Nigeria's Geospatial Value Pipeline

Exploring Nigeria's geospatial ecosystem using the value pipeline framework

The assessment of Nigeria's geospatial data ecosystem explores the current geospatial landscape, unravels the gaps within the ecosystem, identifies opportunity areas within the ecosystem, and leverages a stakeholder validation forum to forge the next steps towards the geospatial development path in Nigeria.

The "value pipeline framework" assessed the ecosystem using three comprehensive pillars – "generation" of the data, "analysis" of the data, and "operationalization" of the data. It further analyzed the ecosystem within the sub-pillars including cross-cutting sub-pillars like capacity building, governance, and stakeholder coordination.

This brief provides a high-level summary of insights on the current landscape and the gaps and challenges within the ecosystem. Further insights can be found in the full value pipeline assessment report.

Findings: Current Geospatial Landscape in Nigeria

The geospatial ecosystem in Nigeria is one of the more mature ecosystems in Africa with increasing diversity of use cases, expanded spatial infrastructure and an advanced web of stakeholders driving impact at the various levels of government and across sectors. The brief summarizes the findings of the geospatial landscape from the full report. Below are the key findings from Nigeria's geospatial landscape (see full report for a detailed account of the findings).

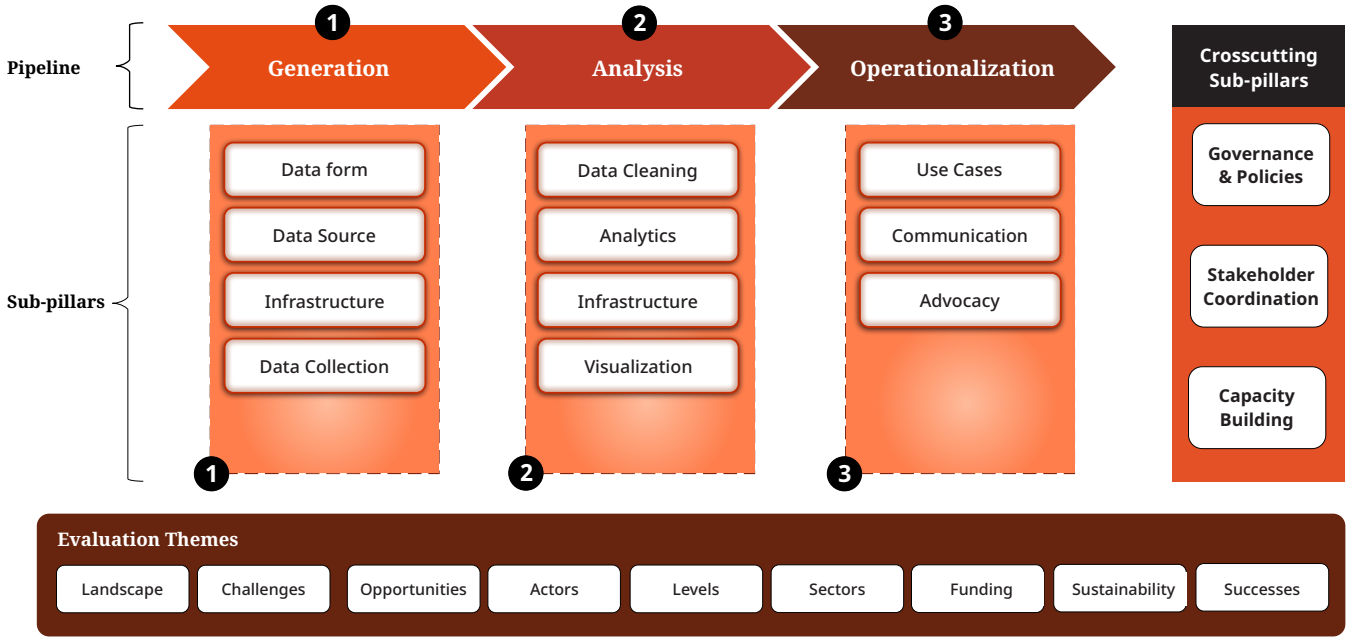

Figure 1: Geospatial Value Pipeline Framework

Geospatial Data Generation

- Nigeria is dominated by diverse forms of geospatial data - the population characteristics form of data, settlements, boundaries, infrastructure, and building footprints - collected across sectors and government levels. These popular forms of data are collected by key actors like the National Agency for Space Research and Development Agency (NASRDA), GRID3, WorldPop, eHealth Africa, NatView Foundation, Geoinfotech, National Population Commission, and the National Boundary Commission. Within the government, the generation of geospatial data is domiciled with key institutions – The National Space Research and Development Agency, The Office of the Surveyor-General of the Federation, the National Population Commission, and the National Boundary Commissions - who have all laid claims to the mandate for geospatial data in Nigeria.
- The Geo-Referenced Infrastructure and Demographic Data for Development (GRID3) – a quasi-government geospatial data program domiciled within NASRDA - is the most expansive and influential geospatial data generation program in Nigeria. The GRID3 program generates the most popular and aggregated forms of geospatial data in Nigeria – population estimates, settlements, boundaries, and infrastructure data - and has worked horizontally at the national level and vertically with the states within the health, agriculture, and education sectors. Kaduna and Lagos states are some of GRID3's most successful use cases.
- Across the various levels of government, the relationship between the national actors and the state actors on geospatial data generation is not fully linear. In certain cases, especially within the health sector, there are well-structured top-down and bottom-up geospatial generation and coordination efforts between the federal, state, and even local actors while in other instances, state governments and the federal government have worked independently.
- 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 accessible sources within government and non-profits such as NASRDA, GRID3 geodatabase, eHealth Africa data portal, and Open Street Map amongst others. Other sources of geospatial data may not be as publicly accessible, and these may include independent government or non-government organizations who have collected geospatial datasets through their mandates or during specific development projects.
- The generation of geospatial data in Nigeria 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 - Office of the Surveyor General of the Federation), however, the value pipeline assessment showed that funding remains insufficient to drive geospatial data generation on a larger scale. As a result, complementary fundings through non-profit actors have catalyzed the development of the geospatial ecosystem in Nigeria. Among the development partners, major funders include the Bill and Melinda Gates Foundation, the United Kingdom's FCDO (Foreign, Commonwealth & Development Office), World Health Organization (WHO), USAID (United States Agency for International Development), the Center for Disease Control, GIZ (Gesellschaft fuer Internationale Zusammenarbeit), Global Fund, World Bank, and GAVI.

Geospatial Data Analysis

- Although geospatial data generation has historically been the focus of most actors within the ecosystem, the analysis pillar of the geospatial value pipeline remains crucial. In Nigeria's geospatial ecosystem, geospatial data analysis involves data cleaning, data validation, data processing, and data visualization.
- Recently, several data processing tools have emerged, and their applications have become prominent in Nigeria's geospatial ecosystem with more stakeholders now offering GIS software training for data processing and analysis of geospatial data. The specialization 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 processes.
- Aside from the traditional geospatial-linked agencies like NASRDA and OSGOF, many national actors conduct basic geospatial analysis and lack the technical expertise and infrastructure to undertake advanced data analysis. Several opportunities around the types of geospatial analysis are yet to be fully explored, including AI/ML and deep learning modeling, and predictive and inferential analysis.
- Most national and state-level actors partner with non-government actors on more advanced forms of geospatial data analysis. States like Kaduna and Lagos stand out as frontier states in the development of geospatial data analysis through partnerships with actors like NatView, GRID3 and Data Scientists Network (DSN).
- No special funding is dedicated to advanced geospatial analysis within the ecosystem despite the expensive cost associated with software procurement and subscription as attributed by stakeholders in the assessment. As a result, more actors – including government agencies - within the ecosystem are now turning to open-source software despite the ecosystem's perceived risks of compromised security or reliability. The sustainability of geospatial analysis within the value chain is strongly linked to successful data generation, data operationalization, capacity building and capacity retention.

Geospatial Data Operationalization

- Geospatial data operationalization covers the translation of geospatial data into use cases, communication, and advocacy around the data and use cases.
- 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 is the most advanced sector in the operationalization of geospatial data in Nigeria. This can be traced to the long history of applying geospatial data to polio eradication efforts which occurred over a period of eight years (2012-2020) and involved actors such as NPHCDA (National Primary Health Care Development Agency), BMGF, eHealth Africa, and GRID3.
- The use-case demand generation processes differ from sector to sector. Findings from the value pipeline assessment show that use-case generation is mostly demand-driven in the public sector. In organizations like NPHCDA, the need to achieve certain health campaigns drive the operationalization of geospatial data. In other instances, geospatial operationalization is supply-driven – in states like Kaduna where government mandated the inclusion of geospatial data in the planning of development interventions.
- In the health sector, use cases that originate at the federal level are eventually translated to the state and local actors with targeted capacity building support to ensure effective implementation. These

use cases may include the development and deployment of geospatial maps to support microplanning activities and health campaigns. Deployment of maps for microplanning purposes has been the most efficient process of deploying geospatial technology from national to level to the local government and wards.

- Use cases deployment has been driven by collaboration between government and non-government actors who provide crucial technical support in the design and execution of use cases from the national level to the last mile. The geospatial data operationalization pillar also receives more funding priorities from government and donor stakeholders – albeit with little coordination. Most geospatial use cases align with the priorities of the donor organization.
- Communication in the geospatial ecosystem in Nigeria focuses on two main aspects- use cases and datasets. Information about geospatial datasets is often disseminated among key stakeholders via in-person channels, especially workshops. These workshops are organized by non-profit actors such as the annual GEOSON conference, GRID3 dissemination workshop and DSN. The amplification of the potential impact of geospatial technology is tied to the level of advocacy with government decision makers. Advocacy at the national level is project dependent while geospatial advocacy in the states is driven mostly by non-profits actors supporting state governments geospatial-linked projects.

Stakeholder Coordination, Capacity Building, and Governance

- Despite the growth of geospatial ecosystem in Nigeria, the governance and policy structures remain weak. Stakeholders within the ecosystem have collaboratively developed and recently revised the policy framework for geospatial data generation, governance, and usage - the National Geospatial Data Infrastructure (NGDI) bill. This policy document is pending approval by Nigeria's legislature.
- Within the geospatial ecosystem in Nigeria, government geospatial stakeholder coordination is centralized around GRID3's technical and steering committee, NASRDA, NPHCDA EOC (Emergency Operation Centre) and OSGOF. Across the states, states' bureau of statistics like Kaduna, have also developed geospatial data coordinating mechanisms like the GIS Development Committees. However, other stakeholder coordinating mechanisms exists outside of government and facilitated by organizations like Geoinformation Society of Nigeria (GEOSON), Data Scientist Network (DSN), and multilateral institutions like the WHO and World Bank.
- Geospatial capacity development is integrated into geospatial data interventions of most actors. As a result, most of the capacity development efforts are not coordinated across the stakeholders operating in the ecosystem, sometimes repetitive and mostly fundamental GIS trainings. Nigeria's geospatial ecosystem has three major approaches to capacity building:
  - Capacity building programs driven non-government organizations which may include focused training initiatives as part of developing programs or large-scale capacity building programs offered by organizations like DSN.
  - Government-led capacity building programs organized by NASRDA and OSGOF and dependent on government and donor funding.
  - Academia-led capacity building programs offered by specialized institutions like AFRIGIST and ARCSSTEE-E and other universities in Nigeria.

What is Working in the Nigeria Geospatial Ecosystem

Over the course of the assessment and the stakeholders' validation forum, Dev-Afrique assessed geospatial stakeholders for the effective attributes of Nigeria's geospatial ecosystem. These attributes span the three core pillars of the value pipeline – generation, analysis and operationalization – and the crosscutting stakeholder coordination, capacity building and governance sub-pillars. These attributes include:

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 include: 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 from eHealth to GRID3	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 towards 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.

Geospatial Data Analysis

Geospatial Data Analysis	
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

Geospatial Data Operationalization	
Several use cases across different sectors	The geospatial ecosystem in Nigeria has contributed several use cases across different sectors. These 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.

Governance, Stakeholder Coordination & Capacity Building

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

Findings: What is not working in Nigeria's Geospatial Ecosystem

The value pipeline assessment also explored major challenges within the generation, analysis, and operationalization pillars through desk research, in-person interviews, and a broader conversation at the 2022 geospatial stakeholders' forum. While the full landscape assessment report enumerates a detailed account of Nigeria's geospatial ecosystem, this section summarizes the major gaps within Nigeria's ecosystem.
(Kindly review the full report for a detailed account).

Geospatial Data Generation

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 a 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	Geospatial data from secondary sources (e.g., data from aggregating portals) 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 a 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 their data. Beyond this, there is no established process for sharing independently generated data with government actors.

Geospatial Data Analysis

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.

Geospatial Data Analysis

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.

Geospatial Data Operationalization

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, wider adoption of geospatial data and funding commitments from the government.
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.

Governance, Stakeholder Coordination & Capacity Building

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.
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.
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.
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.

Governance, Stakeholder Coordination & Capacity Building		
Stakeholder Coordination,	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	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.
	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.
	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.
	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 timeline 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.

Forging the path to geospatial ecosystem development: The stakeholder validation workshop

The geospatial stakeholders' forum is the culmination of the end-to-end assessment of the geospatial ecosystem led by Dev-Afrique. The forum 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.

During this stakeholders' forum, participants selected the highly feasible and the most impactful of the previously identified challenges for the geospatial community (donors and local actors) to prioritize for immediate interventions. Dev-Afrique categorized these challenges and solutions into the most associated pipeline. The stakeholder also aligned on proposed solutions. which are preliminary and will require follow-up engagements with stakeholders on the implementation.

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 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 case repository • Organize use cases-focused 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 regularly reviewed to include modern technologies • 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

Annexure 1: List of Engaged Stakeholders

The list below contains the attendees at the workshop and stakeholders who participated in the value pipeline interviews.

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	
47	Mr AIYEORIBE, Samuel Olubunmi (V)	
48	Ms. BELANGER, Johanna (V)	
49	Mr. EGBINOLA, Oluwaseun Abiola (V)	WHO (NEOC Data Team)
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
58	The Nigerian Oncho Elimination Committee (NOEC)	
59	Geoinformation Society of Nigeria (GEOSON)	
60	GeoInfotech	
61	Fraym Inc	
62	Obafemi Awolowo University	
63	OAU, Center for Energy Research and Development (CERD)	
64	Humanitarian Enhanced Platform for Development (HEDP)	
65	American University of Nigeria (AUN)	