview phase for validation provided further context towards the research.

Stakeholder Interviews

The organizations (35) within the geospatial value pipeline comprising government agencies, development partners, local NGOs, local private organizations, civil society organizations, academia, and international humanitarian and donor organizations, were identified from the desk-based review and prior engagements in Nigeria. Stakeholders were grouped by the research framework pillar that best defined their work – i.e., generation, analysis, or usage of geospatial data. The assessment also used expert sampling to select relevant stakeholders and respondents from those institutions. Donor organizations such as Global Fund that do not operate in any of the pillars, were interviewed for insights on funding and donor perspectives.

After the sampling process, Dev-Afrique interviewed 35 stakeholders by conducting either in-person or online interviews. Annexure 6 summarizes the areas of focus of the stakeholders.

Field Interviews and Thematic Analysis

Geospatial focal points within each sampled organization were interviewed to generate insights. Most of the sampled organizations had their offices in Abuja, Lagos, and Ife. There were eighteen organizations in Abuja, five in Lagos, and six in Ife. Virtual interviews were conducted with organizations outside these locations including Kaduna, Yola, the United Kingdom, and the United States of America.

Insights from interview transcripts were extracted in the form of codes to generate contexts for the different sections of the report. The context was developed against each of the questions in the research framework and condensed for reporting. The codes extracted from the transcripts were used to generate major themes that summarized each section of the report.

5. Findings: Landscape of Nigeria's Geospatial Ecosystem

5.1. Landscape

5.1.1. Geospatial Data Generation

Understanding the Generation Landscape

The generation of geospatial data remains the bedrock of the geospatial value chain in Nigeria. In the last ten years, development partners and the government have scaled up interventions to deepen the generation potential in Nigeria. This pillar transcends the form of data to be generated, the source of these data if available, and the infrastructure required to drive the collection and storage of such data forms.

Forms of data collected remain effectively diversified

Currently, the geospatial ecosystem in Nigeria is dominated by diverse geospatial data collected across sectors and government levels in the country. Today, the most popular forms of geospatial data collected include the population characteristics form of data, settlements, boundaries, and infrastructure and building footprints which may range from health facilities to farmlands and schools (Annexure 1: List of data generating organizations and the data forms they generate). These popular forms of data are collected by leading geospatial generation actors across sectors and levels like the National Agency for Space Research and Development Agency (NASRDA), GRID3, eHealth Africa, National Population Commission, and the National Boundary Commission.

Beyond the popular data forms, geospatial data generation actors in Nigeria continue to explore other forms of geospatial data such as location data, mobility data, meteorological and environmental data (such as water bodies, soil characteristics, deserts and forests), and communication data.

Despite diverse forms of geospatial data available within the country, the landscape assessment of the geospatial ecosystem showed that forms of geospatial data within institutions are mostly demand-driven in many ways:

a. For government agencies such as NASRDA, National Population Commission, and National Boundary Commission, the forms of geospatial data available within institutions primarily depend on the legislative mandate of the government, followed by the objectives of the specific development projects funded by development partners. For example, the recent COVID-19 pandemic influenced the inauguration of the National Soil Analysis and Geographic Information System (GIS) laboratories in Abuja by the Federal Ministry of Agriculture and Rural Development (FMARD) to aid the collection of and analysis of soil samples.

b. For non-profits like GRID3, e-Health Africa, and Data Scientist Network, the forms of data collected are mostly influenced by available project funding and the objectives of the implementing donor or government partner. For instance, National Primary Healthcare Development Agency (NPHCDA) liaises with geospatial actors such as eHealth and GRID3 through the Emergency Operations Center (EOC) to drive the collection and update of geospatial data for the Polio program.

c. For private sector actors, geospatial data priorities are driven by demand for commercial applications. In Nigeria, the commercial market is largely dominated by government purchasers and foreign donors rather than other business sectors.

Diverse forms; Limited sources

Despite the diverse forms of data available within the geospatial ecosystem, sources of these data forms are limited and decentralized. For most users of geospatial data, the first step is to source from existing publicly accessible sources within government and non-profits such as NASRDA, GRID3 geodatabase, eHealth Africa data portal, OpenStreetMap (OSM), Accuweather, Humanitarian Data, WorldPop amongst others.

For background, the GRID3 geodatabase is an open centralized repository of population estimates and characteristics, administrative boundaries, settlements, and diverse infrastructure, which was developed by the GRID3 program and is now hosted by NASRDA through a multi-agency steering and technical committee. Part of the data in the GRID3 geodatabase includes data collected by eHealth during the polio eradication campaign. From field assessments, the GRID3 geodatabase is one of the centralized geospatial data sources in Nigeria.

Similarly, the eHealth Africa data portal – like the GRID3 portal – contains similar forms of public data such as population estimates, infrastructure, and settlements. While the eHealth Africa data portal and GRID3 portal host similar data types. Therefore, understanding the overlaps and differences across these will be important to avoid duplication of efforts.

> *".... There was a point we mapped about 11 states in Nigeria, and we have the information collected in our database. And we're able to leverage that support for whatever type of intervention we have".... eHealth Africa*[2]

Other sources of geospatial data may not be as publicly open and accessible as the GRID3 and eHealth portal and these may include independent government agencies who have collected geospatial datasets through their mandates or during the previous project exercises. For example, the Nigeria Hydrological Services Agency and Nigeria Meteorological Agency collected hydrological data while the administrative boundaries are also domiciled within the National Boundary Commission. Further, sources of data include georeferenced government surveys across national and state governments such as household surveys, demographic and health surveys, (DHS), malaria indicators survey (MIS), and Nigeria HIV/AIDS indicator and impact survey (NAIIS). For most of these government agencies, geospatial data are not publicly available, rather, geospatial data are housed on in-house servers or the personal drive of desk officers in these organizations.

Below are some other organizations across different sectors and their sources of secondary data:

Table 2: Summary of geospatial data generating actors and their sources of secondary data

Organization	Type of Secondary Data	Location of Data Source
Cizoti Nigeria Limited	Meteorological and hydrological data.	Relevant agencies that have accumulated the data over time.
Geoinfotech	Geographic and location data	Independent National Electoral Commission (INEC), open-source maps, and internet research.
Kaduna Bureau of Statistics	Household trends data, Health-facility data	GRID3 Nigeria and National Bureau of Statistics (NBS).
Natview Foundation	Administrative, statistical, and health-related data.	Private companies and state agencies.
Fraym	Household trends data, administrative data, health-related data, and geographic data.	National Statistics Office and GRID3 Nigeria.
Geoinformation Society of Nigeria (GEOSON)	Topographic and cartographic data.	Surveyor General of the Federation and National Space Research & Development Agency (NSRDA).
Sambus Geospatial Limited	Boundary data, husbandry data, and topographic data.	Private companies and relevant government agencies.

[2] Quote has been slightly modified for better understanding of our reader

Stakeholders noted that these geospatial data – if present on public platforms or with governments– are often not updated or not as comprehensive[3] in nature. As a result, several stakeholders at the national and local levels resort to the collection of new datasets for specific project cases rather than leveraging existing resources. For instance, the GRID3 geodatabase was described as foundational for non-health-related projects, such as flood vulnerability mapping, further necessitating the need for additional data collection, such as rainfall and weather data. Despite its robust data on health, the National Primary Health Care Development Agency (NPHCDA) also attributed the need for additional geospatial data collection during its field exercises. In other instances where the needed geospatial data are not available, local geospatial actors defer to international sources for geospatial data and imagery like the WorldPop data for population, and Maxar and Trimble which may be proprietary and often not available for public access.

Table 3: Summary of the common geospatial data types and their sources

Type of Data	Data Sources	Access Type	Link to Data Sources
Population data/estimates	National Population Commission, GRID3, NASRDA and eHealth Africa Data Portal	Open, Open, Proprietary, and Open.	www.grid3.gov.ng
Settlements	GRID3 Open Street Map	Open	www.grid3.gov.ng
Boundaries	GRID3	Open	https://grid3.gov.ng/

Infrastructure as the prerequisite for data generation efforts in Nigeria

NASRDA – through its government mandate - has been primarily at the forefront of satellite imagery data generation in Nigeria through its earth observation satellites and different specialized centers across the country located in Abuja, Ife, and Nsukka. NASRDA has launched five satellites so far. Although all the satellites have exceeded their lifespan, but Sat2 and SatX are still in use for earth observation.

- The NigeriaSat-1, Nigeria's first satellite launched in 2003, is a low earth orbit microsatellite that serves as an early environmental disaster warning satellite, and is a part of the global disaster monitoring constellation network.
- NigeriaSat-2 was launched in 2009 and provides high-resolution satellite imaging for applications in mapping, population estimation, water resources management etc.
- NigeriaSat-X is an Optical 22-meter multi-spectral imaging system that was launched in 2011. It was built to replace NigeriaSat-1.
- The NigComSat-1 was Nigeria's first communication satellite and was later replaced by NigComSat-1R after losing power and losing its solar arrays.

Public and private sector stakeholders use physical infrastructure – such as drones and satellites – for the generation and analysis of these geospatial data while others generate these data through field data collection using digital infrastructures like OpenDataKit (ODK), Kobo toolbox, Trimble mapping tools, ArcGIS Survey 123, SW Maps, CAPI devices and Global Positioning System (GPS)-based surveys, and ArcGIS.

Upon the generation of the data, several organizations across the country utilize physical servers and independent storage systems to store geospatial data. Although sustainability of funding and high-cost limit the adoption of cloud storage,

[3] Data that is not comprehensive does not capture all aspects that it should capture. Usually, it does not capture all sectors or levels. This type of data makes decision making difficult.

private and well-funded non-profit organizations have moved to cloud-based storage like Amazon Web Services (AWS). These organizations – like eHealth, GRID3, and Data Scientist Network – also possess data portals that store the data and serve as an interface for public or partner users.

Generation at the National and State Levels

Understanding the federal – state – local government relationships

Nigeria operates a federalism structure with a federal government and 36 state governments and the federal capital territory. This system reflects in the structure of government agencies. At the federal level, NASRDA, Office of Surveyor-General of Federation, National Boundary Commission, and National Population Commission are the major actors in the collection of geospatial-related data. At the states, the states' bureaus of statistics, mostly under the Ministry of Budget and Planning, Office of Surveyor-General of States, or in some cases, dedicated GIS agencies are the major actors in the generation of geospatial-related data.

In most states – like the federal actors – the major forms of geospatial data generated include population, settlements, infrastructure, forestry, and land (transformers, water points, and markets) amongst others. However, NASRDA operates the satellite missions, and is also responsible for most of the imagery analysis.

The relationship between national and state actors on geospatial data is not formalized. In certain cases, there are well-structured geospatial generation and coordination efforts among federal, state, and even local actors; while in others, states and federal have often worked independently without any coordination. The more structured efforts occur when there is a federal liaison within the state structures or with strong support from state leadership championing geospatial data generation.

Common coordination structure involves federal-led geospatial data generation efforts mostly relating to health and population data by NPHCDA and National Population Commission respectively. At the local government, a local coordinator has the responsibility of collating and consolidating the data collected at the ward level which is later submitted to the State coordinator. All State coordinators are responsible for data submission to the National Coordinator who harmonizes the state-level datasets and integrates them into the existing national database.

Other geospatial data applicable in areas such as settlements, land use planning, and administrative boundaries are managed independently by each state. Recently, programs led by non-profit actors like GRID3 integrated data generated from states into centralized databases in areas where independent efforts have historically occurred. For example, population, settlement, and infrastructure data are collected and shared with GRID3 for integration in its national geodatabase.

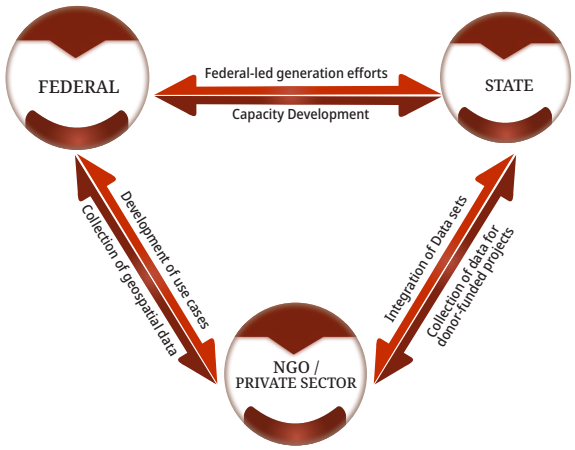


Figure 3: Interaction of federal, state, and non-government actors.

Interaction of states with non-government actors

In addition, state governments collaborate with private and non-profit actors to independently

generate geospatial data. These partnerships often come about from the project priorities of donor partners, proactive engagement by state actors, or the overall need for quality data monitoring by state statistical bureaus. Lagos and Kaduna states are prime examples of states with increased collaboration with non-government actors over the years.

In Lagos state, the government commissioned an e-GIS project which involved the approval of Asseco Software Nigeria Limited through the Ministry of Science and Technology, to deliver two Tiguar S-410 Unmanned Aerial Vehicles, as part of the Lagos Enterprise Geographic Information Systems, e-GIS, Upgrade, and Integrated Land Administration and Automation System Project– Lagos eGIS Project. These UAVs will be used to capture and update the orthophoto of the entire land mass of Lagos State. Similarly, Lagos state worked with Data Scientists Network to launch the Eko360 project, which enables real-time data collection and drives data generation.

In Kaduna, the state government and the Kaduna Bureau of Statistics also recently collaborated with Natview and GRID3 to generate new geospatial data (Annexures 1 and 2 for the type of data generated) for microplanning activities. In 2018, the state also partnered with eHealth Africa on a micro-census activity in the state to generate population estimates.

Major Actors and Sectors

The generation pillar of the geospatial ecosystem in Nigeria is dominated by relatively small circles of providers operating across local, state, and federal levels and various sectors. The major actors can be classified into government, non-profit, and private sectors. There are four agencies across the Nigerian government mainstreaming the use of geospatial data. They include:

The National Space Research and Development Agency is one of the major actors in the geospatial ecosystem at the national level. The mandate of NASRDA is to – pursue the development and application of space science technology. As a result, the organization has positioned itself as Nigeria's only satellite imagery-generating agency. NASRDA also has a role in capacity building through its subsidiary organizations including the African Regional Centre for Space Science and Technology Education (ARCSSTE-E) in Ile-Ife, and the National Center for Remote Sensing in Jos, among others. Beyond the analysis of satellite imagery, NASRDA collects data such as agricultural data, specimen data, population data, facility data, educational data, and raster data and conducts field validation campaigns.

> *"... we usually do the data gathering ourselves. NASRDA staff are the ones that usually do it. However, when we collaborate with other agencies and it is their project, then they will be at the front end...." - NASRDA*

The Office of the Surveyor-General of the Federation (OSGOF) is described as Nigeria's apex authority in surveying and mapping and related matters and provides geospatial information, maps, and surveys for land development purposes. OSGOF uses advanced approaches across remote sensing, geodesy, and hydrography to produce infrastructure and boundary maps.

The National Population Commission is another major player in the development of geospatial information on population in Nigeria. It has statutory powers to collect, analyze and disseminate population and demographic data in the country and also the mandate of conducting a population census every 10 years. The commission has demarcated 97.5% of the country into wards using contact and direct measurement on the field, while the other 2.5% was mapped using high-resolution satellite imagery. The commission collaborates with relevant agencies such as the National Bureau of Statistics (NBS), t National Identity Management Commission (NIMC), and other international development partners for effective service delivery.

The National Boundary Commission also plays a crucial role in the generation of geospatial data on boundaries. It settles internal boundary disputes by defining and establishing internal and national boundaries following statutory law, making recommendations to the presidential office on boundary and border issues between states, local governments, and communities, and promoting the development and effective management of internal boundaries. (Annexure 2 gives the list of other government, geospatial data-generating agencies).

Actors operating at the intersection of the non-profit sectors and government

The actors within the non-profit sectors have exerted a major influence on the generation of geospatial data in Nigeria. One of the major actors includes the Geo-Referenced Infrastructure and Demographic Data for Development (GRID3). GRID3Nigeria facilitates operations across the 36 states in Nigeria to collect accurate, complete, and geospatially referenced data relevant to a variety of sectors.

Since 2020, GRID3 has driven strong government coordination in the development of its core geospatial data layers through its steering and technical committees comprising senior government stakeholders and allied technical actors. The effectiveness of the GRID3 program has enabled its transition into a government-domiciled program hosted by NASRDA in 2020. Globally, GRID3 partners WorldPop, UNFPA, and Flowminder on data generation and analysis.

> "Firstly, we generate a grided population estimate at 400m and 500m details for the country. Secondly, we generate administrative boundaries, that's the second layer. The third layer is the settlement locations. And the fourth layer is the infrastructure data- these are locations of points of interest such as health facilities, schools, markets, and all that. It is both demand and supply."- GRID3 Nigeria

Secondly, eHealth Africa is a strategy-focused organization in the non-profit sector that aims to build stronger health systems through the design and the implementation of data-driven solutions that respond to healthcare-based needs in local communities. They have partnered with both government and development partners such as the National Primary Healthcare Agency (NPHCDA) and the Bill & Melinda Gates Foundation. eHealth played a crucial role in the generation of health data points hosted on its eHA data portal and has continued to provide geospatial support to the NPHCDA's emergency operations center on immunization deployment. The outcome of this support includes increased immunization coverage in missed and hard-to-reach settlements.

> *"We started collecting settlement data alongside points of interest like schools, churches, hospitals, and all that. Collection of health facility data was key for us because most of the interventions we were working on for the Foundation and the States were within the health sector...."- eHealth Africa*[4]

Another major actor includes WorldPop located at the University of Southampton which provides high-resolution data on the human population to government partners in Nigeria. Its notable partners include GRID3 and the Countdown to 2030 initiative. WoldPop is one of GRID3's implementing partner organizations and provides population estimates for use in various government activities including vaccination campaigns. WorldPop has become a major actor due to the absence of a national population census in Nigeria in the last 16 years. WorldPop estimates serve as a secondary source of

[4] Quote has been slightly modified for better understanding of the reader

data for several geospatial data-generating organizations in the country.

Beyond traditional non-profit institutions, organizations like World Health Organization, World Bank, and other multilateral agencies work with government actors to generate geospatial data during various projects.

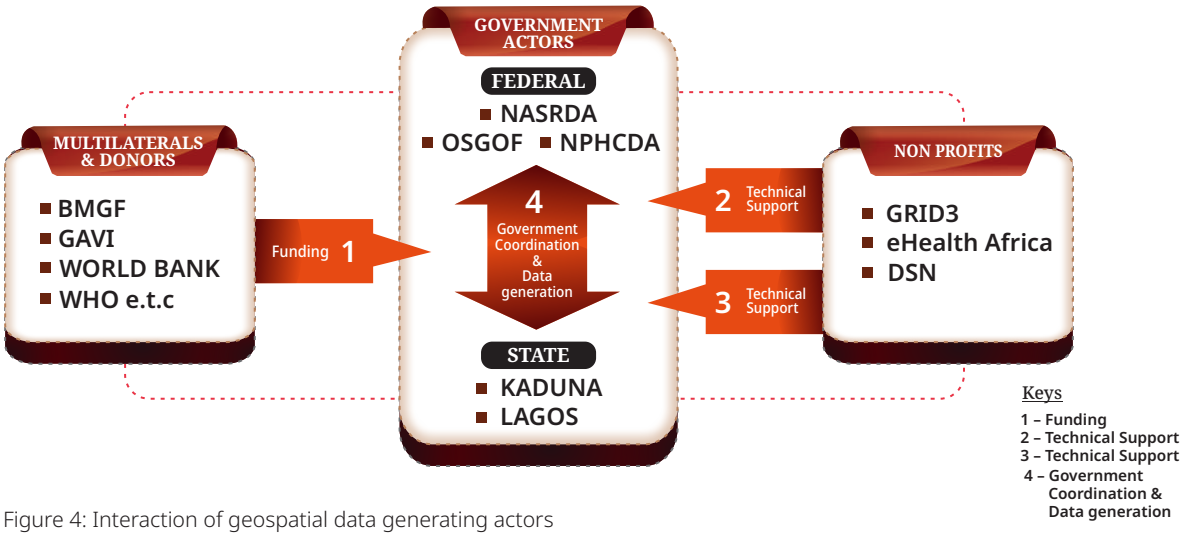


Figure 4: Interaction of geospatial data generating actors

At the sub-national level, State Ministries of Health, State Bureaus of Statistics, State Ministries of Budget and Planning, or the Office of Surveyor-General of the states are responsible for data generation and sourcing within the states. These actors work with local stakeholders like Data Scientists Network (DSN) or Natview towards data generation, analysis, and capacity strengthening.

Interaction of Actors within the Sectors

Geospatial data locations are the same but differ in attribute information. In health sectors, basic GIS data is collected, such as locations of health facilities attached with attribute information like the total number of – doctors in a facility, medical equipment present in each of the facilities, and health personnel, etc. Other points of interest (POIs) include markets, schools, financial institutions, parks, and other public and commerce locations.

The generation of geospatial data within the health sector is more advanced than that in other sectors because the health sector has the longest history of using geospatial data in Nigeria. The NPHCDA collects geospatial data during field mapping visits using ODK with the support of non-profit actors like GRID3 and eHealth Africa. NPHCDA data repository is also a source of government data repository for the health sector.

> *"... we have HMIS tools which are stationed at the health facilities for data on vaccination or activities done at the state levels. We have the tally sheet which is given to the teams that go out during the campaign to do the vaccination. We also have the ODK which is another means of data generation. We have the VTS, now GTS (Geospatial Tracking System), which also generates data...." – NPHCDA*

Moreover, stakeholders within the health and education sector at the national level often use the GRID3 data as one of their main sources of data. Sub-national actors are now increasingly using the GRID3 data. For example, NPHCDA and many state governments (Kaduna and Lagos) have all used GRID3 for vaccination microplanning.

Funding and Sustainability

The generation pillar of the geospatial ecosystem has been fairly funded by the three main actors: government, non-profit and private sectors. The Nigerian government has a budgetary provision for geospatial activities domiciled under the recognized institutions (NASRDA, National Boundary Commission, the National Population Commission, and OSGOF), however, the value pipeline assessment showed that funding remains insufficient to drive geospatial data generation, especially primary data. This is because geospatial field data collection is an expensive exercise requiring many personnel and tools. This is particularly true in Nigeria which has 9, 565 wards. Among the development partners, major funders include the Bill and Melinda Gates Foundation, the United Kingdom's FCDO, World Health Organization (WHO), USAID, the Center for Disease Control, GIZ, Global Fund, World Bank, and GAVI.

Funders such as the Gates Foundation, FCDO, GIZ, and WHO supported actors across the government and non-profits on geospatial data generation efforts. For example, the Gates Foundation supported data generation efforts of GRID3 Nigeria and eHealth Africa. However, other actors like Global Fund and USAID have structured their funding through government partners.

The private sector players received funding often internally but driven by the priorities of the organization. These organizations fund their geospatial interventions through an internal or project-linked budget. The geospatial costs are factored into eventual business planning and execution costs.

Sustainability

Sustainability – frequency of collection and update of geospatial data generation in Nigeria – can be linked to the direct ownership of data generation efforts by the government through the statutory responsibilities of organizations like NASRDA, NPC, and OSGOF, and the continued presence of the geospatial data programs that were historically and currently funded by development partners. Donor-funded programs such as GRID3 have continued to expand nationally and across the states, building capacities and validating datasets in the process.

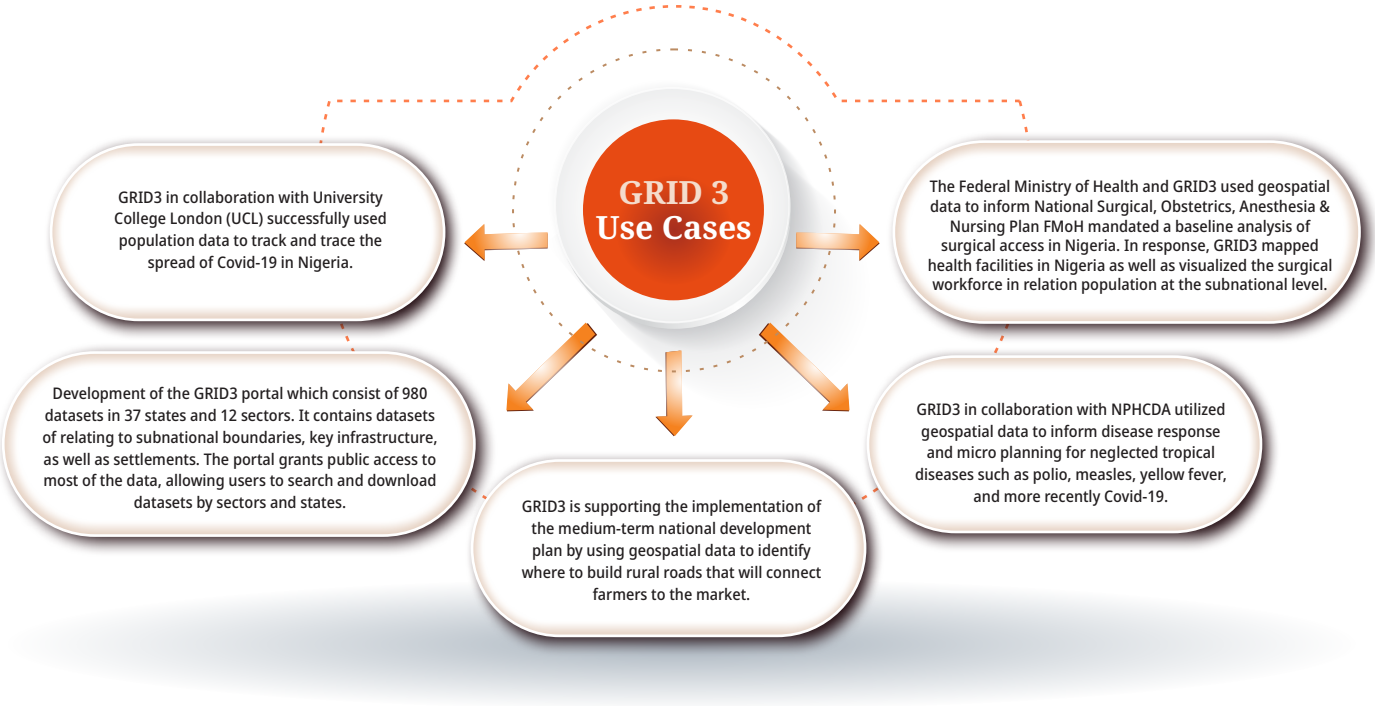
Financial sustainability for locally funded efforts (without donor funds) is still unachieved as evident from this assessment; several stakeholders within the generation pillar of the geospatial value pipeline have diversified their donor-funding portfolio. For example, beyond the initial funding from Gates Foundation and FCDO, GRID3 raised additional support funding from World Health Organization and GAVI.

The transition of GRID3 to a government-owned program also paved the way for its sustainability. In this context, the creation of the National Steering and National Technical Committees helped GRID3 accelerate its adoption as a government program housed within NASRDA.

Successes

The GRID3 Nigeria project, launched in March 2018, aims to facilitate the production, collection, use, and dissemination of high-resolution population, infrastructure, and other reference data in support of national sectoral development priorities, humanitarian efforts, and the Sustainable Development Goals (SDGs) of United Nations. The

GRID3 Nigeria project significantly contributed to polio eradication in the country. The GIS-based maps helped health workers develop effective micro plans at the ward level to ensure every settlement is visited and reaches the target population. The GRID3 Nigeria project successfully produced 774 local government area GIS-based maps for the National Primary Health Care Development (NPHCDA) to support the COVID-19 vaccinations across the country.



5.1.2. Geospatial Data Analysis

Data Cleaning

Data cleaning simplifies the complexity of geospatial datasets and intrinsic geospatial relationships, enabling the synthesis of geographically linked datasets like population information and survey data. It is the process of removing or fixing incorrect, malformed, incomplete, duplicate, and corrupted data within the dataset. Considering that geospatial data are collected through primary and secondary sources either for field data or satellite imagery data, it is important to identify the common errors, understand them and fix them. Invariably, this may require that irrelevant and duplicated data be removed, structural errors fixed, missing data inputted, outliers detected, and the overall data validated.

This process of ensuring that errors and false data are cleaned, is the validation process for quality control, assurance, and confidence in the completeness and accuracy of the data. Stakeholders within the geospatial landscape use Python, R, and Microsoft Excel to clean their data. Thorough documentation of data cleaning methods also enables understanding for other groups using both the data and derived product(s).

Data Validation

Table 4: Examples of data cleaning and validation cases within Nigeria's geospatial ecosystem

Data Validation Methods	Stakeholder	Sample Case
Metadata Documentation	AFRIGIST, NASRDA	Metadata documentation plays an important role in the management of geospatial data within an organization, as well as the linking of the dataset from other sources. AFRIGIST and NASRDA are the two main organizations that have developed in-house metadata documentation for data standardization and spatial data extraction. It also includes a data-sharing procedure that conforms with global and best standard practices.
Field Data Collection	NASRDA, GRID3 Nigeria	Data cleaning passes through quality control before it is sent to the NASDRA core team to update the NASRDA portal. This is carried out by a data team, with support from GRID3 for data collection. For example, the team collected geo-coordinates of all schools across the country. Data collected from existing sources such as the GRID3 portal are validated by consultations with members of the local community. This helps identify missing settlements or data which is then included in the maps. This is usually done in the health sector before the commencement of microplanning activities.
Stakeholder Consultation	eHealth Africa	eHealth Africa realized that about 50% of data is lost after cleaning. This prompted the organization to investigate the reason for data is lost during this process, to reduce the loss of data after cleaning. Pre-validation checks are now in place to reduce the level of erroneous data at the point of entering during the data-gathering stage.
Cross-referencing	OSGOF	Data collected undergo quality control and quality assurance before publishing. Such checks are carried out to ascertain the validity of the data, and the accuracy of the data before dissemination.

Data Processing

In recent years, several data processing tools have emerged, and their applications have become prominent in Nigeria's geospatial ecosystem. Many stakeholders are offering GIS software training for data processing and analysis. This training is primarily focused on two spatial data types—raster and vector data. Specifically, the creation, design, and representation of earth forms using vector datasets are the most acquired skills through conventional GIS training; and are used to analyze the earth's surface elevation, land use, vegetation cover, soil types, and other derived data layers.

The methods and tools used for processing vector and raster data differ, even though vector data can be used to visualize raster data. However, raster data have specialized remote sensing software for analyzing geospatial imagery in 2D and 3D. The data processing methods and tools used by stakeholders in the geospatial ecosystem are given in Table 5.

Table 5: Summary of methods used to process geospatial data by selected geospatial actors

Geospatial Data	Stakeholder	Data Processing Methods
Vector Data	NASRDA, GRID3	NASRDA obtains spatial data, which are cleaned up, standardized, and form a geodatabase. ArcGIS and QGIS software are mostly used for data analysis. Recently NASRDA embraced the use of QGIS because it is open source, and the policy is beginning to shift towards also adopting the use of AI.
Raster Data	NASRDA, AFRIGIST	NASRDA and AFRIGIST also deal with satellite images, and a specialized remote sensing software is used. Software like ENVI and ERDAS are used to run the required analysis and then visualized.

Data Visualization

The digital representation of data based on its associated geospatial information has gained significant importance in communicating spatial meanings and correlation. Several technologies and techniques were developed for geo-visualization that integrate approaches from visualization in scientific computing, cartography, image analysis, information analysis, and GIS for visual exploration, synthesis, analysis, and presentation.

In the Nigerian context, geospatial visualization is a constructive practice that – integrates interactive visualization into traditional maps and allows the exploration of different layers of maps. The process of modeling geospatial data using advanced cartographic technologies allows geospatial analysts in Nigeria to visualize geospatial data. Cartographic technologies are used in the fields of urban planning, transportation, investment, and management, among others.

Demand for Data Visualization

The demand for data visualization is based on the following factors:

- Project needs and requirements
  - i. LAMATA mostly works with digital maps over paper maps to visualize routes and road networks in real time for traffic updates and monitoring.
  - ii. NPHCDA monitors data collection at the state and local level through the DHIS2 for immunization and campaign programs.
- Capacity of the end-users.
  - i. NPHCDA uses paper maps for data collection because the personnel at the state and local levels who are the major data operators do not yet have the technical capacity to interpret and use digital maps. This also applies to GRID3 which is a key player in this regard.
  - ii. NGF utilizes easy-to-read data visualization and reporting for health because their primary audience (state governors) is not a geospatial expert.
- Capacity within the organization
  - i. Octave Analytics, Geoinfotech, and Cizoti have technical capacity for geospatial data visualization because they have in-house geospatial experts and access to advanced and proprietary tools.
  - ii. Natview and DSN have access to a pool of skilled talents through their capacity building and GIS training.

Data Analysis Process in Nigeria

The term geospatial-data analysis connotes the discovery of geospatial knowledge. Geospatial analysis is a combination of spatial modeling for referenced data using different techniques and applications. The typical process of extracting information from geospatial data is depicted in Figure 5. Geospatial data analysis in Nigeria involves data cleaning, data validation, data processing, and data visualization.

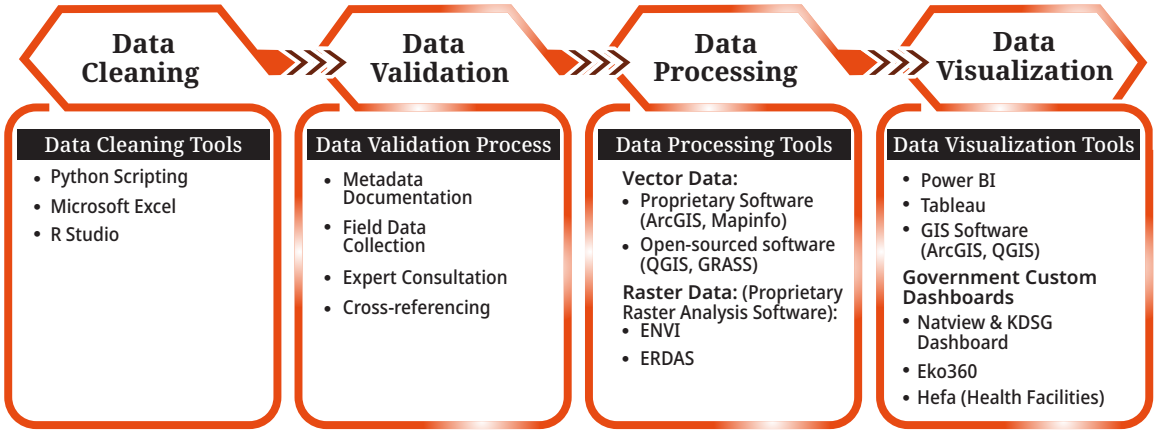


Figure 5: Summary of Nigeria's geospatial data analysis process

The focus area of an organization, skills level of its workforce and the technical capability of geospatial data users influence the choice of the analytic tool(s) and process.

> *"The current needs and the results we are trying to get will determine the kind of analysis to be done. For instance, if we have an assignment to create a topography map or a map for land use, it triggers the kind of analysis to be done." -Geoinfotech*

Geospatial data analysis for change detection, prediction, and monitoring using satellite imagery may not follow the sequence shown in the figure above. This is especially true for satellite imagery analysis, which requires automatic picture detection using real-time aerial photographs, and necessitates the use of entirely distinct processing methods.

The following are sample cases for data analysis by stakeholders within the ecosystem:

- eHealth Africa: Developed its in-house data analysis model, which was used during the COVID-19 pandemic and has been applied to services provided to clinics.
- NASRDA: Offers geospatial data analysis through its Center for Basic Space Science in Nsukka, Enugu State. Data analysis is conducted using high-performance computing (HPC) system with relevant software such as Python, CASA, and AIPS.

Analysis at the National and State Levels

Geospatial data analysis procedures, tools, and infrastructure are consistent across all levels of the ecosystem. This is due to the presence of key actors and players in the analytics spectrum that provides data, tools, and infrastructure in the analytics spectrum across the national and state levels.

Analysis at the national level is somewhat advanced because of the complexity and scale of data they possess, which requires advanced analytical tools. The NPHCDA and NASRDA, major government agencies, are involved in health-related geospatial data analysis at the national level. Within these agencies, there are several program/project implementation units and partners that provide data for decision-making. The collaborating partners are non-governmental organizations like GRID3, international and donor organizations like WHO, UNICEF, NGF, etc., and civil society organizations.

Most national government agencies lack the technical expertise and infrastructure to undertake data analysis and hence rely on the support and services provided by their partners. This is still true at the state level, especially in low-income states.

In addition to this, among the stakeholders interviewed during this assessment, NPHCDA being a federal agency supports all states within the country. Because of the lack of technical expertise and infrastructure to carry out geospatial analysis, most geospatial data are analyzed and visualized at the federal level except for frontier states like Kaduna and Lagos, which developed competency through the support of non-profit actors – NatView Technology, GRID3, and DSN. The visualized data are then distributed to different states of concern for utilization. Uniform standard is maintained across all state levels since geospatial data for government is visualized and produced at the central level.

Major Actors and Sectors

The actors within the geospatial landscape are concentrated at the national level. These actors can be classified as government, non-governmental, and private organizations. National-level actors cascade to the state level as the national-level overview provides the opportunity to broadly present solutions and invite the right stakeholders. At the state level, only states with an established demographic and economic capacity can build and develop their geospatial capacity and, in turn, attract other geospatial organizations. This is true for Lagos, Kaduna, Kano, and the Federal Capital Territory.

The types of organizations that provide data cleaning, data analytics, infrastructure, and visualization at various levels are given in Table 6.

Table 6: Platforms used for data cleaning, analysis, and visualization within Nigeria's geospatial ecosystem

Levels	Types	Actors	Data Cleaning	Data Analytics	Visualization
National Level	Government	NPHCDA	Python, Excel	QGIS, Google Charts, Excel	Google Chart, Tableau, PowerBi
		OSGOF	Nothing discussed in the interview		
		NPopC			
		NBC	ArcGIS	ArcGIS	Power Bi, Chart
		NASRDA	QGIS, ERDAS, ArcGIS	PowerBi, Tableau, QGIS, ERDAS, ArcGIS	Dashboard, Web map,
	Non-government	eHealth Africa	QGIS	QGIS	Dashboard, Web map, Map
		GRID3	ArcGIS	ArcGIS, Tableau	Dashboard, Web map, Map, ArcGIS
		DSN	Python, R	Python, R, ArcGIS	Dashboard, Web map, Map
		Natview Foundation	Python, ArcGIS	ArcGIS, Tableau, Azure, AWS	Dashboard, Web map, Map, ArcGIS
		World Pop	Python, R	Python, R, ArcGIS	Python, R, ArcGIS
	Private Organization	Sambus Geospatial	ArcGIS	ArcGIS	ArcGIS
		Fraym	Python, ArcGIS	ArcGIS	ArcGIS
		Cizoti	Python, R, ArcGIS	ArcGIS	ArcGIS
		Geoinfotech	ArcGIS	ArcGIS	ArcGIS
State Level	Government	LBS	Excel	QGIS, Excel	Dashboard, QGIS, Map
		KDBS	Excel	QGIS	Dashboard, QGIS
		LAMATA	Python, Excel, ArcGIS	ArcGIS, Python	Dashboard, Map, ArcGIS

Funding and Sustainability

Geospatial analysis is not a standalone or isolated process during the execution of a geospatial-related project. Through our interviews, it was also discovered that GIS-related software like ArcGIS, QGIS, and some other software such as PowerBI and Tableau used in the value chain can analyze and visualize geospatial data. Therefore, the funding of geospatial analysis is neither isolated nor separated. Stakeholders like WorldPop and NPC affirm that no special funding is dedicated to geospatial analysis currently.

The sustainability of geospatial analysis within the value chain is also linked to capacity building and human resource management capacity retention. It was identified that due to the low level of engagement within the public sector, the youthful population mostly seek opportunities elsewhere after

being trained but are not engaged in a meaningful way, causing gaps within the public sector. Other organizations like NASRDA, eHealth, DSN, and AFRIGIST have the capacity to train, retrain and further engage their employee. Several opportunities around different types of geospatial analysis are yet to be fully explored, including location-based analysis, AI/ML and deep learning modeling, and predictive and inferential analysis. Additionally, there is limited knowledge sharing and the existing community of practice does not have a wide reach. It is essential to build capacity and keep people engaged.

Successes

In partnership with Natview Foundation, the Kaduna State Government developed a data pipeline where household surveys are collected and analyzed at intervals. The constant collection and analysis of the household survey kept the state government better informed and helped in decision-making. In addition to this, all primary healthcare facilities are mapped, and data are collected daily. Some of the data collected include maternal health, morbidity rate, and doctors' resignation rate to mention but a few. Natview Foundation developed a data pipeline using the Azure platform and AWS for hosting. There is a publicly accessible dashboard where the data analysis is visualized.

The Lagos Metropolitan Area Transport Authority (LAMATA) carries out a series of surveys and data collection such as traffic count data, origin and destination study, amongst others. The data collected over time has helped the agency better inform on areas where the transport service is needed most and identify the potential expansion area. Data are collected at intervals by the data collection team. Also, the buses are equipped with GPS devices and collect data along the dedicated bus lane. LAMATA used this data to develop different transportation models to inform the government and improve service delivery.

The Eko360 is another success story in addition to the LAMATA in Lagos. The Eko360 project, a data warehouse and analytics platform, exhibited the technology-driven data management of the Lagos Bureau of Statistics (LBS) unit of the Ministry of Economic Planning and Budget. The Eko360 project is designed to enhance the statutory functions of the Lagos Bureau of Statistics as an enabler of the Open and Smarter Lagos mission. The Project focuses on the historical aggregation of Lagos data; pattern forecasting based on organized insights from the past; real-time data collection with the Eko360 Mobile App; derived data generation that combines data from different sources to create new and meaningful data; as well as provision of contextual and geospatial insights from Lagos Spatial Data. This includes on-the-go access and usage through a simple presentation interface for all smart devices and the Eko360 website, which will afford the general populace access to Lagos data and insights in a self-service format that assures open and valid access. The state government to improve public service delivery and transparency in governance innovated the Eko360 project. The Project attracted support from the Bill and Melinda Gates Foundation and engaged the Data Scientists Network (DSN).

The mission statement on the About page of the Eko360 website says, "To continually be the one-stop shop for qualitative, reliable, and robust data for the development of the state." However, the dataset available covers the period from 2010 to 2019.

5.1.3. Operationalization

Use-cases cut across several sectors and levels but are most prevalent in the health sector.

The end goal of generation and analysis of geospatial data is solving problems through well informed decisions. The application of insights from geospatial data has revolutionized certain fields and led to

breakthroughs in solving some of the toughest development challenges in the country. These applications of geospatial data are termed as use cases. Geospatial data use cases in Nigeria cut across different sectors including health, environment, education, utility, financial services, telecommunication, and government planning encompassing the federal, state, and local levels.

The health sector has the most use cases in the country. This can be traced to the long history of applying geospatial data to polio eradication efforts. These government-led multi-stakeholder efforts happened over eight years (2012-2020) and involved actors such as NPHCDA, BMGF, eHealth Africa, and GRID3. Geospatial data were used to develop maps for microplanning and monitoring immunization coverage by tracking activities of immunization field workers at the Emergency Operating Centers (EOCs) established in highlighted states in the country.

The successes recorded in polio eradication resulted in continued investments from development partner organizations in the health sector, as the NPHCDA is currently extending the application of geospatial data to other areas including measles, neglected tropical disease, and integrated immunization campaigns including Covid-19.

Use case generation process differs across sectors

The use-case demand generation process differs from sector to sector. The interviews revealed that use-case generation is mostly demand-driven in the public sector. In organizations like NPHCDA and NOEC, the need to achieve certain results on their projects (polio eradication and black fly tracing respectively) led to the demand for geospatial data. The same applies to GRID3, which was born out of the demand for geospatial data by governments, donors, and even communities to solve identified problems linked to polio, as well as the need to develop existing data.

Organizations like NASRDA, National Boundary Commission, and OSGOF also receive demands from government organizations, departments, and agencies to provide geospatial support for their projects. The same applies to the Kaduna and Lagos State Bureau of Statistics. In Kaduna state, a need to increase the number of SDG indicators necessitated the use of geospatial data.

However, there are instances of supply-driven use cases in the public sector. NASRDA for instance has GEOLABS, a commercial training facility, which provides training to members of the university community, government agencies, and the private sector. Through this facility, they prospect clients and stimulate demand by developing solutions to meet project needs, reference previous use cases, and provide incentives such as free training. Another case of supply-driven use-case demand is in Kaduna state, where the government mandated that geospatial data be embedded in all forms of data collection by its ministries, agencies, and departments. In some instances, donor agencies such as BMGF and WHO also request that geospatial data be embedded in project delivery.

In the private sector, the narrative is different. Most of the assessed private organizations mentioned that they proactively stimulate demand in several ways. This includes developing solutions and use- cases based on their research on potential clients' needs sourced from requests for proposals, government bids, and opportunities to develop existing data.

Communication focuses on use cases and datasets

Communication in the geospatial ecosystem focuses on two main aspects- use cases and datasets. Information about geospatial datasets is often disseminated via in-person channels, especially workshops. These workshops are organized by data-generating organizations such as GRID3 and non-profit organizations such as Data Scientist Network

(DSN). However, these actors engage different media channels in amplifying these communication efforts. GRID3 for instance deploys predominantly print media for the amplification of its workshops, while DSN leverages digital media such as Twitter and Telegram. The choice of media channels is closely connected to the intended audience; GRID3's direct workshop audience consists mostly of government stakeholders, while DSN targets mostly young people.

Communication of geospatial use cases focuses on the challenge to which geospatial data was applied rather than the geospatial data used to complete the project. It is done individually and can be completed through different channels; print media, digital media such as websites and social media, and mass media. The websites of various organizations serve as individual repositories of use cases. Their assessment revealed that the output of the geospatial analysis is not often communicated as they are tied to projects and are thus treated as proprietary.

Horizontal advocacy structure

The current advocacy structure observed in the geospatial ecosystem in Nigeria is horizontal, that is advocacy between organizations at the same level. GRID3 has an excellent model of stakeholder coordination due to its organizational structure, which brings together a wide array of government MDAs and thus focuses its advocacy efforts on government MDAs at the federal level. GRID3's advocacy at the state level is driven through projects at the national level involving state actors e.g., immunization campaigns. The same applies to NASRDA which advocates for government agencies such as the Universal Basic Education Commission (UBEC), the Central Bank of Nigeria (CBN), and the Ministry of Agriculture, to mention a few.

At the state level, advocacy is driven by non-government actors, e.g., Natview Foundation and Kaduna State Government as well as DSN and Lagos State Government. The bureau of statistics in these states also leads advocacy efforts for other MDAs in the state.

Use cases

A variety of geospatial data use cases exist in Nigeria across different sectors and levels. In the health sector, geospatial data supports microplanning, immunization campaigns (polio, measles, and NTDs), routine immunization expansion (RI) activities, resource allocation, mapping immunization coverage, disease surveillance, health facility registry, and vaccine delivery. In the environmental sector, use cases include flood prediction and vulnerability mapping, deforestation studies, pollution mapping, risk, and vulnerability assessment of lakes, etc.

In education, telecommunications, and utility sectors geospatial data are used to inform infrastructure development and resource planning/siting. For example, GRID3 worked with Flowminder Foundation and Universal Basic Education Commission and developed a school optimization tool to help the Nigerian government optimize school locations and out-of-school children. In the social sector, geospatial data were used to support the reporting of SDG indicators (Annexure 3 – summary of use cases by the organization).

Some highlighted use cases are discussed here.

Health

Fraym, a company specializing in ML-derived population data, worked with Johnson & Johnson's Global public health team to map and address COVID-19 vaccine hesitancy. There were often no indicators for vaccine trust, which forced them to create novel indicators. They used the Demographic and Health Survey combined with existing maps, health facilities, road networks, electrical grids, and geospatial imagery to forecast the rates of hesitancy. They georeferenced survey results further increasing the regional accuracy of their findings (Annexure 3 – list of the use cases).

Communication and Amplification

GRID3 is the most vocal actor communicating information on the benefits and opportunities that geospatial data provide. They are actively disseminating their large dataset collection, putting them in a unique position among the other actors.

Their broad focus allows their communication efforts to reach past just one sector or level of government. Beyond GRID3, other actors in the ecosystem conduct specific workshops to communicate information about geospatial data as follows:

- Africa Intellectual Property Rights and Innovation Project (AfrIPI) conducted a high-level public sector capacity-building workshop on Geographical Indications (GIs)[5] in 2021 and brought together officials from across Nigeria's federal government.
- Geoinfotech organized a free workshop in Lagos that introduce more advanced topics to current users. They were taught GPS and GIS data integration, GPS settings, and navigation, GIS data accuracy, measurement, and coordinate systems, among others[6].
- A Workshop on post-evaluation assessment of the Eko 360 Project[7].
- A Workshop for Quality Assurance Officers in Edo State by UBEC, Edo State Universal Basic Education Board (SUBEB) and NASRDA[8].

Geospatial workshops are conducted continuously in the ecosystem as these provide an avenue for new users to interact with more technical aspects of geospatial data. There are also recorded cases of partnership among stakeholders in organizing workshops. For instance, GRID3 has consistently supported DSN in its annual AI bootcamp[9], providing training on the link between geospatial data and AI applications.

Some of the actors we assessed opined that communication of use cases is more prevalent than communication about geospatial data itself. While they advocate for more communication around geospatial data, they believe that amplification of use cases is a good way to convince new adopters/potential users.

Another existing main channel of communication in the geospatial ecosystem is academic research and publications, and publications by internal agencies such as the UN-GGIM. A list of some publications on the geospatial ecosystem and data is given in Annexure 4. Universities across the country train users and amplify the message. Perhaps the most notable is the African Regional Institute for Geospatial Science and Technology (AFRIGIST). They largely focus on training users in geospatial skills, and are not a strictly Nigerian institution, though they do have a large campus located in the country.

Other forms of communication that exist within the ecosystem include white papers, dashboards, maps, and slides from use cases/projects. An example is the DSN white paper and codes on the use of mobile network data. Communities of practice created by government agencies such as GRID3 and private sector organizations also serve as a channel of communication.

Advocacy using use cases

In advocacy in the geospatial ecosystem, GRID3 plays a central role due to its extensive organizational structure that includes key stakeholders within and outside the government, convened through the Ministry of Budget and National Planning. GRID3 has leveraged this structure to advocate for geospatial data primarily at the federal level. Another stakeholder with a similar extensive coverage across

[5] https://internationalipcooperation.eu/sites/default/files/afripi-docs/AfrIPI_23apr2021_Press%20Release_Workshop-on-GIs-in-Nigeria.pdf
[6] https://geoinfotech.ng/project/lagos-october-1st-free-gis-training-workshop/
[7] https://thenationonlineng.net/importance-of-data-in-planning-decision-making/
[8] https://www.withinnigeria.com/broadnews/2022/08/20/edobest-ubec-partners-edo-subeb-nasdra-to-train-officers-on-e-quality-assurance/
[9] https://grid3.org/news/supporting-artificial-intelligence-with-geospatial-data-in-nigeria-grid3-joins-data-science-nigerias-ai-bootcamp

actors is the Geoinformation Society of Nigeria (GEOSON), a non-government association, which represents geospatial professionals and organizes platforms for its members to dialogue on key issues in the ecosystem such as its annual forum. However, GEOSON lacks the convening power that GRID3 owns.

Development patrons also provide leadership and funding support for projects, as well as dedicated communities such as DSN. Asides from GRID3 and GEOSON, advocacy in the ecosystem is not centralized and different actors do it independently also. The major driver of individual efforts of advocacy is the need to prospect for new clients.

The NGDI policy, however, is a potential driver of advocacy with the capacity to drive it across the board. Most of the assessed stakeholders agreed that a policy for the geospatial ecosystem will provide coordination for advocacy efforts within the ecosystem. The NGDI currently exists as a draft bill and certain actors such as NASRDA and GEOSON are working towards ensuring the NGDI is enacted as a policy. GEOSON organized a review session for the policy in its 2021 forum, to ensure alignment of stakeholders on details of the bill. The bill is currently undergoing review in the country's national assembly.

Use Cases at the National and State Levels

There are intersections of geospatial use cases across levels and sectors. Across levels, use cases that originate at the federal level may involve actors at the state and local levels. For instance, use cases at the NPHCDA typically involve state primary health care development agencies as well as ward-level officials at the local governments. The same applies to GRID3 and OSGOF who work with the surveyor general offices in the 36 states in the country.

A typical example of use cases emanating across levels is the microplanning activities of the NPHCDA, which involves the deployment of geospatial maps for microplanning activities to state primary health development agencies and subsequently local government and ward focal points. These maps utilize geospatial data often generated by major actors supporting NPHCDA like GRID3 or eHealth Africa. These maps serve different functions for stakeholders at the national, state, and local levels.

At the national level, the maps are used for the planning, allocation, and targeting of funding and resources. At the state and local levels these are used to identify gaps and risks in immunization services delivery and ensure no settlements are missed during microplanning. The maps are also used to calculate the distance of health facilities to settlements and health facility catchment areas, navigate communities during field campaigns and develop outreach plans. The use of maps for microplanning purposes has been the most efficient process of applying geospatial technology through maps to the local government and wards.

In other instances where use cases originate from the state level, little reference to national agencies was observed. The Lagos Metropolitan Area Transport Agency (LAMATA) uses geospatial data heavily in its operations but has not had interactions with stakeholders at the federal level, including NASRDA, OSGOF, etc. In Kaduna state, demand generation for geospatial use cases is driven by the state government priorities and requests from other MDAs within the state. However, the state bureau of statistics shares some of its data with federal agencies such as NASRDA and the National Bureau of Statistics (NBS) upon request.

Private organizations are also involved in the development of use cases at the federal and state levels. SAMBUS geospatial for instance works with defense agencies at the federal level and private electricity distribution companies at the state level. Some non-government organizations work across all levels e.g., eHealth, which supports NPHCDA and collaborates with actors at the state and local levels, while others such as DSN and Natview Foundation are involved in use cases originating at the state level.

Major Actors and Sectors

The Nigerian geospatial ecosystem comprises stakeholders across different sectors and levels. These stakeholders have different priority areas –more involvement in use cases than in communication and advocacy. Table 6 gives a sample of stakeholders indicating the sub-pillar they operate in their sector priorities.

Table 7: Summary of sub-pillar by stakeholder

Operationalization Sub-Pillar	Stakeholders Involved	Category	Sector Priority
Use Cases	NPHCDA	Government (Federal)	Health
	State Primary Health Care Development Agencies (PHCDA)	Government (State)	
	GRID3	Government (Federal)	Health
	eHealth	Non-Governmental	Health
	National Population Commission	Government (Federal)	Population
	UBEC	Government (Federal)	Education
	Nigerian Oncho Elimination Committee	Government (Federal)	Health
	CHAI	International Development Organization	Health
	World Pop	International Development Organization	Population
	LAMATA	Government (State)	
	Kaduna State Bureau of Statistics	Government (State)	Multiple Sectors
	Lagos State Bureau of Statistics	Government (State)	Multiple Sectors
	Octave Analytics	Private Organization	Telecommunication & Financial Services
Communication	GRID3	Government (Federal)	Health
	Academic Institutions	Various	
Advocacy	GEOSON	Non- Governmental	All sectors
	Ministry of Budget and National Planning	Government (Federal)	All sectors
	GRID3	Government (Federal)	All sectors
	NASRDA	Government (Federal)	All sectors

Funding and Sustainability

The key finding of our assessment is that funding for geospatial data operationalization focuses on use cases and is often closely linked to project funding. However, sources of project funding differ from sector to sector. Projects and organizations in the health sector such as NPHCDA, eHealth, and GRID3 have significantly benefited from donor funding from development partner organizations compared to other sectors. In other sectors, it is a combination of government and donor funding, and the proportion varies across projects.

Most donor funding is organized by sector because of the need to align with donor organization priorities but there are instances of donor-funded projects by level. The Eko360 project in Lagos and the Kaduna State data labs are examples of state-level donor-funded projects cutting across all sectors. At the state level, we also see examples of government-led funding, where the government MDAs earmark budgetary allocations for geospatial data operationalization. The Kaduna State Bureau of Statistics and LAMATA are examples of government MDAs with budgetary allocation for geospatial data and technology.

The prevalence of donor-funded projects for use cases poses a serious challenge for the ecosystem, which is sustainability. Sustaining use cases beyond the project funding lifecycle tends to be difficult in all sectors and at levels. However, the ecosystem is

beginning to witness instances of counterpart funding for projects, as actors especially the government are placing increased value on geospatial data. For instance, the Ministry of Budget and National Planning is working towards including GRID3 in its annual budget.

Successes

An example of success from GRID3 of a federal government-driven use case is their Measles campaign in 2017-2018. The government reached out to GRID3 and requested GIS maps for microplanning, with all the key features present. The government was interested in seeing markets and schools on maps because that is where the target population is. This also required population estimates to see whether they vaccinated enough children in the locations that were affected. So, they informed the GRID3 team of these processes and incorporated them into the maps and trained them on how to interpret and use these maps.

5.1.4. Stakeholder Coordination, Governance, Policies, and Capacity Building

5.1.4.1. Governance and Policies

The Nigeria geospatial ecosystem has witnessed organic growth, including the development of governance and policy structures. The first attempt at a policy for the geospatial ecosystem was the development of the National Geospatial Data Infrastructure (NGDI) bill. It was developed in 2003 in response to the call by UNECA's (United Nations Economic Commission for Africa) Committee on Development Information, Geo-information Sub-committee (CODI-GEO) to member states to establish spatial data infrastructures (SDI) in their respective countries. The bill was revised in 2021 following efforts by stakeholders such as NASRDA and GEOSON. GEOSON brought together stakeholders in the ecosystem across levels and sectors during her annual conference in 2021 to get feedback and alignment for the bill.

The draft NGDI bill in summary aims to achieve the following:

- Establish frameworks that are consistent for geospatial data distribution.
- Access to efficient sharing and exchange.
- Integration of datasets through the application of common standards.
- Facilitate the use of geospatial information for schemes that would improve the standard of living in the three levels of government.
- Encourage the geospatial stakeholders by promoting synergy and amicable resolution of conflicts.
- Encourage NGDI-endorsed standards for quality and consistency.

The bill is currently at the country's National Assembly where efforts are still being made to get it enacted as a legislative Act. The implementation of the NGDI is pending, hence at present, GRID3 serves as a bridge providing a platform to bring together key stakeholders in the ecosystem.

Beyond the NGDI which is to serve as an overarching policy for the ecosystem, certain guidelines exist in individual organizations on data generation, harmonization, validation, and interoperability. However, the enactment of the NGDI bill will serve as a central governance and policy structure for all stakeholders in the ecosystem.

Major Actors

Our assessment revealed that the actors involved in governance and policy are at the federal level. The most visible actors include NASRDA, GEOSON, and members of the academic community. NASRDA has been in the driving seat of the NGDI bill. Following the first draft of the NGDI in 2003, NASRDA embarked on some implementation strategies such

as the inauguration of the NGDI Committee[10]. GEOSON has also provided a platform for stakeholders to review the NGDI policy.

5.1.4.2. Stakeholder Coordination

Stakeholder coordination remains a major challenge in Nigeria's geospatial ecosystem, despite the growing awareness of the relevance of geospatial technology and the need for stakeholders to collaborate. The closest coordinating structure is GRID3. Its governance structure is multi-layered with the National Steering Committee at the highest level. The National Steering Committee consists of the Ministers of seven ministries including the Ministry of Health, Education, Agriculture, etc. It also includes the governors of seven states– Edo, Ekiti, and Kaduna to mention a few, as well as the Director General, and the Nigeria Governors Forum. Other federal agencies also make up the committee such as the Central Bank of Nigeria, the National Bureau of Statistics, the National Population Commission, etc. Non-profit and international organizations such as Bill and Melinda Gates Foundation, Center for International Earth Science Information Network, Columbia University, and World Bank are also members of the National Steering Committee.

Next to the National Steering Committee is the National Technical Committee, made up of experts and technocrats in the departments and agencies represented. Some additional MDAs in the technical committee include National Boundary Commission, Universal Basic Education Board, etc. A full list of the members of the National Steering and Technical Committees can be found here. The NTC is followed by the Secretariat, which comprises representatives from agencies who meet to share understanding and develop a complimentary workplan. The National Steering Committee is co-chaired by the Ministry of Finance and the Ministry of Budget and National Planning. These ministries were selected to chair the committees because of the convening power they wield among all ministries of the government.

Aside from GRID3, another coordinating platform that stands out is the Geoinformation Society of Nigeria (GEOSON). Although a voluntary professional association with no convening power as GRID3, the association serves as a connecting platform for stakeholders within the organizations, including the private sector, academia, and indigenous non-profit organizations, who are not represented in the GRID3 committees.

Beyond the federal level, Kaduna state has also developed the GIS Development Committee, which is a coordinating mechanism. It consists of all MDAs within the state involved in the collection of geospatial data including Kaduna Geographic Information Service (KADGIS), Kaduna State Bureau of Statistics (KDBS), Kaduna State Urban Planning and Development Agency (KASUPDA). The committee is domiciled with the Chairman and the Commissioner of Planning and Budgets Commission.

A successful example of stakeholder coordination exists with the non-polio-integrated SI campaign being conducted by the Emergency Operation Center (EOC) at the NPHCDA. The campaign comprises COVID-19, measles, meningitis, and yellow fever supported by GAVI. The government through the NPHCDA Emergency Operating Centre (EOC) sets the agenda and leads partner coordination for this campaign. All team members on this campaign have the same training, tools, scope of work, supervisory checks, and reporting platform regardless of their partner organization affiliation. There is also one technical and strategy working group, with all partners working towards government goals.

Funds for the field component of the integrated campaign are provided by GAVI but payment is made

[10] Kufoniyi, O. and Agbaje, G. I. (2005). "National Geospatial Data Infrastructure Development in Nigeria: The Journey So Far". Paper presented at FIG Working Week 2005. Available at Microsoft Word - ts41_07_kufoniyi_agbaje.doc (fig.net)

to the staff through UNICEF or WHO. Government counterpart funding also goes through these channels. Beyond these structures, development patrons/donor organizations provide leadership, interventions, and funding for stakeholders in the ecosystem.

5.1.4.3. Capacity Building

The development of human capital is one of the key priority areas for most actors within Nigeria's geospatial ecosystem. Currently, there are three approaches used to offer training and skills development programs within Nigeria:

1. **Non-government organization-led:** This is the most common approach used within Nigeria's ecosystem in which non-government actors take training initiatives that are mainly tied to projects, with a finite run time and resources. This approach is the most prevalent due to the funding and skills that non-government actors normally have. For example, eHealth trained staff at the Kaduna State Bureau of Statistics and sent support staff to work with them throughout the six-month training period. The training focused on the use of GIS in data generation and analysis.

   DSN also offers free mass online and offline training across Nigeria, building a network of learners who can collect geospatial data for the country when needed and reportedly training over 500,000 learners in artificial intelligence, data science, and digital skill-related courses.
2. **Government agency-led:** In this approach, government agencies provide training to other actors throughout the country and at all levels of government. For example, NASRDA provides free training to members of academia and other government actors at multiple levels. This approach relies on funding from the government and other donors.
3. **Academia-led:** Geospatial data training can also be driven by both public and private universities and colleges. One of the typical examples is the Obafemi Awolowo University (OAU), which offers certificate, undergraduate, and post-graduate qualifications in GIS. These academic offerings are regulated by the National Universities Commission (NUC). The university further houses AFRIGIST and ACSSTEE-E – UN institutes – which focus on building geospatial data skills across Africa.

Asides from these institutions, other capacity building resources include online learning platforms (including those hosted by indigenous private sector organizations), workshops by private sector organizations such as ESRI, inter-agency exchange programs, and ad-hoc training. Also, free and open-source software and data such as QGIS and GRID3 are available for people to train and build their capacity.

Even though there are three main approaches used within Nigeria's geospatial ecosystem, most capacity-building efforts are driven by non-governmental organizations and the private sector. A mix of the three approaches is seen at the national and state level. There are no clear linkages between the national and state levels when it comes to capacity building. Although this may be the case, NASRDA and GRID3 provide a linkage between the national and state levels as they cascade their training to actors at sub-national levels with support from the donor community.

Major Actors and Sectors

Capacity building within Nigeria's geospatial ecosystem is driven by academia, government, non-profits, and private actors (as highlighted in the previous section). The major actors driving capacity-building efforts in Nigeria include NASRDA, GRID3, OAU, AFRIGIST, and ARCSSTEE-E. A summary of the actors, what they do, and the type of training that they offer are given in Annexure 4.

5.1.5. Stakeholders' Reflections on what is working within the ecosystem

During the assessment and validation forum, stakeholders were asked to identify what is working in the country's geospatial ecosystem currently across the three pillars- generation, analysis, and operationalization (Annexure 8-- The contributions). What was identified by the participants at the stakeholders' forum is given in Table 11.

Table 11: Summary of the existing effectiveness within the geospatial ecosystem

Geospatial Data Generation	Collection of diverse forms of geospatial data at national and state levels	Diverse forms of geospatial data are currently being collected by stakeholders within the value chain. These collections are sometimes complementary and contribute to the depth of data within the ecosystem. Some of the acknowledged data included: baseline data, data on vaccination campaign outcomes, building footprints, energy infrastructure data, boundaries, ward and enumeration data, census data, settlements, and population estimates to mention a few.
	The role of the GRID3 program in data generation and stakeholder coordination	GRID3's provision of settlement-level population data, infrastructure data, and boundary data, supports institutions that cannot afford comprehensive data generation. In addition, the steering committee structure of GRID3 – comprising different government actors – is achieving effective stakeholder coordination at the national level.
	Adoption of digital data collection tools	More digital tools are being deployed for geospatial data collection in Nigeria. These tools include ODK, Kobo toolbox, GPS, Drones, CAPI Devices, and ARCGIS Survey 123.
	Continuity in data collection	The transition of the data collection program of the Polio campaign from eHealth to GRID3 demonstrated some form of sustainability and ensured that geospatial data are available for health use cases.
	Increasing adoption of open-source secondary sources	Geospatial stakeholders are increasingly using open-source secondary sources such as WorldPop, OpenStreetMap, Humanitarian Data, and Accuweather.
	Quality control on the field	More stakeholders within the ecosystem are integrating quality control and assurance mechanisms into the data collection tools to minimize errors during field data collection.
	Steps taken to actualize the NGDI bill	Over the last 10 years, several steps have been taken toward the development and passage of the NGDI and the geospatial bills. Currently, stakeholders are awaiting the enactment of the NGDI bill – actual timelines are unknown.
	Different coordination structures at the state level	Some states have developed institutional coordination mechanisms for geospatial data. An example is the GIS development committee in Kaduna state, which is made up of key government agencies and departments involved in the generation and analysis of geospatial data.
Geospatial Data Analysis	Inbuilt Data Quality Checks in geospatial data collection tools	Data collection tools being utilized in the country have inbuilt data quality control (coded) to clean the data during collection
	Open-source tools for data cleaning and analysis	Several open-source tools exist and are increasingly being used for data cleaning and analysis. These tools include Microsoft Excel, QGIS, FME, SQL DB, Access DB, JOSM, EMID (Electronic Management of Immunization Data), and MSDAT (Multisource Data Analytics & Triangulation). In addition, proprietary tools such as ArcGIS are being used for data analysis.
	Online platforms for visualization	Stakeholders are also familiar with online platforms to digitize geospatial data visualization including Tableau, PowerBI, GeoServer, Carto, GitHub, and other locally built platforms. These provide real-time data checking.
	Non-digital visualization	Non-digital visualizations such as reports, printed maps, tables, and charts are also widely used in the ecosystem, especially at the local government levels
	Availability of skills for data analysis	Skills available for geospatial data analysis in the ecosystem. Stakeholders acknowledged that the skills are mostly basic to intermediate levels of geospatial analysis.

Geospatial Data Operationalization	Several use cases across different sectors	The geospatial ecosystem in Nigeria has contributed several use cases across different sectors. These may range from the health sector (COVID 19 management and tracking, polio eradication, digital mapping to use in routine immunization and vaccine campaigns, and health facility monitoring) to agriculture (soil testing and harvest predictor in food security, mapping settlement grazing reserves, MTN Network's animal identification, and management solution) to mobility data use cases (COVID19 application and human mobility pattern).
	Exploratory platforms to build use cases	Exploratory platforms such as ESRI Africa geospatial platform and osgeo.org (the first Africa open-source geospatial laboratory) are enabling the communication of use cases.
	State-level application of GRID3	GRID3 data are now actively being used by state-level actors to generate last-mile use cases in areas like vaccine microplanning.
	Access to international data repositories	Nigeria's geospatial ecosystem is exposed to international data repositories such as the humanitarian data exchange platform with over 20,000 datasets available for use cases.
Stakeholder Coordination, Capacity Building, and Governance	Launching of communication satellite and implementation of African geodetic reference frame	Launch of the communication satellite and the implementation of the African geodetic reference frame (AFREF) enabled the planning and execution of development activities.
	Specialized institutions for training	Specialized institutions dedicated to training on geospatial data exist. Examples include AFRIGIST and ARCSSTE-E.
	Regulatory bodies for academic institutions	National Universities Commission (NUC) regulates academic institutions-universities and polytechnics-to ensure standards.
	Free and open-source software and data like QGIS and GRID3 portal deployed for capacity building	Free and open-source data and platforms such as GRID3 data portal and QGIS are used for training.
	National and international geospatial conferences hosted for Nigeria-focused geospatial conversations	Several conferences both at the national and international levels were hosted by geospatial organizations, societies, and private sector organizations providing platforms for Nigeria-focused conversations. In Nigeria, GEOSON national conference provides such a platform.
	Availability of affordable online courses	There are several massive open online courses on geospatial data that are affordable for people to access. They are also flexible which allows people to learn at their own pace.
	Ad-hoc training for different sectors on geospatial analysis	Different organizations conduct ad-hoc trainings within their projects and for governments

5.2. Challenges

5.2.1. Geospatial Data Generation

Despite the major strides that Nigeria has made in the generation of geospatial data, stakeholders within the ecosystem still face challenges in generating various geospatial data forms. The landscape assessment of the geospatial ecosystem of Nigeria revealed the major challenges into the following main themes:

Lack of harmonization and standardization of geospatial data collection efforts and outputs

Currently, the geospatial data ecosystem of Nigeria has no universally accepted data generation standards to guide stakeholders on how to generate different forms of data. The lack of standardization causes polarization in data generation practices among different actors. Each organization uses its standards and practices during data generation.

The polarization in data generation is further exacerbated by the lack of coordination (coordination is discussed in the policy, governance, coordination, and capacity building section of this report) and the harmonization of data generation efforts among different key actors. Most agencies and/or actors work in isolation, generating the same data but using different standards and metrics. For example, the National Population Commission, INEC, and OSGOF generate their respective ward data which differ from each other in terms of format and standard. Data generating and analytics stakeholders have found it

difficult to determine which of the sources is reliable and standard for usage.

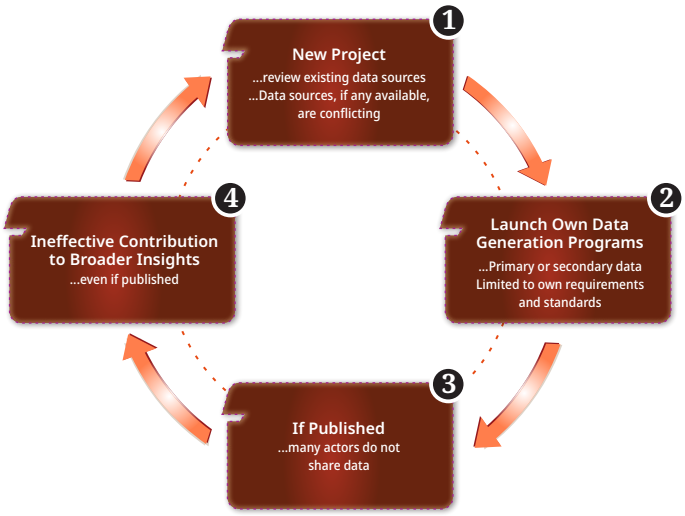


Figure 6: Impact of the lack of geospatial data harmonization

Co-registration and synthesis of different geospatial datasets are impossible without shared standards. For instance, the lack of an official digital baseline map[11] has resulted in the generation of various forms of data that cannot be compared, integrated, or modeled. Also, the overlay of rivers and topographic maps often results in river open contour lines and even water-shared boundaries. Similarly, city maps overlayed with river or road data often show the road over buildings. The major cause of this erroneous overlay is a difference in the Coordinate Reference Systems (CRS) of datasets resulting from a lack of standardization across federal and state systems.

Limited geospatial data sharing and access among stakeholders

Geospatial data sharing and data access among actors remain a challenge in Nigeria's geospatial ecosystem. During the landscape assessment, multiple actors referenced the geospatial industry as a new and strategic area for their funding. They noted that the data they generate provide them a competitive advantage over others, in terms of funding and relevance, acting as incentives not to share. This is not only seen among private sector actors but government agencies as well. Also, government-generated geospatial data is difficult to access, largely because of the licensing restrictions and cumbersome process of accessing data.

For instance, Cizoti wanted to generate geospatial data for one of their projects but realized that the data had already been generated by another agency. The agency could not share its generated data with Cizoti, even if they knew that it would inform critical work. Some actors also noted that some donor agencies do not share geospatial data even for their supported projects. Indigenous private sector actors also noted that the data they generate is not recognized and accepted by government agencies. Instead, government agencies use foreign secondary data sources.

However, GRID3 and eHealth Africa are model institutions – representing both government and private sector – that have open and publicly accessible geospatial data within the ecosystem.

Inaccurate, incomplete, and un-updated geodata

In Nigeria, the data is generated using both primary and secondary sources. However, most actors use secondary sources more often due to the high costs of primary data generation. Most of the participants in the landscape assessment noted with concern the quality gaps that secondary geospatial data sources have within the ecosystem. NPHCDA attributes data inaccuracies and incompleteness to satellite imagery and map development's inability to capture high population dynamics – rapid shifts in population and migration – in the country. Some regions and states have very fluid populations with high movements while other regions are more static.

Incomplete and missing data are mainly due to inconsistencies in generating data and aggregation of data. For example, the NPHCDA recorded cases of

[11] A base map is the graphic representation at a specified scale of selected fundamental map information; used as a framework upon which additional data of a specialized nature may be compiled (American Society of Photogrammetry, 1980).

entire settlements not captured in the GIS maps during microplanning activities in some states because neighboring settlements were depicted as single dwellings. The aggregation of data sometimes causes an unrealistic representation of data and loss of detail. Another example is Cizoti's flood prediction project in North Central Nigeria, where they observed some missing rainfall values and irregular patterns of the stream flow – all affecting their predictive model. Environmental data such as rainfall and stream flow patterns sourced from secondary sources are not usually accurate and up-to-date. This is because the data must be collected over a long period – from 20 to 30 years – hence, it is not easy to validate in the field. Therefore, Cizoti estimates missing data using mathematical computation, but this affects the accuracy of the model.

Further, different actors also note that data from secondary sources – including GRID3 – are not comprehensive enough to cover data needs for projects. Therefore, stakeholders rely on international sources such as WorldPop and OSM for their data. They noted the consistent data flow as the main advantage that these data sources have over the local ones.

High data generation costs; Low funding

Inadequate funding is one of the major challenges that Nigeria's geospatial ecosystem encounters.

Government agencies - NASRDA, NPC, and OSGOF - and states rely heavily on government budget allocations, which are often not enough to cover their activities or are not even provisioned as noted in several states. While there is additional funding from donors and other stakeholders, actors still note the need for more funding to strengthen data generation efforts.

Limited human capital and skills for data generation among stakeholders within the Ecosystem

Despite the presence of a spatial agency in Nigeria (NASRDA) and a mapping agency (OSGOF), respondents in this assessment noted that there is limited staff dedicated to the generation of geospatial data. Most government actors – beyond the mandated agencies – noted that they do not have staff whose role is solely geospatial data collection, hence making it difficult for them to multitask with their other roles. Government actors sometimes outsource data collection services to the private sector but even this is not enough. This challenge may be indicative of the lack of coordination amongst government agencies on the responsibilities of geospatial data generation and coordination.

Further, insights from the Landscape assessment showed that there are some staff members with geospatial data generation skills. Some stakeholders noted that even basic skills such as the interpretation of maps remains a challenge and hinders the exploration of new geospatial data forms within an ecosystem.

Geospatial data-generating actors also noted a lack of sustained capacity-building initiatives within the ecosystem. This was mainly because most capacity-building projects are driven and funded by donors, not government or key local actors. For instance, in 2016, GRID3 supported Kaduna state with geospatial data-generating training for a year and six months. The state is keen on having sustainable capacity-building initiatives; hence their GIS committee has prioritized capacity building in their action plan.

On skills development, the landscape assessment also showed a lack of information and skills on the capability and functionality of geospatial infrastructure for work automation, efficiency, and effectiveness. This made actors – especially public sector actors – accord less value towards the use of advanced and high-end geospatial tools and infrastructure for data generation.

Lack of a centralized geospatial data repository for all stakeholders within the ecosystem

Nigeria currently has no centralized geospatial data repository that all stakeholders can utilize. As highlighted earlier in this section, geospatial data-

generating actors mostly work in silos within the ecosystem. The lack of a centralized data repository has led to duplication of efforts, increased costs of generating already existing data, and difficulties with data access.

The current practice is that data is stored locally by individual stakeholders, apart from open sources like GRID3 and the eHealth Africa portal. Some stakeholders have made efforts to develop a centralized repository but could not execute it due to regulations and the high costs of setting up such a platform. However, Kaduna state has made significant progress in developing a centralized data repository, which is currently used by actors both within the state and federal levels.

Generated data is not disaggregated and has limited spatial resolution

Stakeholders mentioned that the data generated is not granular enough to allow for the generation of multiple insights. They note that data should be disaggregated into micro-level units. Currently, the available data exist in an aggregated from, thus, making it difficult to generate multiple insights.

No incentives for the private sector to share their data

With no incentives to share privately funded generation efforts, private sector stakeholders are hesitant to share their data. Beyond this, there is no established process for sharing independently generated data with government actors.

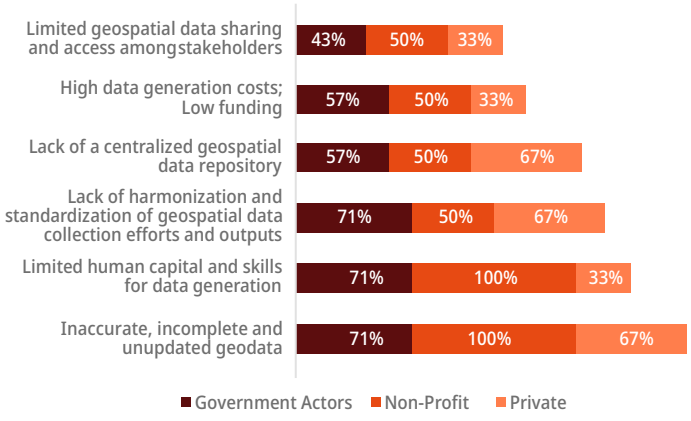


Figure 7: frequency (as a percentage) of how often a challenge was mentioned by the actor's category

5.2.2. Geospatial Data Analysis

Combining spatial data remains challenging because of the disparities in standards, quality, compatibility, confidentiality, and update frequency, among others. Unfortunately, analyzing and integrating geospatial data into decision-making is not without its obstacles. The landscape assessment of Nigeria's geospatial ecosystem summarized the crucial challenges into the following main themes data standardization and interoperability, data quality, capacity building, resource pooling, and funding.

Poor data quality for data analysis

A lot of substandard data exists, caused by limited expertise in how to collect and process data or simply human error. Lack of standardization plays a large part in this as stakeholders reported that it caused analysts to miss critical details. Other inaccuracies in geocoding and digitizing physical places and features can cause a cascade of inconsistencies in their geographic representation. For example, eHealth Africa mentioned that the lack of standardization which causes poor data quality led to losing a considerable amount of collected data during the cleaning process. Errors in data collection can also be due to the use of manual tools such as paper surveys.

Despite this concern, some organizations have established standardization models. An organization like NPC usually ground truth and validates data from secondary sources; this is a policy to ensure that the data is of good quality and can better inform their decision(s) while WorldPop's secondary sourced data are often harmonized and fact-checked with several other data layers to ascertain usability and accuracy. A private organization like Geoinfotech also confirmed that metadata of secondary data is adequately checked and overlaid on validated data for revalidation purposes.

Unavailability and inaccessibility data

The availability of data is one of the biggest challenges. Typically, the vector or spatial data are

obtained on an as-needed basis. For example, NASRDA only gathers some datasets when there is a need for them. Data sharing and data improvement are major challenges within Nigeria's geospatial ecosystem. Many agencies have geospatial data within its repository but refuse to share – with significant number of actors not even aware that such datasets exist within their organizations.

There is no open-source algorithm to localize and exchange analytics code. Natview referenced the challenge of the geospatial landscape being segmented in the country, with many actors working in isolation – highlighting the need for a greater focus on knowledge sharing and capacity building to fill the gaps associated with advanced analysis.

Limited use of advanced geospatial data analysis

Similarly, there is a dearth of more advanced geospatial analysis within the Nigerian geospatial ecosystem such as web-based computing and deep learning tools. Geospatial analyses have been limited to basic GIS analysis with limited utilization of advanced geospatial techniques or tools like machine learning or artificial intelligence. Stakeholders interviewed showed an interest in the deployment and upskilling in advanced geospatial capabilities like Artificial intelligence (AI) and Machine learning (ML).

Multiple analyses, no insight

Despite the prevalence of various geospatial analysis outputs, including dashboards and maps, stakeholders noted that these do not necessarily translate to insights. This is due to several factors including limited awareness and understanding of these analysis outputs by the non-technical end users. Even when the end-users are aware of these analysis outputs, they may not be able to access them. The outputs may not be user friendly in the case of dashboards or are communicated in ways that the end-users may not understand – such as the absence of legends on geospatial maps. Further, when end users discover disparities between analysis output and field data and there are no feedback channels to update those analyses, these data become non-functional.

Limited infrastructure

The lack of tools required for geospatial data analysis is a major challenge in the ecosystem. These tools include the internet, electricity/power, high processing computers, and proprietary software licenses. This affects both the organizations conducting the analysis and end users using the analysis output, especially for digital based analysis.

Low funding for geospatial data

Challenging issues have always existed for real-time data migration. In terms of pricing, it is cost-effective, and there is a need for a central server hosted in the cloud for smooth integration. However, managing a commercial cloud server on a national level can result in high costs, especially with lots of data migration. Migration of data using different APIs connectors also involves mounting and maintaining infrastructures so that visualization applications can use the data seamlessly.

The challenge of sustainability is closely linked to that of funding. The lack of funds for continuous licenses for visualization outputs beyond the funding lifecycle poses a challenge to sustainability. Funding is opportunistic and mostly driven by the need for collection and analytics. Limited options exist for funding of sustainability of continuous analytics. WorldPop and NPC affirm that no special funding is dedicated to geospatial analysis currently.

Funding and sustainability of visualization outputs are also a challenge in visualizing data. Dashboards and web-based visualizations are often expensive to maintain due to licenses and hosting fees. This poses a challenge for the end-users who might be unable to afford these fees. On the other hand, while paper maps are cheaper to maintain, they are difficult to

update and harmonize. In case missing data is discovered after a map has been printed then it can take a longer time for the map to get reprinted. These are instances that have been recorded by GRID3 and NPHCDA, where some settlements were not found or incorrectly lumped together on maps for microplanning.

Some stakeholders like NASRDA, Natview, and Cizoti address this challenge by building customized dashboards and web-based platforms that do not require a continuous subscription. NASRDA uses JavaScript and Geoservers to render web maps to reduce costs. Humanitarian Enhanced Platform for Development (HEDP) also encourages the use of open-source software for sustainability.

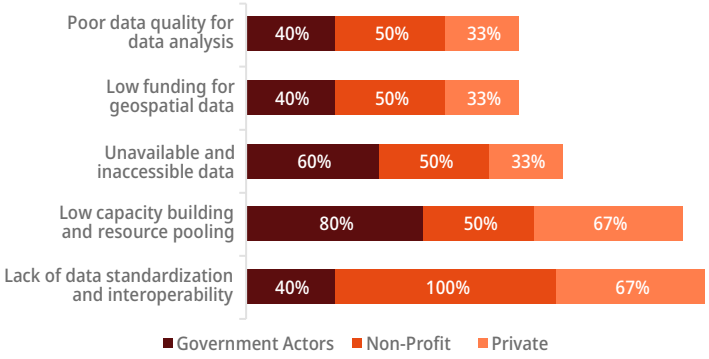


Figure 8: frequency (as a percentage) of how often a challenge was mentioned by the actor's category

5.2.3. Geospatial Data Operationalization

Duplication of use cases

Our research revealed that despite the existence of several use cases, there was no coordination for sharing and storage. This means that there is duplication of efforts with different agencies conducting similar use cases. This challenge is closely linked to donor activity. Donor organizations often unknowingly encourage competition and the duplication of efforts across stakeholders, as they do not communicate with each other when working on overlapping areas or issues.

Capacity limitations at state and local levels limit the localization of use cases

Despite the immersion of geospatial technology into the state, local, and ward levels, the capacity of actors at these levels remains limited. Several states and local governments do not have dedicated staff with basic GIS skills for the interpretation of geospatial maps. In cases where there are present, the staff is not well trained to use the maps optimally. The assessment revealed that sometimes maps are distributed to the local and ward levels with no clear instructions on the identification of features and structures. At other times they are not legible, the colors are not sharp, and the demarcations are not clear. This has greatly limited the usage of the maps at the local level. Nonetheless, actors such as GRID3 are working to train immunization officers at the state level on the utilization of geospatial maps for microplanning efforts. Beyond the health sector, there is a limited capacity amongst actors at the local levels of other sectors.

Lack of a Central Repository for Use Cases

Currently, there is no dedicated platform for sharing use cases with other players in the ecosystem. This is because use cases are often project driven and their outcomes are owned solely by project owners who may share these use cases on their websites or other platforms. This sometimes leads to the duplication of use cases by different actors.

Some actors produce use cases for research purposes and share them on customized platforms. An example is Geoinfotech's customized platform - Geostore. This platform contains some of their research work and training data sets. Some are made available for free, while others are for sale. SAMBUS geospatial, together with the Africa Geoportal, also has the Nigeria Geoportal platform with some free-to-access dashboards. eHealth Africa also has its data portal with free access to data sets, maps, and use case repositories.

Low levels of awareness of the benefits of geo-data

Despite the wide array of existing use cases, the country still has low levels of awareness of geospatial data and its benefits. The policymakers are receptive to geospatial data and technology, yet it is not prioritized especially for funding. This is primarily because information about geospatial data is not widely communicated. Academic and non-academic publications about geospatial data exist but are mostly used by existing actors in the ecosystem. The limited communication of geospatial data is linked to another major challenge in the operationalization of geospatial data, which is low levels of advocacy and lack of stakeholder coordination.

No dedicated platform for cross-learning of use cases

Post-evaluation learnings from projects and use cases across sectors are not shared due to the ad-hoc approach to use case development. For instance, learnings from use cases in the government sector are not shared with the private sector and vice versa. Also, there is little communication of use cases, data, best practices, and insights between experts in the private and public sectors, and academia to drive research products for public use. For instance, most research based on GRID3 data in Nigeria was conducted mostly by the private sector and non-profit organizations. Another example is the private mobile telecommunication operator, MTN's Animal Identification and Management Solutions (AIMS) for nomad movement tracking.

Hesitancy to embrace geospatial data

Although there has been commendable uptake of geospatial data by stakeholders in the country, some government stakeholders are still hesitant to embrace geospatial data. The existence of limited evidence of success beyond the health sector has made it difficult to secure the buy-in of some stakeholders. In some other cases, costs of infrastructure, license fees, and dashboard maintenance make it unattractive. The lack of internal technical capacity also limits the capacity of some agencies to utilize geospatial data and technology.

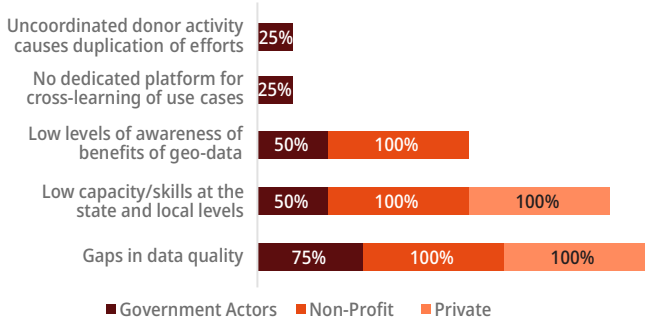


Figure 9: frequency (as a percentage) of how often a challenge was mentioned by the actor's category

5.2.4. Stakeholder Coordination, Governance, Policies, and Capacity Building

5.2.4.1. Governance and Policies

Lack of national geospatial policy: The absence of an active overarching policy to provide direction and coordination is a major gap within the ecosystem. Although, there is a draft of the National Geospatial Data Infrastructure (NGDI) policy which was drafted in 2003 and updated by stakeholders at the Geoinformation Society of Nigeria (GEOSON) conference in 2021, it is currently being reviewed at the country's National Assembly for legislative ratification.

The absence of an overarching policy for the geospatial ecosystem has led to several challenges including:

1. **Lack of delineated mandates: Mandate Conflict and Institutional Rivalry**

   Conflict exists among government agencies on the ownership of geospatial interventions in the country and the subsequent roles of relevant agencies. Currently, there are several government agencies with overlapping mandates on geospatial data generation (OSGOF, NASRDA, NBS, and NPC),

leading to mandate conflict and institutional rivalry. This mandate conflict impedes inter-agency cooperation and limits the advancement and advocacy efforts for geospatial data and technology within government agencies. This institutional rivalry also negatively impacts the effectiveness of GRID3 in the country.

2. **Lack of Standards for Data Harmonization and Interoperability**

   The generation of geospatial data in the country is being conducted by different organizations, each using its internal standards. This poses a challenge for data analysts who source data from different sources and thus expend time on data cleaning. The lack of accepted standards leads to spending significant time simply cleaning data before it is usable. For instance, timestamps may be from different time zones, co-ordinate reference systems of various geospatial data sources from different providers, or measurements may have been taken using different units that sometimes do not neatly convert between each other (metric vs. imperial).

   Given that no specific standards are widely used, the challenge of data interoperability is usually faced at the analysis stage. Presently in Nigeria, there is no framework guiding standardization and data interoperability that is generally acceptable and used. During the assessment, we discovered that organizations like AFRIGIST and NASRDA developed in-house policies to drive standardization and how data are used internally. Individual actors tend to have some sort of standards that they use or adapt based on the project they want to execute and the required data type.

3. **Duplication of Efforts by Stakeholders**

   The lack of a policy to delineate the roles of stakeholders in the ecosystem has led to multiple stakeholders performing the same tasks such as collecting the same set of data or the same type of analysis.

5.2.4.2. Stakeholder Coordination

Our assessment showed that stakeholder coordination remains a huge challenge in Nigeria's geospatial ecosystem. Some of the major issues regarding stakeholder coordination include:

No designated lead agency

The lack of a clearly designated lead agency in the ecosystem has made stakeholder coordination difficult for stakeholders within the ecosystem to lean to a particular government agency for coordination. This is closely related to the absence of a policy assigning the mandate to different organizations.

Limited collaboration among geospatial stakeholders

Limited collaboration among stakeholders in the ecosystem cuts across different sectors. In the government sector, for instance, mandate conflict has limited collaboration among relevant agencies. However, non-profit organizations have multiple coordination mechanisms that are either based on projects or thematic areas. There is also a lack of collaboration between industry and academia on applying existing assets (mobile network data, GRID3 to mention a few) to develop papers and products.

Lack of Incentives for Continued Participation

The assessment revealed that another challenge came from the lack of incentives to drive continued participation. In Kaduna, the GIS Development Committee has not been convened for a long time because of the busy schedules of its representatives. It is also important to note that in GRID3 and Kaduna State, there is funding to support stakeholder coordination. However, with GEOSON, the scenario is different with sustained participation given its status as a professional membership-based organization and its role as a non-profit organization.

5.2.4.3. Capacity Building

Capacity building was one of the key areas highlighted to be slacking by multiple stakeholders. Some of the major reasons for this are summarized as challenges in this section.

Capacity building initiatives have no sustainability plan

As highlighted earlier, most capacity-building activities are tied to projects and are mostly driven by non-government actors. This makes capacity-building initiatives finite because the funding and execution are tied to projects. Initially, corporate partners intend for the government to take up the management and funding of capacity-building activities post their support. Therefore, post-donor and corporate partner funding, the capacity-building program significantly declines.

Further, academia is mostly limited to providing the geospatial ecosystem with fresh graduates. However, post their graduation from universities or colleges, there are no lifelong learning opportunities in the form of continuous professional development short courses. The geospatial landscape assessment found that there are no lifelong learning opportunities due to the inability of staff to leave their jobs. This is exacerbated by the fact that their courses are not modular, but rather tied to the duration of the program.

Currently, AFRIGIST and ARCSTTEE – E have continuous professional development programs that are using a modular system. According to the academic community, modular systems provide learners in full-time employment with the opportunity to pick a module of interest as part of their continuous capacity development. The module accrues points that can allow the learner to later continue with classes and advance to getting the associated degree.

No coordination around capacity building systems

Dev-Afrique's assessment showed the prevalence of project-linked capacity-building initiatives amongst the government and the non-profit actors. There have been few efforts to consolidate the various capacity building initiatives amongst the various stakeholders – leading to a replication of fundamental geospatial training without a system to validate the historical training delivered by several actors to the government officials.

Similarly, the lack of coordination on capacity building within the geospatial ecosystem also leads to the disparity in the depth and scale of training conducted by actors within and outside the government. There are no uniform curricula, for example, the massive open geospatial training conducted by DSN and other non-profits for recent university graduates has not directly closed the gap in geospatial capacity demand in government (Kaduna state Bureau of Statistics is now adopting geospatial fellows from non-government actors). Although the opportunity to coordinate and centralize geospatial capacity building may rely on national geospatial actors like NASRDA and OSGOF, the lack of--coordination on capacity building of government agency, funds, and clarity of political mandates-, continue to limit the scalability and sustainability of capacity building within the system.

Limited funding and inadequate enabling technology for capacity development

All actors – sampled as part of the assessment – working to build geospatial capacities in Nigeria mentioned funding as one of the major challenges. Lack of funds affects their ability to generate data for student practice, get licensing for data analysis software, get required technology (power, hardware, and instruments), and support student apprenticeships. Further, as mentioned above, funding is mostly tied to projects, after which there are insufficient resources from local actors to sustain capacity-building efforts.

Currently, AFRIGIST has one of the best infrastructures and equipment for capacity building within the ecosystem. Even though this is the case,

AFRIGIST is a shared resource that caters not only to Nigeria's geospatial data needs but of the region.

Low-capacity building and resource pooling

Traditionally, geospatial data and geographic information systems (GIS) are in a class of their own, separate from data science and engineering fields, resulting in a small group of people in these fields being properly equipped to work with geospatial data. Geospatial data do not behave the same way as, say, tabular data, so many organizations lack the human capacity to integrate spatial data into their workflows because of the skills gap. Bridging that skills gap can be difficult, because not only do organizations have a limited talent pool to draw from, but they also must hire people with the unique skill sets and experience they need.

Currently, in Nigeria, various institutes offer a degree program in GIS-related fields from the first degree up to the Ph.D. level. Currently, the geography department of Obafemi Awolowo University, which is the mother department for geography and GIS-related programs does not have sufficient capacity to train using state-of-the-art technology in GIS. The lecturers within this department do not have the technical competency for advanced geospatial applications.

Owing to the peculiarity of the younger population in Nigeria's geospatial industry and the inability of most government agencies and institutes to retrain and retain them, the youths with the ability to drive the industry tend to seek better opportunities in private firms or outside the country.

Highly trained government staff are lost to better-paying organizations

The landscape assessment also found that there is a high staff turnover of trained geospatial data experts from government agencies to the private sector or NGOs. This is mainly due to better conditions of service offered by the NGOs and private sector. Some stakeholders noted that once the government actors are trained, they are likely to explore other work options, as the newly acquired skills make them more marketable and competitive within the ecosystem.

Generic and Obsolete/Rigid Curriculum

Existing training curricula do not reflect the advancement in technology, especially in artificial intelligence. The courses are not only generic but also do not address the specific needs of the ecosystem. This limits the demand for local training. Further, they are structured with little flexibility, which makes it difficult for working professionals to enroll.

Limited capacity of advanced geospatial analytics

The assessment showed that there is limited capacity for advanced geospatial analytics and training. There are currently few institutions that have staff trained in advanced geospatial analysis techniques like machine learning and artificial intelligence. However, with the growing demand for more robust insights, stakeholders have shown interest in building their skills in Artificial intelligence and Machine learning.

Capacity building programs are not aligned to the needs of stakeholders

Tied to the obsolete curriculum, stakeholders within the ecosystem noted that the current training initiatives and the current ecosystem needs are misaligned. With the need for more advanced skills to address the most pressing challenges, there is a need for GIS training institutions to align their training curriculum to the needs of the actors within the ecosystem.

5.3. Opportunities

5.3.1. Geospatial Data Generation

The Landscape assessment showed that many actors in Nigeria's geospatial ecosystem used geospatial data for quality control and enumerator tracking. However, over the past decade, Nigeria's geospatial data demand has increased since the polio use case and the introduction of GRID3. There has been increased awareness of geospatial data's ability to improve decision-making processes within the ecosystem among both government and private actors.

In the landscape assessment, most actors observed a positive shift in attitudes toward geospatial data. Specifically, NPHCDA highlighted the need for quality and expansion of programs to hard-to-reach communities has and will continue to trigger demand for geospatial data.

Further, some actors mentioned an increase in political support as a key opportunity and driver of success for geospatial data. Nigeria's geospatial ecosystem has recorded a steady increase in political support, for example, states like Kaduna and some agencies (e.g., LAMATA) have government budget allocations for geospatial data.

Table 8: Challenges and opportunities within the geospatial data generation pillar

	Challenge	Opportunities
Data Generation	Geospatial data collection efforts are not harmonized, standardized, and coordinated among stakeholders	• Set up a national coordinating structure that is co-chaired by key geospatial institution • Establishment of an inter-organization technical working group to increase coordination and collaboration among geospatial data generating actors • Establish a centralized data repository
	Limited geospatial data sharing and access among stakeholders at all levels of the value chain	
	Inaccurate, incomplete, and out of date geodata	• Conduct regular data revalidation
	Need for more disaggregated and higher spatial resolution data	• Advocate for data generating agencies to collect data that is disaggregated to the lowest level
	High data generation costs; Low funding	• Funding allocations from government (such as subsidies for private stakeholders) and donor partners to support geospatial data generation efforts • Promotion of collaboration among stakeholders within the ecosystem to consolidate on efforts of others and avoid duplication
	Limited human capital and skills for data generation among stakeholders within the ecosystem	• Utilization of local talent to build local solutions
	Lack of a centralized geospatial data repository for all stakeholders within the ecosystem	• Expansion of the GRID3 geodatabase into a national centralized repository • Develop centralized repository or dashboard across levels and sectors • Set up an advisory committee within the office of the president • Use security use cases to drive government buy-in and build an investment case for geospatial data infrastructure
	No incentives for the private sector to share their data	• Incentives such as tax breaks can encourage private organizations to share their data • Recognition and acceptance of private sector-generated data by government agencies can serve as an incentive • The provision of an enabling business environment can also reduce the additional costs that the private sector incurs in generating and analyzing data

The opportunities highlighted in table 8 can be summarized using six main points:

1. **Increased collaboration and coordination among geospatial data-generating actors:** As discussed in the challenges section there is currently no harmonization of data-generation efforts within the ecosystem. However, multiple actors expressed the need for concerted efforts in the coordination and harmonization of geospatial data collection. They observed that there is an opportunity to reduce data generation costs, duplication of efforts, and siloed work.

   There is also a need for harmonized data generation and quality guidelines, as well as spatial data committees at national and subnational levels to ensure the effective and efficient use of resources and the standardization of data generation practice.

2. **Increased demand for geospatial data skills:** With the increasing demand for geospatial data observed within the ecosystem, there is a need for increased skills in geospatial data generation. Currently, there is a shortage of skilled workers in the public sector. Increased awareness of the need for training and the prioritization of training among actors – as seen in Kaduna and other states – provides an opportunity to explore. Similarly, stakeholders have also suggested a potential integration of the talent pipeline from mass capacity building programs like DSN training to address government geospatial shortages.

3. **Increase funding to support geospatial data generation:** There are opportunities for the generation of comprehensive and consistent geospatial data sets, training of the geospatial data workforce, exploration of new data forms, and expansion to a more robust collection infrastructure. However, the landscape assessment showed more funding is required for all of these to take place. The government has shown commitment by providing some resources towards spatial data activities, which provides a platform for more support from the donor community.

   Therefore, the provision of funding for the generation of geospatial data would be a key driver and first step in addressing most challenges within the ecosystem.

4. **Increased data updates:** The assessments showed that emphasis was placed on the validity of geospatial data to ensure accurate operationalization of the data. A suggested solution is open-source data validation through crowdsourcing (just like the Open Street Map).

5. **Expansion of the GRID3 Geodatabase into a national centralized repository:** The landscape assessment showed that GRID3's geodatabase – now housed at NASRDA – is widely used and the closest to a comprehensive geospatial data repository in Nigeria. There is an opportunity to expand the GRID3 repository into a nationwide centralized database. This would increase access to standardized data sets for further analysis and decision-making.

6. **Exploration of new geospatial data forms:** The assessment revealed that there are opportunities to explore new geospatial data forms such as mobile phone data to capture population movements and mobility patterns. The provision of incentives such as tax breaks can stimulate and encourage private sector organizations to share their data.

5.3.2. Geospatial Data Analysis

Combining multiple datasets into the same application or database for visualization and analysis should be a widespread practice in every industry today. This practice should be typically done by

centrally integrating existing public data from disparate sources that facilitate new analyses to be conducted more efficiently and at a lower cost. This practice would be particularly vital for those preparing for monitoring and responding to emergencies, natural hazard events, and disasters.

Geospatial data is a powerful tool as it links information to specific places in the physical world. It also shows relationships between different temporal-spatial instances, for example, microplanning in the health sector. Of course, there are many other applications where spatial data point and their relationships are applicable, such as mapmaking, urban planning, and disaster management.

Table 9: Challenges and opportunities within the geospatial data analysis pillar

	Challenge	Opportunities
Data Analysis	Lack of data standardization and interoperability for analysis	• Stakeholder coordination and standardized geospatial data forms • Build systems with standard APIs
	Multiple analyses, no insight	• Align analysis to specific objectives • Explore the use of multiple data analysis approaches to generate more insight
	Limited funding for geospatial data analysis: Cost of geospatial analysis software are exorbitant; increasing need to move from physical to cloud servers	• Budgetary provisions and allocations for infrastructure including software and licenses • Support transition from physical to cloud servers. • Promotion of the use of open-source tools. • Collaboration with other stakeholders • Improve services of NICOM SAT to facilitate internet services/capacity at the national level
	Limited use of advanced geospatial data analysis e.g., Artificial intelligence (AI) and Machine learning (ML)	• Enhance collaboration between institutions using advanced geospatial data analysis and those that are not. • Refocus capacity building interventions to include advanced geospatial data analysis
	Poor data quality for analysis	• Investment in capacity building programs for data generators • Implementation of the NGD to drive data standardization and coordination across multiple stakeholders
	Unavailability and inaccessibility of geospatial data for analysis	

The opportunities highlighted in the table can be summarized into the themes highlighted below:

Advance Analytics and Visualization

Basic analysis such as descriptive analysis, one-way and two-way ANOVA, is the commonly requested form of geospatial analysis within the government sectors. The government actors being the largest users of geospatial data in Nigeria are limited to the basics, not because of need but the limitation in knowledge and capacity to carry out advanced analytics. NASRDA, a major stakeholder in Nigeria's geospatial industry identifies leveraging AI/ML for more robust analysis and solutions.

ML and deep learning models, predictive analysis, location-based analysis, and capacity developed around them would further inform decision-making.

Stakeholder Coordination/Centralize Operation

A framework to harmonize and guide how geospatial data is received, stored, and shared, is considered an essential requirement. NASRDA believes harmonizing various actors within the geospatial industry and providing a framework that will be a broad guide that people can adopt and personalize, is going to aid sustainability at large. This framework would also guide the standard data format to be produced. It was identified earlier that so many actors operate in isolation thereby duplicating efforts instead of building on and improving existing capacities. NASRDA also mentioned there is a need for a central data hub, which would improve data accessibility and make spatial data readily available for analysis.

Frequent/Scheduled Updates of Geospatial Data

GRID3 has generated various datasets across different sectors nationwide and stated that updating geospatial databases regularly or at specific intervals serves as a great opportunity to improve access to the most recent datasets. Recommendations from our assessment suggest a yearly update of data and maps for microplanning, with consideration for the population dynamics and size of the country. GRID3 also supports the notion that centralized datasets, especially data on settlement and settlement extent for mapping, would also provide support for geo-enabled microplanning for the health sector.

Exploring sustainable solutions for the purchase of geospatial software licenses and cloud storage

There is a huge demand for transitioning data storage and hosting to cloud-based platforms from physical computer-based servers. Most respondents flagged this as a key area of need. Further, respondents mentioned the need for sustainable funding for the purchase of relevant analysis software and licenses. One way to overcome this hurdle is the exploration open-source platforms that allow for robust data analysis and visualization.

5.3.3. Geospatial Data Operationalization

Our interviews discovered multiple opportunities for growth across the ecosystem, but most could be sorted under a common theme. These are the four general buckets that the possible opportunities fell under.

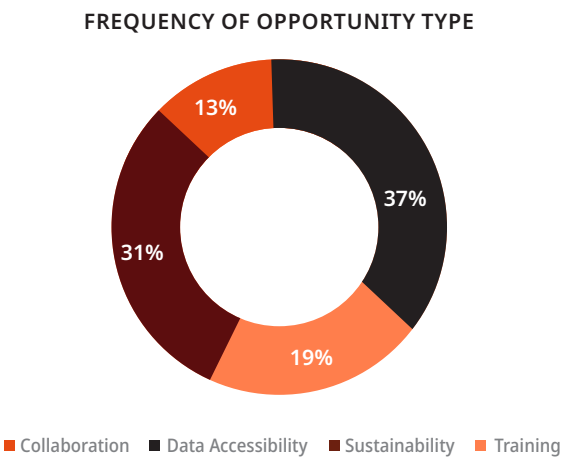


Figure 10: frequency (as a percentage) of how often an opportunity was mentioned by the actor's category.

Collaboration and sustainability were the two biggest areas for growth, but as overarching categories, they are vague in what that opportunity truly is. Owing to the variety of organizations, we interviewed, these categories must be distilled to their most broad.

Table 10: Challenges and opportunities within the geospatial data operationalization pillar

	Challenge	Opportunities
Data Operationalization	Low levels of awareness of geospatial data limiting government adoption despite high use cases	• Sensitization of high-level government officials on the importance of geospatial data for national development • Intensify awareness and advocacy using geospatial use cases
	Capacity limitation at the state and local levels limits the localization of use cases	• Advocacy on the localization of use cases • Collaboration between industry and academia on the application of use cases at local levels
	Lack of a central repository for use cases	• Develop a centralized repository for use cases • Host use case seminars for actors within the ecosystem
	Low levels of awareness of the benefits of geo-data	• Shared learning and curriculum update to focus on use cases • Implement an integrated national use case repository • Organize use cases-focused conferences by geospatial societies, MDAs, and private organizations • Explore the utilization of the Africa geoportal by ESRI
	There is no platform for sharing use cases within the ecosystem	
	Hesitancy to adopt geospatial data	
	Lack of synergy between industry and academia on documentation of use cases through publications and public lectures	• Support the development of more white papers by academia on geospatial data for adoption by the industry and government

Opportunities highlighted in table 9 can be summarized using the following points:

- **Communication and Collaboration:** This applies to all actors in the geospatial ecosystem. Inter-governmental, as well as public-private collaboration on use cases, as well as communication of learnings, best practices, and data, should be encouraged. Of specific interest is a collaboration between academia and experts in the private and public sectors for research and development.
- **Use Case Repository:** To facilitate communication of shared learnings, a use-case repository should be developed. This would help prevent duplication of efforts and foster collaboration across actors. This could be complemented by a use cases conference by geospatial societies, MDAs, and private organizations.
- **Expansion of Use Cases beyond Microplanning:** Some stakeholders within the health sector noted the opportunity to use geospatial data to evaluate the performance of the microplanning strategy. This can be achieved by combining geospatial data with data from collected with ODK after implementation. Geospatial data can serve as baseline and target data, while post-implementation data will provide actual coverage.
- **Sustainability:** To ensure the sustainability of use cases beyond project funding, innovative funding arrangements need to be implemented. For instance, as part of the pilot case plan implementation for any project, budget costing for subsequent maintenance should be included in the budget. Also, counterpart funding from inception with a strong sustainability plan can be explored. The counterpart funding can be shared among several relevant government agencies to the use-case to reduce the financial weight on a single government agency. This will also help drive inter-agency collaboration.

  Another dimension to the sustainability of use cases is to increase the localization of geospatial use cases. Our findings showed the need for a bottom-up approach in the development of use cases, by including end-users and local actors in the development of geospatial data outputs such as maps and dashboards. This will ensure that outputs are tailored to their specific needs and current capacity levels.

• 5.3.4. Stakeholder Coordination, Governance, Policies, and Capacity Building

5.3.4.1. Governance and Policies

Our assessment showed that getting the NGDI bill will go a long way in advancing the geospatial ecosystem. The assessment also suggested - to have an independent geospatial information management structure directly under the Office of the President or Vice-President that is responsible for standards and structure and dedicated solely to driving these policies and governing the ecosystem.

5.3.4.2. Stakeholder Coordination

Most of the assessed stakeholders agreed with the value of having stakeholder coordination in the ecosystem. This interest can be leveraged to bring together stakeholders in the sector. Pending the enactment of the NGDI bill, collaborations, especially public-private partnerships can be explored to advance the ecosystem. Examples of such partnerships include the GRID3 and DSN partnership on capacity building, Natview Foundation and Kaduna State Government partnership on capacity building and the Memorandum of Understanding signed between NASRDA and Cizoti Nigeria Limited to promote capacity building[12].

5.3.4.3. Capacity Building

Growing demand; Limited skills

The assessment showed a growing demand for geospatial data usage, but less skilled personnel to manage it. Few institutions are running sustainable capacity development efforts. There are opportunities to invest in more capacity-building efforts within the ecosystem.

Also, there are still gaps in basic skills such as the interpretation of maps for decision-making. This entails that there is a need for more segmented modular training – i.e., starting from basics and advancing to more complex skills. The development of new skills will enable Nigeria to explore new data forms and analysis methods to enable policymakers and program implementers to maximize their social impact.

The assessment helped to identify that if there are fellowship, scholarship or post-doc, and post-doc exchange opportunities in academia, it would encourage young adults to be more active in academic spaces. It was found that the geography department of OAU has about 11 out of 15 lecturers on the Ph.D. level and above. If partners and funders can put in place an MoU with tertiary institutions of repute, it can ensure that a sustainable system is in place within academics.

Also, DSN for example is a strong community of enthusiastic data users interested in geospatial data. Investing in the capacity building should be a long-term base and user training should be segmented. User segmentation can be trained in three ways.

- Train to perform analysis– this is majorly the youth, the young and energetic group that will oversee data collection, perform analysis, and visualize data. They are the class of people who follows the trend of technological advancement the most and can easily understand, interact, and make use of geospatial technology.
- Train to accept or adopt insight – the mid-level or senior officers who supervise the younger group need to understand the benefit and purpose of adopting the technology.
- Train to understand– this is majorly the top-level officials of the government. They are required to understand geospatial technology to inform and defend policies using spatial technology.

This training needs to focus on and be tailored to specific industry needs. There should also be free learning resources that make use of indigenous content and examples that learners can relate to easily.

[12] NASRDA Director Emphasizes the Importance of PPP in Promoting National Development - Space in Africa (africanews.space)

Table 11: Challenges and opportunities within the geospatial data cross-cutting sub-pillar

	Challenge	Opportunities
Governance and Policies	Mandate conflicts and institutional rivalry	• Review of the NGDI bill to update and integrate new development in the industry • Expedite the enactment of the NGDI bill • Establish stakeholder coordinated structure within the ecosystem • Establish a national steering committee to oversee actors within the space
	Lack of standards for data harmonization and interoperability	
	Lack of National Policy for the democratization, ownership, and integration of data / Delay in implementation of the NGDI bill	
	Duplication of efforts among actors	
Stakeholder coordination	Lack of a clearly designated lead coordinating agency within the ecosystem	• Convene relevant stakeholders in development and implementation of policy by Ministry of Budget and National Planning with clear definition of roles and responsibilities • A national coordination structure should continuously bring all the stakeholders to the round table to resolve institutional rivalry and set guidelines for collaboration
	Lack of incentives to drive continued participation	
	Lack of delineated mandates among agencies within the ecosystem	
Capacity Building	Capacity-building initiatives are not sustained and monitored for quality control	• Secure political buy-in to training relevant institutions on state's priority use-cases • Develop an inventory of courses and curriculum to enable regulatory agencies to access and accredit the courses e.g., IVUC, NBTE, and professional regulatory body • Regular refresher training and integration of feedback mechanisms into trainings. • Implementation of train-the-trainer model by scaling up the skills and competencies of government staff • Integration of assessment of needs (to avoid duplication of training) prior to the commencement of new capacity building for government agencies
	Lack of coordinated capacity building efforts	• Partner with other stakeholders to enhance the effects of training • Set up of a national coordination working group to coordinate and align government trainings
	Limited funding for capacity development	• Budgetary allocation and donor support
	Highly trained government staff are lost to better-paying organizations	• Incentivize GIS-related positions within government to ensure employee retention
	Training not specific – too generic for current needs within the ecosystem	• Design trainings for different levels – i.e., beginners, intermediate, advanced, and strategic (for policymakers and leaders. It should include business and policy aspects) • The curriculum should be clearly defined, harmonized, and standardized • Conduct assessment of needs before the commencement of training
	Obsolete/rigid curriculum on GIS	• Review of curriculum to include modern technologies regularly • Courses should be modularized to accommodate short courses
	Limited capacity of advanced geospatial analytics	• Support capacity development in advanced analytics (power, hardware, and software) • Training agencies should partner with local actors that are doing advanced analytics
	Poor capacity building and resource pooling	• Focused capacity building tailored to specific needs – Conduct assessment of needs • Collaboration with other stakeholders • Inter-agency capacity transfer • More accessible online/in-person training and mentoring fo skills development

6. The Geospatial Stakeholders' Forum:

Exploring the Opportunities for Investment

This section summarizes the key opportunities for investment within the ecosystem. Dev-Afrique held a geospatial stakeholder consultative forum – which brought together key geospatial stakeholders in the government, private, non-profit and academia in Nigeria - to drive discussion and alignment on priority challenges and their proposed solutions. The geospatial stakeholders' forum is the culmination of the end-to-end assessment of the geospatial ecosystem (Annexure 7-- List of attendees).

During this stakeholders' forum, participants aligned on the most feasible and the most impactful challenges for the geospatial community (donors and local actors) to prioritize for immediate interventions (Annexure 9 for snippets of the session). Dev-Afrique categorized these challenges and solutions into the most associated pipeline. Summary of the most impactful and feasible challenges alongside the proposed opportunities as aligned by the participants at the stakeholders' forum are given in Table 12.

Table 12: Summary of the existing effectiveness within the geospatial ecosystem

Geospatial Data Generation	
Highly impactful and feasible challenges to address	**Aligned Solutions**
Geospatial data collection efforts are not harmonized, standardized, and coordinated among stakeholders	• Set up a national coordinating structure to put in place a steering committee that is co-chaired by key geospatial institution • Establishment of an inter-organization technical working group to coordinate geospatial data generation efforts
Limited geospatial data sharing and access among stakeholders at all levels of the value chain	
Poor accuracy, and completeness and are not comprehensive	• Conduct regular data revalidation
High data generation costs; Low funding	• Funding allocations from government (such as subsidies for private stakeholders) and donor partners to support geospatial data generation efforts • Promotion of collaboration among stakeholders within the ecosystem to consolidate on efforts of others and avoid duplication
Need for more disaggregated data	• Advocate for data generating agencies to collect data that is disaggregated to the lowest level
Data are unavailable and inaccessible for analysis	• Regular data updates • Develop a national centralized geodata portal for all stakeholders to access within the ecosystem • Institute a national geospatial data-sharing policy
No centralized national geospatial data infrastructure	• Develop a centralized repository or dashboard across levels and sectors
No incentives for the private sector to share their data	• Recognition and acceptance of private sector generated data by government agencies can also serve as an incentive
Geospatial Data Analysis	
Highly impactful and feasible challenges to address	**Aligned Solutions**
Inadequate enabling technology (power, software, hardware, instruments)	• Explore open-source software
Limited funding for geospatial data analysis: Cost of geospatial analysis software are exorbitant; increasing need to move from physical to cloud servers	• Budgetary provisions and allocations for infrastructure including software and licenses • Support transition from physical to cloud servers. • Promotion of the use of open-source tools. • Improve services of Nigerian communication satellite (NICOM SAT) to facilitate internet services/capacity at the national level

Geospatial Data Operationalization	
Highly impactful and feasible challenges to address	**Aligned Solutions**
Capacity limitation at the state and local levels limits the localization of use cases	• Integrate capacity development on use cases into program design and implementation
There is no platform for sharing use cases within the ecosystem	• Shared learning and curriculum update to focus on use cases • Implement an integrated national use cases repository • Organize use case conferences by geospatial societies, MDAs, and private organizations
Low levels of awareness of geospatial data limiting government adoption despite high use cases	• Sensitization of high-level government officials on importance of geospatial data for national development • Intensify awareness and advocacy using geospatial use cases
Lack of synergy between industry and academia on documentation of use cases through publications and public lectures	• Support the development of more white papers by academia on geospatial data for adoption by the industry and government
Stakeholder Coordination, Capacity Building, and Governance	
Challenges from Assessment	**Aligned Solutions**
Stakeholder Coordination and Governance	
Lack of delineated mandates among agencies within the ecosystem	• Convene relevant stakeholders in development and implementation of policy by the Ministry of Budget and National Planning with clear definition of roles and responsibilities • A national coordination structure should continuously bring all the stakeholders to the round table to resolve institutional rivalry and set guidelines for collaboration
Lack of National Policy for the democratization, ownership, and integration of data/ Delayed implementation of the NGDI bill	• Advocacy to expedite the passage of the NGDI bill • Review of the NGDI bill to update and integrate new development in the industry • Distribute the NGDI bill amongst key stakeholders for familiarization with the provisions of the bill
Lack of data standardization and interoperability for analysis	• Build systems with standard APIs
Capacity Building	
Limited funding for capacity development	• Budgetary allocation from government and donor support
Capacity-building initiatives are not sustained and monitored for quality control	• Develop an inventory of courses and curriculum to enable regulatory agencies to access and accredit the courses e.g., IVUC, NBTE, and professional regulatory body • Regular refresher training and integration of feedback mechanisms intro training. • Implementation of train-the-trainer model by scaling up the skills and competencies of government staff • Integration of assessment of needs (to avoid duplication of training) prior to the commencement of new capacity building for government agencies
Limited capacity of advanced geospatial analytics	• Establish and strengthen GIS institutions to provide large scale localized training on geospatial data analysis and application • Support the training of advanced geospatial analytics through current programs • Embed technical staff in MDAs with priority use cases • Internships and secondment of relevant officers in MDAs
Training not specific – too generic for current needs within the ecosystem	• Conduct training at different levels – i.e., beginners, intermediate, advanced, and strategic (for policymakers and non-technical audiences) • Conduct assessment of needs before the commencement of training
Obsolete/rigid curriculum on GIS	• Curriculum should be reviewed to include modern technologies regularly • Courses should be modularized to accommodate short courses
Poor capacity building and resource pooling	• Focused capacity building tailored to specific needs – Conduct needs assessment • Collaboration with other stakeholders • Inter-agency capacity transfer • More accessible online/in-person training and mentoring for skills development

7. Conclusion

Nigeria's geospatial ecosystem has evolved from geospatial data being used for enumerator quality control to informing decisions that tabular data would otherwise not comprehensively address. Its contribution to the polio eradication program was the tipping point to explore its use in other sectors.

Nigeria now generates various forms of geospatial data as highlighted in the findings section, has government agencies mandated to provide oversight, and is currently reviewing a bill to regulate the field. Geospatial data analysis has heavily relied on the private sector, which has the expertise. Few government actors conduct their own analysis due to a lack of analytical skills. Further, Nigeria currently has many use cases in the health sector, with actors exploring the use of geospatial data in education, security, energy, and transport.

However, the ecosystem still has a lot of opportunities for improvement ranging from the generation of new forms of geospatial data, venturing into advanced analytics, finalizing the NGDI bill, enhancing stakeholder coordination, capacity building, and continued advocacy campaigns for the uptake of geospatial data.

The report provides – a detailed account of Nigeria's ecosystem, and prioritized challenges and solutions as defined by stakeholders within the ecosystem.

8. Annexure 1: List of data-generating organizations by data form

Level	Organization	Forms of data
Government	National Agency for Space Research and D evelopment Agency (NASRDA)	Agricultural data, specimen data, population data, facility data, educational data, and raster data.
	GRID3	General geospatial data, population data, administrative boundaries, settlement locations; data on schools, health facilities, and markets.
	Office of the Surveyor General of the Federation (OSGOF)	Data on flood mapping, electoral process, health, and satellite data.
	Lagos Bureau of Statistics	Data on poverty, literacy, household trends, transport, consumer spending, state GDP, and population data.
	Lagos Metropolitan Area Transport Authority (LAMATA)	Transportation data, population data, GPS/geographic data, and capacity supply data.
	National Population Commission	Boundary/settlement data, geophysical data, population data, and data on maritime activities.
	National Boundary Commission	Boundary data, satellite data, population data, and historical data.
	Cizoti Nigeria Limited	Population data, boundary/settlement data, meteorological data, stratigraphic data, and data on businesses and commercial activities.
	Sambus Geospatial	Location data, satellite data, boundary data, topographic data, husbandry data, and oil pipeline data.
	Geoinfotech	Geographic data, agricultural data, household data, boundary data, and data on infectious diseases e.g., Ebola & COVID 19.
	Fraym	Location and settlement data such as data on which communities are best suited for solar home systems, mini-grids, grid extension, and grid rehabilitation, etc.
NGO	eHealth	Location and settlement data such as data from hospitals, schools, churches, and health facilities.
	Natview Foundation	Administrative data from the state, hospitals, the ministries, and the board, remote sensing data

Annexure 2: Other government geospatial data-generating actors

Actor	Context on organization	Types of data generated
National Primary Health Care Development Agency (NPHCDA)	The NPHCDA was established in 1992 and merged with the National Program on Immunization (NPI) in 2007. The NPHCDA is the main focal point for healthcare development in Nigeria. It is tasked with the duty of improving health and quality of life through effective primary healthcare service delivery.	Satellite data, geographic data, data on Neglected Tropical Diseases (NTDs), and other diseases.
Federal Ministry of Agriculture and Rural Development (FMARD) And the Office of the Special e Adviser on Agriculture	The Federal Ministry of Agriculture and Rural Development (FMARD) is a ministry of the federal government of Nigeria. FMARD was established in 1966 with the mandate of regulating agricultural research, agriculture and natural resource management, forestry, and veterinary research.	Agricultural data, settlement data, boundary data, and geographic data.
National Bureau of Statistics (NBS)	The National Bureau of Statistics is tasked with overseeing the generation and distribution of official statistics across all federal Ministries, Departments, and Agencies, as well as state and local government statistical agencies.	Boundary and settlement data, population data, immunization coverage statistics and other health-related data, petroleum trends statistics, unemployment data, household data, and foreign trade statistics.
Universal Basic Education Commission (UBEC)	The Universal Basic Education Commission (UBEC) is a government agency with the responsibility of organizing and executing the UBE program. The Federal Government of Nigeria launched the Universal Basic Education Program in 1999 as a reform initiative aiming at increasing access to and assuring the quality of basic education across Nigeria.	Literacy data and other educational-related data.
States Ministry of Budget and Planning	The Lagos State Ministry of Economic Planning and Budget is an agency of the Lagos State Government responsible for the budget preparation and implementation of the state's development plan. The Ministry together with the Lagos Bureau of Statistics houses the Data Lab- the Eko360 Data Warehouse and Analytics platform.	Population data, household data, and data on investment trends.
States Bureaus of Statistics	The Lagos Bureau of Statistics is a department in the Lagos State Ministry of Economic Planning and Budget concerned with the coordination of statistical activities in Lagos State.	Unemployment statistics, household trends, population statistics, housing and welfare statistics, finance statistics, GDP statistics, transport statistics, education statistics, administrative data, and water access statistics.
States GIS Agencies – Octave Analytics	Octave Analytics provides business services solutions using data. Octave Analytics has worked with major telecommunications companies within and outside Nigeria including Airtel Nigeria, MTN Nigeria, Vodacom DRC, Telkom Kenya, etc. It provides market intelligence, customer value management, analytics outsourcing, etc.	Financial and banking trends, demographic data, data on BVN enrollment rates, and consumer trends.

Annexure 3: List organizations and their use cases

Use Case	Organization	Sector
Polio Microplanning and Campaign	NPHCDA and eHealth	Health Sector
Integrated NTD Campaign	NPHCDA	Health Sector
Covid 19 Immunization Coverage	eHealth Africa	Health Sector
Regional risk and vulnerability assessment of the Lake Chad	NASRDA	Environment and Climate Change
Deforestation Studies	NASRDA	Environment and Climate Change
Health Facility Registry (HFR)	eHealth Africa	Health Sector
Eko360	Lagos Bureau of Statistics and Data Science Network	Multiple sectors
EdTech (Personalized and Adaptive Learning powered by SMS)	Data Science Network	Education
SpotOn	Data Science Network	Entrepreneurship/Start-Up
ATM & Agency Banking Deployment	Octave Analytics	Financial Services
Harnessing geospatial data to reduce malaria's burden in Nigeria and the DRC	GRID3	Health Sector
Spatial data at the forefront of vaccination strategies in Zambia and Nigeria	GRID3	Health Sector
GRID3 microplanning maps to support non-polio immunization activities in Nigeria	GRID3	Health Sector
Campaign aimed at controlling malaria in Kano State, Nigeria, gets a boost with GRID3 maps	GRID3	Health Sector
GRID3 data as a building block for COVAX interventions: spotlight on Nigeria microplanning	GRID3	Health Sector
Tackling COVID-19 in Nigeria: using population data to model virus spread post-lockdown	GRID3	Health Sector
Outside the box: how Nigeria won the fight against polio	GRID3	Health Sector
Taking on COVID-19 with data: Nigeria's government collaborates with GRID3 on response and prevention	GRID3	Health Sector
Understanding access to education in Nigeria	GRID3	Education
Geospatial analysis of measles immunization coverage in Nigeria	GRID3	Health Sector
Nigeria's Federal Ministry of Health uses geospatial data to inform National Surgical, Obstetrics, Anaesthesia & Nursing Plan	GRID3	Health Sector
How geospatial data can help solve Nigeria's educational challenges	GRID3	Education
The Nigeria GeoPortal	SAMBUS	Multiple sectors
Spatial Analysis (NDVI) of Basin in AMAC, Abuja Nigeria	SAMBUS	Environmental
Case Study of Kuje Area Council (NEWMAP)	SAMBUS	Environmental, Food Security, Health
Flood prediction and vulnerability mapping in Northcentral states in Nigeria- Kogi, FCT, Kwara, Kaduna, and Niger state.	CIZOTI	Environmental Sector

Development of enumeration area maps of the 774 local governments in the country to support a census on all commercial and industrial businesses in Nigeria.	CIZOTI	Environmental Sector
Microplanning: evidence-based policy and decision making for policymakers in the health and education sector.	NATVIEW	Health and Education Sector
Covid 19 vaccination distribution	NATVIEW	Health Sector
Health insurance-To understand who has access, touchpoints not covered, and how to cover it	NATVIEW	Health Sector
Investment satisfaction in Kaduna State	NATVIEW	
General household survey- local surveys to inform investment priorities by the state government	NATVIEW	Environmental Sector
Flood mapping	OSGOF	Environmental Sector
Disease tracking	OSGOF	Environmental Sector
Electioneering	OSGOF	Environmental Sector
Addressing vaccine hesitancy	FRAYM	Health Sector
Sustainable Energy (SE) for All-Sustainable Energy for All | Sustainable Energy for All (seforall.org)	FRAYM	Environmental Sector
Hefa | Health Analytics Platform (kdbs.ng)	Kaduna State Bureau of Statistics	Health Sector
Building, street naming, and house numbering for Zaria Metropolitan Authority and Kafachan Municipal Council	Kaduna State Bureau of Statistics	Environmental Sector
Mapping the infrastructure and activities of all 27 local governments	Kaduna State Bureau of Statistics	Environmental Sector
Annual school census used for monitoring education progress goals	Kaduna State Bureau of Statistics	Environmental Sector
SDG reporting- using geospatial data, Kaduna state has been able to increase the number of SDGs reported from 69 in 2017 to 126 in 2021	Kaduna State Bureau of Statistics	Environmental Sector
Introduction of new vaccines and include them in the routine schedule	CHAI	Health Sector
GIS micro planning-microbiome services	CHAI	Health Sector
Implementation of supplemental immunization activities	CHAI	Health Sector
Support the use of data using GIS map for decision-making	CHAI	Health Sector
Plotting of GIS map for boundary maintenance	National Boundary Commission	
GIS Installed drones capture aerial photographs for data collection in inaccessible sites	Geoinfotech	Environmental Sector
Mobile application of GIS Mobile photographer	Geoinfotech	Environmental Sector
Geostore website application for data on Map creation	Geoinfotech	Environmental Sector
A project that was done in delta state on drone expertise	Geoinfotech	Environmental Sector
Using GIS to map out clean water for the south-south	Geoinfotech	Environmental Sector
Hybrid mapping using high-resolution satellite imagery and neighborhood analysis	Npopc	Environmental Sector
Collaborated with NASDRA to come up with a standard port level for Nigeria	Npopc	Environmental Sector

LAMATA	LAMATA	Transportation
Black Fly tracing	NOEC	Health
COVID-19 - Clinton Health Access Initiative	CHAI	Health
Hepatitis - Clinton Health Access Initiative	CHAI	Health
HIV/AIDS - Clinton Health Access Initiative	CHAI	Health
Malaria and Neglected Tropical Diseases - Clinton Health Access Initiative	CHAI	Health
Tuberculosis - Clinton Health Access Initiative	CHAI	Health
Cervical Cancer - Clinton Health Access Initiative	CHAI	Health
Diarrhea and Pneumonia - Clinton Health Access Initiative	CHAI	Health
Maternal, Newborn, and Reproductive Health - Clinton Health Access Initiative	CHAI	Health
Nutrition - Clinton Health Access Initiative	CHAI	Health
Oxygen Therapy - Clinton Health Access Initiative	CHAI	Health
Vaccines - Clinton Health Access Initiative	CHAI	Health
Health Financing - Clinton Health Access Initiative	CHAI	Health
Health Workforce - Clinton Health Access Initiative	CHAI	Health
Cancer - Clinton Health Access Initiative	CHAI	Health
Assistive Technology - Clinton Health Access Initiative	CHAI	Health
Climate Change - Clinton Health Access Initiative	CHAI	Health
Diagnostics - Clinton Health Access Initiative	CHAI	Health
Digital Health - Clinton Health Access Initiative	CHAI	Health
Global Health Sciences - Clinton Health Access Initiative	CHAI	Health
Market Shaping - Clinton Health Access Initiative	CHAI	Health
Boundary project for creation of maps with OSGOF	National Boundary Commission	Environmental
Nigeria off-stream commission, Navy, NUPRC, Ministry of Justice, NNPC for maritime charts, hydrography, charts, and others.	National Boundary Commission	Environmental
VDD — eHealth Africa - Building stronger health systems in Africa	eHealth Africa	Health
VaxTrac — eHealth Africa - Building stronger health systems in Africa	eHealth Africa	Health
Integrated National Serosurveillance in Nigeria — eHealth Africa - Building stronger health systems in Africa	eHealth Africa	Health
HemeChip — eHealth Africa - Building stronger health systems in Africa	eHealth Africa	Health
CornBot — eHealth Africa - Building stronger health systems in Africa	eHealth Africa	Health
National Food Consumption and Micronutrient Survey (NFCMS) — eHealth Africa - Building stronger health systems in Africa	eHealth Africa	Health
Health Telematics Infrastructure — eHealth Africa - Building stronger health systems in Africa	eHealth Africa	Health

Annexure 4: Summary of publications by sector

Title of Publication	Type of Publication	Focus Area
Application of the Geographic Information System (GIS) in immunization service delivery; its use in the 2017/2018 measles vaccination campaign in Nigeria	Academic Research/Use case success story	Health
High-Level Forum on Global Geospatial Management Information- Country Report of Nigeria	UN-GGIM Conference proceeding (Submitted by NASRDA)	General
National Geospatial Data Infrastructure Development in Nigeria: The Journey So Far	Academic Conference Paper (Written by fmr NASRDA Director of Mission Planning, IT & Data Management- Dr. Agbaje & Professor Kufoniyi)	Governance & Policy
Geospatial distribution and bypassing health facilities among National Health Insurance Scheme enrollees: implications for universal health coverage in Nigeria	Academic Research Paper	Health
Geospatial analysis of cholera patterns in Nigeria: findings from a cross-sectional study	Academic Research Paper	Health
Creation of Geospatial Database for Educational Facilities in Oredo Local Government Area of Edo State, Nigeria	Academic Research Paper	Education
Geospatial analysis of desertification vulnerability using Mediterranean desertification and land use (MEDALUS) model in Kebbi State, Nigeria	Academic Research Paper	Environment (Desertification)
NIGERIA'S SATELLITE DATA UTILISATION FOR SUSTAINABLE DEVELOPMENT	Academic Research Paper (written by NASRDA staff)	Socio-economic development
SE for All Geospatial Inception document	Use Cases Success Story	Energy

Annexure 5: Summary of actors offering capacity building training in Nigeria's geospatial ecosystem

Category	Actor	Context on Organization	Types of training offers
Government Agency	NASRDA	The National Space Research and Development Agency (NASDRA) was established in 1999 to pursue the development and application of space science and technology for the socio-economic benefits of the Nation. NASRDA under the Federal Government of Nigeria, took over the management, hosting and maintenance of GRID3 Nigeria's data and portal in 2020.	One-off Training of different actors who make use of data and produce data, Training of NASDRA staff to do data cleaning, collection, and standardization.
	GRID3	Geo-Referenced Infrastructure and Demographic Data for Development (Grid 3) works to generate, validate and use geospatial data for population, settlements, infrastructure and boundaries. Although part of the GRID3 global network, GRID3 in Nigeria is domiciled within the federal government under the Ministry of Budget and National Planning.	One-off training with different actors at various levels of government
Academia	OAU	Obafemi Awolowo University, Ile-Ife is a federal government owned university established in Nigeria between 1961 and 1962. The university is home to several faculties including Agriculture, Arts, Economics, and Social studies (now Social Sciences), Law, Science, and Environmental Design and Management. The university is also home to several institutes and agencies including ARCSSTE-E and AFRIGIST.	BSc, MSc, Ph.D., Certificates in GIS and remote sensing
	AFRIGIST	The African Regional Institute for Geospatial Science and Technology (AFRIGIST) is an educational institution with a focus on geospatial information science and technology training. Formerly known as Regional Centre for Training in Aerospace Surveys (RECTAS), it established in 1972 under the auspices of the United Nations Economic Commission for Africa (UNECA) and is located within the campus of Obafemi Awolowo University, Ile-Ife, Nigeria.	Ph.D., MSc, Professional Master, Diploma, Certificate in GIS, Cartography, photogrammetry, and Remote sensing
	ARCSSTE-E	The African Regional Centre for Space Science and Technology Education in English (ARCSSTE-E) was inaugurated to enhance indigenous capacity in the utilization of space science and technology. It is affiliated to the UN Office for Outer Space Affairs (OOSA) and established in 1998. It is located within the campus of Obafemi Awolowo University, Ile-Ife Nigeria, within the same area as The African Regional Institute for Geospatial Science and Technology (AFRIGIST), the Centre for Energy Research and Development (CERD), and National Centre for Technology Management (NACETEM). The Centre is supervised by the National Space Research and Development Agency (NASRDA).	Postgraduate programs.

Non-Profit Organization	NATVIEW	Natview Foundation for Technology Innovation (NFTI) is a non-governmental organization using geospatial data to for social good. It provides innovators across the public sector and development space with platforms for experimenting with data and the power of technology to confront real-world challenges and policy issues. NFTI plays a crucial role in the implementation of Kaduna's State Data Lab Project.	Digital Skill Programme
	Data Scientists Network	Data Scientists Network (DSN) formerly known as Data Science Nigeria, works with developing government and private sector actors to develop solutions for governance, education, health, retail, and finance.	Artificial intelligence bootcamps, data science and digital skill-related training

Annexure 6: Sampled stakeholders with their area of focus within the research framework

Category	Organization	Pillar of focus within the research framework			
		Generation	Analysis	Operationalization	Cross-cutting
Government	Kaduna State Bureau of Statistics	X		X	X
	National Space Research & Development Agency (NASRDA)	X	X		X
	Nigeria Governors Forum (NGF)	X			
	The Nigerian Oncho Elimination Committee (NOEC)			X	
	National Primary Healthcare Development Agency (NPHCDA)		X	X	
	The Geo-Referenced Infrastructure and Demographic Data for Development (GRID3)	X	X		X
	National Bureau of Statistics (NBS)				
	National Population Commission (NPC)	X	X		X
	Office of the Surveyor General of the Federation (OSGOF)	X	X		X
	Senior Special Assistant to the President on Agriculture	X	X		X
	Ministry of Budget and National Planning	X	X		X
	Lagos State Ministry of Economic Planning and Budget			X	
	National Boundary Commission	X	X		X
	Lagos State Bureau of Statistics		X	X	X
NGO	Natview Foundation for Technology Innovation (NFTI)	X	X		
	Data Scientist Network (DSN)		X		

NGO	Humanitarian Enhanced Platform for Development (HEDP)		X		
	Clinton Health Access Initiative (CHAI)		X		
	WorldPop		X		
	Global Fund				
	Flowminder		X		X
	GEOSON		X		
	eHealth Africa	X	X	X	
Private sector	Geoinfotech	X	X		
	Fraym		X	X	
	Sambus Geospatial Nigeria Ltd	X	X		
	Cizoti Nigeria Ltd	X			
	Octave Analytics	X	X		X
Academia	Obafemi Awolowo University (OAU), Department of Surveying and Geoinformatics	X	X		
	OAU, Department of Geography	X	X		X
	OAU, Department of Geography, Department of Urban and Regional Planning	X	X		X
	Africa Regional Centre for Space Science and Technology Education in English (ARCSSTE-E)	X			X
	Africa Regional Institute for Geospatial Information Science and Technology (AFRIGIST)	X			X
	OAU, Center for Energy Research and Development (CERD)			X	
	American University of Nigeria (AUN)				X

Annexure 7: List of Workshop Attendees

The following list contains the external (invited guests) attendees who were present for at least one of the two Forum event days in-person or virtually (indicated by "V").

No	Name	Organization
1	Mrs. Edidiong Amos	Cizoti Nigeria Limited
2	Mr. Busayo Fashoto	eHealth Africa
3	Juliet Odogwu (V)	
4	Mr. Muhammad Nazir Halliru	GRID3 Nigeria
5	Mr. Mahmud Suleiman	
6	Mrs. Joy Imanyi	SAMBUS Geospatial Ltd.
7	Mr. Abel Ighavodha	
8	Mr. Khalilu Muhammad	UNICEF
9	Dr. Andrew Kwasari	Office of the President, Nigeria
10	Dr. Rakiya Babamaaji	NASRDA
11	Mr. Nsofor Elvis	
12	Mr. Marc Levy	GRID3 Africa
13	Dr. Audu Liman	American University of Nigeria
14	Dr. Olubayo Adekanmbi	Data Scientist Network (DSN)
15	Ms. Chinazo Anebelundu	
16	Mr. Yusuf Dauda	Kaduna State Bureau of Statistics
17	Mr. Iyegbu Innocent (V)	
18	Mr. Rasheed Lawal	Lagos State Bureau of Statistics
19	Mr. Dahiru Hassan	NPHCDA
20	Mr. Abdullahi Shuaibu	
21	Surv. Azeez Afeez	OSGOF
22	Surv. Adesope Adedayo	
23	Dr. Hamza Abubakar	Kaduna State Primary Healthcare Agency
24	Dr. Joseph Oteri	Nigeria Governors Forum
25	Prof. Jide Kufoniyi	Department of Surveying & Geoinformatics, Obafemi Awolowo University (OAU)
26	Mrs. Omolara Kareem	LAMATA
27	Prof. Joseph OLOUKOI	AFRIGIST

28	Mr. Blessing Oladeji	Octave Analytics
29	Dr. Boubacar Dieng	GAVI Nigeria
30	Dr. Akinpelu Adetola	Lagos State Primary Healthcare Agency
31	Dr. Mofoluso Fagbeja	ARCSSTE-E
32	Dr. Tubolayefa Warekuromor	United Nations Resident Coordinator's Office (UNRCO)
33	Ahmed Ibrahim	WHO (NEOC Data Team)
34	Dr. Edson Utazi	WorldPop, University of Southampton
35	Mr. Prince Friday	Clinton Health Access Initiative (CHAI)
36	Mr. Rowland Okon	Ministry of Budget & National Planning
37	Mr. Opaleke Demilade	National Population Commission
38	Ms. Comfort Adebusuyi	
39	Mr. Gideon Ugbenyo (V)	African Field Epidemiology Network (AFENET)
40	Ms. Cathy Riley (V)	Flowminder
41	Mr. Nuradeen Maidoki	Natview Foundation for Technology Innovation
42	Mr. Biyi Fafunmi (V)	National Bureau of Statistics
43	Mr. Kazeem OWOLABI (V)	World Food Programme/HEDP
44	Mr. Nibretie Workneh (V)	The Global Fund
45	Mr. Mathias Kueipe (V)	UNFPA
46	Mr. Ahmed Ibrahim	WHO (NEOC Data Team)
47	Mr AIYEORIBE, Samuel Olubunmi (V)	
48	Ms. BELANGER, Johanna (V)	
49	Mr. EGBINOLA, Oluwaseun Abiola (V)	
50	Ms. FERRIS, Denise Nicole (V)	
51	Mr. JUNG, Christopher (V)	
52	Mr. KIPTERER, John (V)	
53	Mr. OVIAESU, David Osayi (V)	
54	Mr. TOURAY, Kebba (V)	
55	Ms. RAPOSO DA COSTA LOURENCO, Ana Lucia (V)	
56	Ms. Omolara Kareem	LAMATA
57	Mr. Aare Segun Oyedijo (V)	N/A

Annexure 8: Pictures from the workshop

Figure 11: Cross section view of the room showing workshop attendees

Figure 12: Brainstorming Session: Group one members including representatives from NASRDA, NPHCDA, SAMBUS Geospatial, eHealth Africa, Lagos State Bureau of Statistics, LAMATA, ARCSSTE-E, AFRIGIST and others

Figure 13: Welcome message from Dr Mollie Van Gordon, Senior Programs Officer, Geospatial Insights, Bill and Melinda Gates Foundation

Figure 14: Brainstorming Session: Group two members including representatives from OSGOF, NPC, SAMBUS Geospatial, OAU, Octave Analytics and others

Figure 15: Brainstorming Session: Group 3 members including representatives from GRID3 Nigeria, GRID3 Africa, DSN, KDBS, Kaduna PHCDA, UNICEF, and Office of the President on Agriculture

Figure 16: Group 4 members including representatives from NASRDA, GAVI, CHAI, WorldPop, UNRCO, Cizoti, DSN, NGF& Lagos PHCDA

Dev-Afrique