GEOSA
الهيئة العامة للمساحة والمعلومات الجيومكانية
General Authority for Survey and Geospatial Information

www.geosa.gov.sa

GEOSandbox Guideline

General Authority for Survey and Geospatial Information

May 2025

Table of Contents

1 Introduction

1.1 Purpose of the GEO-Sandbox Initiative

The GEO-Sandbox initiative aims to establish a dedicated environment in the Kingdom of Saudi Arabia (KSA) for the design, development, and implementation of cutting-edge geospatial projects. The sandbox will serve as a controlled space where innovative projects can be developed and demonstrated. This effort is intended to accelerate the advancement of geospatial technologies and set a precedent for future initiatives in KSA.

1.2 Vision for KSA as a Geospatial Innovation Hub

KSA, with its unique urban landscape and historical significance, presents an ideal location for the establishment of a geospatial sandbox. Today, it is in the stage of establishing the methodology and foundational pathway by leveraging diverse geography and rapidly growing infrastructure, the GEO-Sandbox will create an ecosystem that fosters creativity and innovation in geospatial solutions. This initiative aligns with GEOSA strategy and the national geospatial ecosystem, contributing to the nation's transformation into a global leader in technology and digital innovation.

1.3 Role of GEOSA in Pioneering Geospatial Solutions

The General Authority for Survey and Geospatial Information (GEOSA) plays a pivotal role in driving the adoption of advanced geospatial technologies across the Kingdom of Saudi Arabia. As part of its mandate to establish a robust national geospatial ecosystem, GEOSA is spearheading the development of the GEO-Sandbox, an initiative designed to provide a controlled environment for testing, validating, and deploying innovative geospatial solutions.

By facilitating the GEO-Sandbox, GEOSA seeks to establish a structured regulatory and technical framework that enables public and private sector stakeholders to explore and refine emerging geospatial technologies. The sandbox supports experimentation with AI-powered geospatial analytics, digital twin technologies, high-resolution mapping, and real-time spatial data processing. These capabilities are essential to addressing the evolving demands of smart cities, transportation networks, infrastructure planning, environmental monitoring, and disaster management.

As highlighted in the Emerging Technology Adoption Readiness Index 2025 [6, 7], the adoption of advanced geospatial technologies must be systematic, scalable, and aligned with national digital transformation strategies. Accordingly, GEOSA ensures that the GEO-Sandbox follows structured evaluation criteria, including interoperability, scalability, and compliance with global geospatial standards.

Furthermore, the sandbox aims to strengthen industry partnerships by fostering collaboration between geospatial technology providers, AI solution developers, and digital infrastructure stakeholders. This collaborative ecosystem is expected to accelerate knowledge transfer, promote regulatory compliance, and facilitate the practical application of emerging technologies.

1.4 GEO-Sandbox as an Innovation Catalyst

In alignment with the emerging technology readiness recommendations for 2025 [6, 7], GEOSA will implement the following strategic initiatives through its GEO-Sandbox:

a. Advanced Research & Development:
    a. Identify critical data gaps and enhance real-time data updating processes using automated AI-driven geospatial analytics.
    b. Promote collaboration with international geospatial organizations to adopt cutting-edge methodologies in geospatial intelligence, data integration, and 3D mapping.
    c. Invest in AI-based predictive geospatial modeling to strengthen spatial decision-making capabilities.
b. Stakeholder Collaboration & Engagement:
    a. Leverage participation in global emerging technology summits and strategic workshops to enhance geospatial innovation awareness and adoption.
    b. Develop training programs for AI-powered geospatial systems to upskill public and private sector stakeholders.
    c. Foster partnerships with international geospatial technology leaders (e.g., ESRI, Open Geospatial Consortium) to standardize interoperability.
c. AI & Big Data Utilization:
    a. Deploy AI-driven geospatial intelligence systems to analyze vast amounts of spatial data for better urban planning, transportation optimization, and disaster management.

b. Utilize machine learning models to enhance geospatial risk assessments and ensure real-time policy adaptability.
c. Strengthen the integration of multi-source data, including IoT-based geospatial feeds, to develop sustainable digital twin solutions.

d. Metaverse & Immersive Technologies:
    a. Explore metaverse applications to visualize complex geospatial data within immersive digital environments.
    b. Develop 3D interactive maps and VR-based simulation tools for enhanced geospatial scenario planning and stakeholder decision-making.
e. Integration of Advanced Spatial Analytics:
    a. Implement AI-driven geospatial analytics for real-time processing of HD mapping, panoramic imagery, and high-resolution geospatial datasets.
    b. Establish a framework for predictive geospatial modeling to optimize infrastructure planning and urban expansion strategies.
    c. Enhance automated anomaly detection systems to improve geospatial data accuracy and reliability.

Through these efforts, the GEO-Sandbox will act as a catalyst for geospatial innovation, supporting data-driven decision-making, optimized resource allocation, and enhanced national geospatial capabilities. The initiative is a fundamental step toward positioning Saudi Arabia as a global leader in geospatial intelligence and digital governance.

1.5 Expanding the GEO-Sandbox: Including Globally Emerging and Technologies New to the Local Saudi Market

The GEO-Sandbox is designed to accelerate the adoption and deployment of cutting-edge geospatial technologies. While some technologies are still in early adoption stages worldwide, others have already achieved maturity in international markets but remain new to Saudi Arabia's ecosystem. To position KSA as a leader in geospatial innovation, the GEO-Sandbox will serve as a structured platform to validate, integrate, and scale both categories of technologies:

1.5.1 Globally Emerging Technologies

The sandbox will provide a safe testing environment for technologies that are currently being pioneered internationally but have not yet reached mass adoption. These include:

a. AI-powered geospatial analytics for automated feature extraction and predictive modeling.
b. Digital twins for real-time geospatial monitoring and simulation.
c. 5G-enabled HD mapping for ultra-precise, real-time navigation applications.
d. Autonomous mobility technologies that rely on V2X communication, real-time LiDAR mapping, and high-precision positioning.
e. Blockchain-based geospatial data validation for secure and immutable location-based records.
f. Metaverse-integrated spatial environments for enhanced urban planning and infrastructure simulation.

These globally emerging technologies will be evaluated based on their scalability, interoperability, and compliance with regulatory frameworks before being introduced into the broader Saudi geospatial ecosystem.

1.5.2 Locally New but Internationally Mature Technologies

While many technologies are already widely adopted internationally, their implementation in Saudi Arabia remains in early stages. The GEO-Sandbox will accelerate their integration by establishing infrastructure, regulatory pathways, and localized adaptation strategies. These include:

a. Panoramic Imaging & Mobile Mapping Systems:
While internationally used for urban mapping, asset tracking, and infrastructure management, large-scale panoramic imaging deployments are still limited in Saudi Arabia. The GEO-Sandbox will support their integration into municipal planning, traffic monitoring, and environmental analysis.
b. Automated Geospatial Data Processing Pipelines:
AI-driven geospatial feature extraction, change detection, and automated labeling—commonly used in global HD mapping applications—will be introduced for infrastructure planning, agriculture, and environmental monitoring in Saudi Arabia.

c. **High-Resolution 3D Mapping & Digital Twins:**
   While global markets have widely implemented 3D geospatial visualization for smart cities and disaster resilience, adoption in Saudi Arabia's urban development strategies is still evolving. The sandbox will support pilots for large-scale implementation.
d. **Cloud-Based GIS & Geospatial Data Platforms:**
   Cloud-native GIS platforms have revolutionized spatial analytics, cross-sector collaboration, and real-time decision-making worldwide, but many Saudi entities are still transitioning from on-premises solutions to fully integrated cloud GIS. The sandbox will guide this shift with secure, scalable implementations.
e. **Autonomous Navigation & HD Mapping for Smart Mobility:**
   Saudi Arabia is witnessing rapid mobility transformation, but the widespread adoption of HD maps for autonomous driving, delivery robots, and precision agriculture remains in the early stages. The GEO-Sandbox will support pilots to localize HD map development and optimize map update cycles.

By facilitating the introduction of both globally emerging and locally new technologies, the GEO-Sandbox ensures that Saudi Arabia remains competitive in the global geospatial landscape while addressing national priorities in infrastructure, mobility, urban planning, and environmental sustainability.

2 Objectives of the GEO-Sandbox

The GEO-Sandbox is designed to drive technological advancement, regulatory alignment, and market readiness for geospatial innovations in Saudi Arabia and beyond. By providing a structured testing environment, the sandbox facilitates the adoption of emerging geospatial technologies, localization of internationally mature solutions, and the development of scalable applications for national infrastructure and digital transformation.

2.1 Driving Innovation in Geospatial Technologies

The GEO-Sandbox aims to accelerate the development of innovative geospatial solutions by fostering the adoption of AI-powered analytics, digital twins, high-resolution mapping, and IoT-enabled geospatial intelligence.

The initiative will integrate research-backed methodologies to evaluate globally emerging and locally new technologies, ensuring that Saudi Arabia leads regional geospatial innovation.

Collaboration with technology providers will enable experimentation with automated feature extraction, machine learning-driven geospatial insights, and 5G-powered spatial computing.

2.2 Establishing a Controlled Environment for Project Implementation

The sandbox provides a safe testing space where geospatial projects can be designed, tested, and refined under a structured regulatory framework.

Emerging technologies-such as blockchain-backed geospatial records, metaverse-integrated visualization, and autonomous navigation systems-can be assessed before full-scale national deployment.

The sandbox ensures that geospatial solutions meet data governance, security, and compliance benchmarks, mitigating risks before adoption.

2.3 Supporting Local and National Development Goals

The GEO-Sandbox is aligned with GEOSA's strategic vision and Saudi Arabia's digital transformation roadmap, contributing to advancements in smart cities, mobility, environmental monitoring, and infrastructure planning.

The sandbox will drive private sector participation by offering a testing ground for innovative startups, technology firms, and research institutions.

It will support AI-driven geospatial services for key industries, including transportation, public safety, agriculture, energy, and urban planning.

2.4 Building a Knowledge Base for Future Projects

The sandbox will document technology adoption pathways, regulatory best practices, and geospatial data management insights to ensure knowledge continuity. Standardized methodologies for HD mapping, real-time spatial analytics, and AI-based geospatial intelligence will be compiled for reference.

Lessons learned will be shared across government agencies, private sector innovators, and academic institutions, ensuring data-driven decision-making.

2.5 Enhancing Collaboration Among Stakeholders

The GEO-Sandbox will foster collaboration between public sector authorities, private technology providers, AI researchers, and cloud computing experts.

Strategic partnerships with leading global geospatial firms (e.g., ESRI, Open Geospatial Consortium, and major cloud GIS providers) will ensure that Saudi Arabia adopts internationally recognized best practices.

The sandbox will support multi-sector innovation, allowing autonomous mobility companies, telecommunications providers, and digital government entities to work on next-generation geospatial applications.

2.6 Ensuring Alignment with Global Standards & Local Regulations

The GEO-Sandbox will ensure compliance with international geospatial data governance frameworks, including ISO geospatial standards, UN-GGIM guidelines, and emerging AI ethics principles.

It will incorporate Digital Government Authority (DGA) policies, ensuring that cloud-based GIS solutions, digital twin integrations, and AI-powered location intelligence comply with national security and data protection laws.

The sandbox will act as a benchmarking hub to assess the readiness of Saudi Arabia's geospatial sector in comparison to global leaders.

3 Scope of the GEO-Sandbox

3.1 Focus Technology Areas

The GEO-Sandbox initiative will focus on several key geospatial technology domains to drive innovation and impactful outcomes, such as:

1. Aerial Surveying
    - Utilizing drones and other airborne platforms for high-resolution geospatial data collection.
2. Remote Sensing
    - Processing and analyzing remote sensing data for applications such as land use planning and environmental monitoring.
    - Engaging in research and development, satellite manufacturing, and data analytics services, often collaborating with governments, commercial enterprises, and research institutions.
3. Geospatial Consulting and Advisory Services
    - Providing expert consultation on geospatial strategy, policy, and implementation.
    - Supporting organizations in leveraging geospatial technologies.
4. Panoramic Imaging and Geospatial Data Services
    - Capturing and processing panoramic imagery for geospatial applications.
    - Integrating high-resolution imagery with GIS for advanced spatial analysis.
5. Navigation Application Design
    - The development of innovative navigation systems will be a key focus, with an emphasis on integrating geospatial intelligence to enhance routing, location accuracy, and user experience.
    - Projects may also explore the use of AI and machine learning to optimize navigation in complex urban environments.
6. Cartography and Map Production
    - Developing topographic, thematic, and urban maps.
    - Updating national and regional mapping datasets for accurate geospatial representation.

7. Geographical Names Standardization
    - Collecting, verifying, and managing geographical names databases.
    - Supporting national efforts in standardizing place names for cartographic and administrative purposes.
8. Geodetic and Surveying Consultancy
    - Offering specialized geodetic consulting services.
    - Providing solutions for positioning, reference frame establishment, and geospatial accuracy.
9. Geophysical Surveying and Applications
    - Conducting subsurface geophysical surveys for resource exploration and infrastructure projects.
    - Applying geodetic methods to support seismic studies and land stability assessments.
10. Land Surveying and Cadastral Mapping
    - Executing large-scale land surveys for property registration and land management.
    - Integrating cadastral systems with GIS for effective land administration.
11. Geospatial Database Development
    - Building and managing spatial databases for efficient data storage and retrieval.
    - Ensuring data interoperability with existing GIS and geospatial infrastructures.
12. Geospatial Web Applications and Services
    - Developing web-based platforms for geospatial data visualization and analysis.
    - Implementing cloud-based GIS solutions for scalable services.
13. Development and Operation of Geospatial Portals
    - Creating and maintaining geospatial data portals for various stakeholders.
    - Providing centralized access to spatial datasets for decision-makers.
14. Geospatial Information Systems (GIS) Operations

- Developing, managing, and analyzing spatial data using GIS technologies.
- Implementing GIS solutions for urban planning, environmental monitoring, and smart cities.

15. Atlas Production

- Designing and publishing national and thematic atlases.
- Aggregating and visualizing spatial data for different applications.

16. Hydrographic Surveying and Marine Mapping

- Conducting bathymetric surveys to map underwater topography.
- Producing nautical charts and marine spatial datasets for navigation and coastal management.

17. Tide and Sea-Level Monitoring

- Measuring and analyzing tidal movements for maritime and coastal planning.
- Supporting climate change studies through long-term sea-level monitoring.

18. Hydrographic Consulting Services

- Providing advisory services for marine and coastal infrastructure projects.
- Supporting sustainable ocean and marine spatial planning initiatives.

19. Marine Cartography and Nautical Chart Production

- Generating and updating nautical charts for safe maritime navigation.
- Integrating hydrographic data with GIS for marine applications.

20. Geospatial Data Quality Assurance and Control

- Implementing quality assurance processes for spatial datasets.
- Ensuring data accuracy, consistency, and compliance with industry standards.

21. HD Mapping Solutions

- The design and implementation of high-definition mapping frameworks tailored to local geographic and infrastructural contexts.

- These projects will focus on producing highly accurate and detailed maps suitable for advanced navigation systems, urban planning, and smart city applications.

22. GeoAI analytics

- AI-driven automated feature extraction, spatial classification, and predictive analytics.
- Deep learning for object recognition in HD maps, panoramic imagery, and satellite data.
- GeoAI-assisted spatial decision support for disaster management, urban planning, and resource optimization.
- Automated quality assessment of geospatial datasets using AI-driven anomaly detection.

23. Digital Twin Technology

- Development of real-time 3D models of urban environments, integrating live data from IoT sensors, AI analytics, and geospatial datasets.
- Simulation of infrastructure projects (roads, bridges, smart cities) for optimized planning and cost efficiency.
- Integration of 5G and V2X for autonomous vehicle testing within a geospatially enabled digital twin environment.
- Predictive analytics for urban expansion, infrastructure resilience, and environmental sustainability.

24. Blockchain for Geospatial Data Security

- Immutable geospatial records for land administration, cadastral mapping, and data authentication.
- Decentralized data-sharing models to enhance interoperability and transparency across national geospatial platforms.

25. Metaverse-Enabled Geospatial Solutions

- 3D interactive urban modeling for city planning, smart traffic simulations, and immersive decision-making.
- Spatial computing integration for enhanced geospatial collaboration in metaverse environments.

3.2 Geographic Scope

The GEO-Sandbox is designed for implementation in all KSA territories based on the technologies we target and the ones that provide the diverse topographical and urban features with suitable options with it. The KSA rich cultural heritage and dynamic infrastructure make it an ideal location to pilot projects that can later be scaled to other regions.

3.3 Stakeholder Engagement

The sandbox will engage a wide range of stakeholders, including:

- **Government Entities**: Supporting regulatory and policy alignment for projects.
- **Private Sector Companies**: Encouraging the participation of technology providers, startups, and SMEs.
- **Non-Profit Organizations**: Facilitating collaboration on social impact initiatives, supporting open-data policies, and promoting the ethical use of geospatial technologies.
- **Academic and Research Institutions**: Leveraging academic expertise to drive innovation and conduct rigorous evaluations.
- **Local Communities**: Ensuring that projects align with community needs and contribute to local development.

3.4 Technological Integration

The GEO-Sandbox is designed to integrate a comprehensive range of geospatial technologies spanning land, maritime, and aerial domains, ensuring seamless data collection, processing, and analysis across multiple environments. This integration follows a three-tiered approach, aligning with both globally emerging technologies and locally new but mature innovations to position Saudi Arabia as a leader in geospatial intelligence.

3.4.1 Structured Technological Adoption

The GEO-Sandbox technology stack is categorized into three levels:

a. **Globally Emerging Technologies:**
   Innovations still in early adoption worldwide, requiring testing and regulatory alignment.
b. **Locally New but Internationally Mature Technologies:**

Proven technologies being integrated into Saudi Arabia's geospatial ecosystem.

c. **Foundational Geospatial Technologies:**
Core geospatial capabilities that require scaling and optimization for national impact.

3.4.2 Key Technologies for Integration

All geospatial technology integrations must comply with the National Geospatial Data Standards [1] to ensure interoperability and data consistency.

Key technologies in phase one include:

- **Panoramic Imaging Technologies**: Utilizing high-resolution 360-degree imaging for detailed environmental documentation and spatial analysis.
- **Artificial Intelligence (AI) and Machine Learning (ML)**: Enhancing automation, image recognition, predictive modeling, and decision-making processes.
- **Aerial Surveying**: Deploying drones, and airborne sensors to capture geospatial data across various terrains.
- **Remote Sensing**: Designing remote sensing satellites and primarily operating within the aerospace, defense, and geospatial technology sectors.
- **Hydrographic and Marine Technologies**: Leveraging sonar, LiDAR bathymetry, and underwater mapping systems for marine spatial applications.
- **Geospatial IoT (Internet of Things)**: Integrating real-time sensor networks for dynamic data collection and analysis in urban and natural environments.
- **Cloud Computing and Big Data Analytics**: Enabling scalable data storage, processing, and AI-driven insights for geospatial projects.
- **Digital Twin and 3D Modeling**: Creating virtual replicas of real-world environments to enhance planning, simulation, and geospatial decision-making.
- **Cybersecurity for Geospatial Systems:** Implementing robust security measures to protect geospatial data, networks, and infrastructure from cyber threats. This includes data encryption and secure storage, network

security, access control and authentication, incident response and threat monitoring, and compliance with international security standards.

3.4.3 Globally Emerging Technologies

These innovations are still evolving at the global level and will undergo sandbox evaluation to ensure feasibility for large-scale adoption:

a. **GeoAI (Geospatial Artificial Intelligence):**
   AI-powered automated feature extraction, spatial prediction models, and anomaly detection.
b. **Digital Twin Technology:**
   Real-time 3D models integrating AI and IoT for urban planning, infrastructure resilience, and predictive analytics.
c. **Metaverse-Integrated Geospatial Visualization:**
   Advanced 3D mapping and geospatial simulations for urban development and transportation.
d. **Blockchain for Geospatial Data Security:**
   Immutable record-keeping for land administration, cadastral mapping, and data verification.

By incorporating a holistic technological approach, the GEO-Sandbox ensures that innovations are adaptable across land, maritime, and air, supporting geospatial applications in panoramic imaging, AI-driven analytics, and beyond for all geospatial economic activities and technologies.

3.5 Outputs and Deliverables

The GEO-Sandbox will produce outputs and deliverables that encompass all technologies across land, maritime, and air domains. These outputs will evolve as the initiative progresses, ensuring adaptability to emerging geospatial advancements. The listed deliverables reflect the current implementation phase.

Key deliverables at phase one of the GEOSandbox include:

- **High-Quality Geospatial Data**: Processed datasets from aerial, terrestrial, and marine sources, supporting diverse geospatial applications.
- **Panoramic Imagery and HD Mapping**: Enhanced visualization tools integrating high-resolution imaging and mapping solutions.
- **Advanced Navigation and Spatial Analysis Applications**: AI-powered systems for navigation, urban planning, and environmental monitoring.

- **Remote sensing Decision-Making data:** Raw and preprocessed satellite data, georeferenced imagery and raster products, digital elevation models (DEMs), thematic and analytical maps, climate and environmental data Products, and geospatial intelligence and decision support Systems.
- **Geospatial Data Standards and Methodologies**: Frameworks ensuring data accuracy, interoperability, and compliance with national and international standards.
- **Documentation of Processes and Best Practices**: Comprehensive reports detailing methodologies, workflows, and lessons learned for knowledge transfer and future scaling.
- **Cybersecurity Framework for Geospatial Systems:** A set of security protocols and best practices to protect geospatial infrastructure.

By incorporating a holistic technological approach, the GEO-Sandbox ensures that innovations are adaptable across land, maritime, and air, supporting geospatial applications in panoramic imaging, AI-driven analytics, and beyond for all geospatial economic activities and technologies.

3.6 Exclusions

The GEO-Sandbox is designed to support structured, scalable, and strategically aligned geospatial innovations. To ensure effective resource allocation and project viability, the sandbox excludes the following:

3.6.1 Non-Strategic or Unstructured Projects

a. Projects without clear objectives, defined outcomes, or measurable impact metrics.
b. Exploratory initiatives that lack a clear use case or alignment with national geospatial strategic priorities.
c. Research projects that do not contribute to Saudi Arabia's geospatial infrastructure, economic development, or regulatory frameworks.

3.6.2 Unaligned or Unvalidated Technologies

a. Experimental technologies that have no clear roadmap for real-world deployment or regulatory alignment.
b. Solutions that do not align with GEOSA's focus on emerging technologies, geospatial data governance, or interoperability standards.

c. Concepts that are purely theoretical and lack a functional prototype or proof-of-concept demonstration.

3.6.3 Non-Scalable or Premature Innovations

a. Initiatives that lack the technological readiness, infrastructure, or industry adoption required for large-scale implementation.
b. Projects that do not meet the technical, security, or compliance standards required for integration into Saudi Arabia's digital ecosystem.
c. Solutions that cannot be tested, validated, or scaled within the sandbox's defined operational timeline.

4 Framework for the GEO-Sandbox

4.1 Methodology for Designing Geospatial Projects

The GEO-Sandbox will follow a structured methodology to guide the design, implementation, and evaluation of projects. This methodology will include:

- **Needs Assessment**: Identifying specific geospatial challenges and opportunities in KSA.
- **Solution Design**: Developing customized geospatial applications using cutting-edge technologies.
- **Iterative Development**: Employing agile processes to refine solutions based on feedback and testing results.
- **Evaluation and Documentation**: Assessing project outcomes and documenting findings to inform future initiatives.
- **Aligned and integrated with the government entities**: to make sure they are aligned with the national policies, regulations, and acts related and support us through our tracks of enabling the geospatial solutions and technologies.

4.2 Infrastructure and Technological Foundations

The sandbox will be supported by a robust infrastructure that facilitates seamless project execution to achieve our target in early phases from this environment and to be ready for continuous work of the next phases of the initiative:

- **Data Collection Infrastructure**: Deployment of advanced sensors, cameras, and drones for panoramic imagery and HD mapping.

- **Processing and Analysis Platforms**: High-performance computing systems for processing large datasets, supported by in-country cloud solutions for scalability.
- **Visualization Tools**: AR/VR platforms and GIS software for presenting data in an interactive and user-friendly manner.
- **Connectivity**: Integration with IoT networks and 5G technology to enable real-time data exchange and analysis.

4.3 Policies, Standards, and Regulatory Context

The GEO-Sandbox will operate within a defined regulatory framework to ensure compliance, consistency, and alignment with the industry's best practices. The sandbox operations will comply with national geospatial data policies [2] regarding licensing, access control, and data governance. This also includes collaboration with key stakeholders to establish policies and standards that support the successful implementation of geospatial technologies.

- **Regulatory Alignment**: Adherence to National Geospatial Data Policies [2], GEOSA's geospatial policies and DGA guidelines, developed by alignment and integration with the participation of all stakeholders involved and related to it.
- **Standardization**: Establishing guidelines and standards for data quality, imagery resolution, mapping accuracy, and interoperability to ensure consistency across projects.
- **Risk Mitigation Policies**: Implementing safeguards to protect users, stakeholders, and the environment from potential risks associated with geospatial data collection, processing, and Publishing/using it through the services, products, and applications.

4.4 Stakeholder Roles in Implementation and Oversight

The roles of GEOSA, project teams, and local authorities in sandbox management were defined in light of the National Geospatial Data Governance Framework [3]. The sandbox will assign clear roles and responsibilities to ensure efficient collaboration:

- **GEOSA**: Acting as the primary governing body, providing oversight, technical support, and regulatory guidance.

- **Project Teams**: Designing and implementing the projects, including technical specialists, data analysts, and project managers.
- **Local Authorities**: Offering logistical support and facilitating access to locations and data, as well as applying their relevant regulations based on the impact of technologies and solutions emerging from the sandbox.
- **Private Sector Partners**: Supplying technology solutions and expertise.
- **Academic & Research Institutions**: Providing R&D support, innovation validation, and talent development.
- **Community Stakeholders**: Providing feedback and insights to ensure projects address real-world needs.

4.5 Collaboration with the Broader Ecosystem

The GEO-Sandbox will actively engage with a wider ecosystem to leverage collective expertise and resources:

- **Public-Private Partnerships**: Building synergies between government agencies and private enterprises.
- **Academic Collaborations**: Partnering with universities and research institutions for R&D and talent development.
- **International Benchmarking**: Drawing insights from global best practices and standards to ensure the sandbox aligns with international advancements.

4.6 Monitoring and Reporting Mechanisms

The sandbox will include robust monitoring and reporting systems to track progress:

- **AI-Driven Performance Dashboards**: Providing real-time insights into project milestones and outcomes.
- **Regular Reporting and Impact Assessment**:
    - Periodic evaluations aligned with Saudi Arabia's emerging technology readiness index.
    - Ensuring transparency and accountability through periodic updates to stakeholders.

    - Risk analysis reports for AI-powered geospatial projects, ensuring transparency and accountability.

- **Feedback Loops**: Integrating feedback into ongoing projects to continuously improve processes and outcomes.

5 Project Design and Implementation Process

5.1 Conceptualization and Objective Setting

The GEO-Sandbox will begin with a clear definition of project objectives, aligning them with the broader goals of the sandbox, GEOSA strategy, and the national geospatial ecosystem. The GEO-Sandbox projects should strictly follow government-established guidelines for geospatial project planning and execution [4]. This phase will include:

- **Identifying Challenges**: Understanding the specific geospatial challenges in KSA.
- **Defining Objectives**: Establishing measurable goals for each project, such as improving mapping accuracy, enhancing navigation capabilities, or increasing data accessibility.
- **Engaging Stakeholders**: Consulting with local authorities, businesses, and the community to ensure the objectives address real-world needs.

5.2 Project Design Principles and Framework

Projects within the GEO-Sandbox will follow a set of design principles to ensure consistency, innovation, and scalability:

- **User-Centric Design**: Prioritizing the needs of end users, including residents, businesses, and government entities.
- **Scalability**: Ensuring that solutions can be expanded to other regions of KSA.
- **Interoperability**: Designing systems that can integrate with existing geospatial platforms and tools.
- **Sustainability**: Incorporating environmentally friendly practices and long-term viability into project design.

5.3 Testing and Validation of Outcomes

The GEO-sandbox will include a comprehensive testing and validation process to ensure project success:

- **Performance Evaluation**: Using predefined KPIs to assess functionality, efficiency, and reliability.
- **Risk Assessment**: Identifying and mitigating potential risks to data accuracy, user experience, and system performance.

- **Feedback Integration**: Collecting input from stakeholders during the testing phase and incorporating improvements.

5.4 Documentation and Reporting

Throughout the implementation process, projects will maintain detailed records to ensure transparency and replicability:

- **Project Documentation**: Comprehensive records of methodologies, workflows, and outcomes.
- **Progress Reports**: Regular updates to GEOSA and stakeholders on milestones, challenges, and adjustments.
- **Final Project Report**: A summary of the project's achievements, lessons learned, and recommendations for future initiatives.

5.5 Stakeholder Engagement

Engaging with relevant stakeholders will be integral to the implementation process:

- **Workshops and Consultations**: Collaborating with government agencies, private companies, and community members.
- **Government Engagement:** Participants in the sandbox should follow the Guide for Establishing and Operating Geospatial Information Units in Government Entities [4] in their planned project activities that involves government bodies.
- **Public Outreach**: Sharing project goals and progress with the broader community to foster awareness and support.

5.6 Scaling and Knowledge Transfer

Upon successful implementation, projects will be scaled and shared as guidance for future initiatives:

- **Scaling Plan**: Developing strategies to expand the project to other regions in KSA.
- **Knowledge Sharing**: Publishing guidelines, methodologies, and case studies to serve as resources for other geospatial projects.

6 GEO-Sandbox Roadmap

The GEO-Sandbox roadmap follows a structured, multi-phase approach to ensure that geospatial projects are strategically designed, validated, and deployed in a way that aligns with Saudi Arabia's national geospatial strategy [8], regulatory frameworks, and the Emerging Technology Readiness Index (ETRI) [6, 7].

6.1 Phase 1: Initial Assessment (1-2 months)

- **Objective**: Application submission, evaluation requirements, existing geospatial infrastructure, and the overall feasibility of building the sandbox environment. This will result in a letter of acceptance or rejection.
- **Emerging Technology Readiness Evaluation (ETRI Phase 1)**
    - Assess each project's alignment with emerging technology benchmarks and geospatial maturity models.
    - Identify the adoption level (early-stage vs. deployable technology) and its relevance to the Saudi market.
- **Requirements Gathering and Gap Analysis**
    - Conduct detailed stakeholder interviews to identify current geospatial challenges (e.g., data availability, regulatory constraints, local capabilities).
    - Inventory existing data sources (satellite imagery, cadastral maps, hydrographic surveys) and ongoing projects to see where the GEO-Sandbox can add value.
    - Review local regulations (airspace permits for drones, data privacy laws) that affect geospatial data collection.
- **Feasibility Study**
    - Analyze potential sites or facilities for sandbox operations (e.g., existing data centers vs. building a dedicated facility).
    - Explore partnerships with public and private entities for cost-sharing and technology support.

- Preliminary Stakeholder Engagement
    - Establish an initial working group under GEOSA to coordinate feedback from government agencies, private tech partners, and local communities.
    - Summarize stakeholder needs and priorities in a short "Initial Assessment Report."
- Key Deliverables:
    - Needs Assessment and Gap Analysis Document.
    - Initial Stakeholder Engagement Report.
    - High-Level Feasibility Study.

6.2 Phase 2: Planning (1-2 months)

- Objective: Create a detailed blueprint for the sandbox, covering governance, timelines, and resource allocation.
- Emerging Technology Readiness Evaluation (ETRI Phase 2 - Strategic Alignment)
    - Ensure selected technologies align with Saudi Arabia's geospatial innovation priorities.
    - Assess how proposed projects integrate with national geospatial data platforms.
- Governance Model and Organizational Framework
    - Form a Steering Committee (with GEOSA as lead) to oversee sandbox strategy and decision-making.
    - Define roles and responsibilities for technical teams, data management, regulatory compliance, and communications.
- Technical Planning
    - Select the appropriate technologies (drones, LiDAR sensors, marine survey equipment, AI/ML tools) based on the Phase 1 gap analysis.
    - Outline the data architecture, including cloud infrastructure, storage requirements, and security measures to protect the geospatial data.

- Regulatory Alignment
    - Work closely with relevant authorities to secure any necessary permits (aerial and hydrographic surveying, personal data protection, etc.).
    - Develop a "Regulatory Compliance Plan" to ensure sandbox activities meet national standards.
- Resource Mobilization
    - Draft a detailed budget for capital expenditures (sensors, computing hardware) and ongoing operational costs (software licenses, staff).
    - Identify potential funding streams, including government allocations, private sector contributions, and research grants.
- Key Deliverables:
    - Governance Charter and Organizational Chart.
    - Technical Requirements Specification.
    - Regulatory Compliance Plan.
    - Detailed Budget and Resource Plan.

6.3 Phase 3: Pilot Development (3–6 months)

- Objective: Develop prototypes or proof-of-concept projects within the newly established sandbox environment.
- Pilot Project Selection
    - Using inputs from Phases 1 and 2, select up to two or three pilot projects (e.g., an advanced navigation app, panoramic imaging for urban mapping, or hydrographic surveying for coastal management).
    - Choose high-impact pilots based on ETRI [6, 7] readiness assessment and geospatial data integration potential.
    - Ensure each pilot aligns with GEOSA's priorities and addresses a clear local challenge.

- Pilot Design and Execution
    - Form cross-functional teams (geospatial analysts, data scientists, software developers, and policy experts) to execute each pilot.
    - Develop detailed prototypes or demonstration models that showcase the sandbox's capabilities—e.g., real-time mapping dashboards, and AI-driven data processing.
- Internal Testing
    - Validate the pilot projects in a controlled setting, ensuring data accuracy and checking compliance with established standards.
    - Collect internal feedback from sandbox staff and refine pilot scope as needed.
- Key Deliverables:
    - Pilot Project Charters (technical objectives, timelines, expected outcomes).
    - Initial Prototypes or Proof-of-Concept Solutions.
    - Internal Testing and Validation Reports.

6.4 Phase 4: Testing and Validation (3–6 months)

- Objective: Move beyond internal trials to rigorous testing of pilot projects in real or near-real operating conditions.
- ETRI-Based Performance Evaluation (Phase 3)
    - Each pilot project will be assessed against Key Performance Indicators (KPIs) derived from the Emerging Technology Readiness Index (ETRI) [6, 7] methodology.
        - Research: The level of geospatial innovation, feasibility, and alignment with industry trends.
        - Communication: Effectiveness in data exchange, system interoperability, and cross-sector collaboration.
        - Evidence: Availability of validated geospatial datasets, AI model accuracy, and test results.

    - **Integration:** Readiness for full deployment, scalability, and seamless adoption into Saudi Arabia's national geospatial ecosystem.

- **Performance Evaluation and KPI Tracking**
    - Assess each pilot against the Key Performance Indicators (KPIs) outlined in Section 7 (e.g., positional accuracy, data integrity).
    - Conduct user experience tests if the pilot is a public-facing application (e.g., a navigation tool).
- **Risk Assessment and Mitigation**
    - Identify any unforeseen issues: data security gaps, interoperability challenges, or user adoption hurdles.
    - Refine the project approach—e.g., update software modules, reconfigure hardware, or enhance user interface.
- **Stakeholder Engagement and Feedback**
    - Organize workshops with government stakeholders, private companies, and end-users.
    - Solicit feedback regarding the practicality, scalability, and cost-effectiveness of each pilot.
- **Key Deliverables**:
    - Final Validation Reports, including KPI dashboards.
    - Updated Risk Registers and Mitigation Strategies.
    - Stakeholder Feedback Summaries.

6.5 Phase 5: Deployment and Exiting (1–2 months)

- **Objective**: Launch each fully tested project within the sandbox environment and establish a clear path for knowledge transfer, handover, or scale-out.
- **Deployment in the Sandbox**
    - Officially activate pilot projects, granting broader access to relevant stakeholders.

    - Monitor usage metrics and system load to ensure ongoing performance.

- Transition and Handover
    - If a project is intended for a specific government agency, private operator, or community group, provide comprehensive documentation, training, and SOPs.
    - Clarify ownership of data, software licenses, and IP rights.
- Project Review and Lessons Learned
    - Conduct post-project reviews to capture best practices and challenges.
    - Publish the final documentation and case studies within the sandbox repository (aligns with Section 9 on Documentation).
- Scaling and Next Steps
    - Identify opportunities to replicate or expand successful pilots to other regions or new domains.
    - Refine the sandbox framework based on feedback, preparing for future phases of innovation.
- Key Deliverables:
    - Deployed Pilot Projects (operational in the sandbox).
    - Handover Documentation and Training Guides.
    - Post-Project Review and Final Reports.
    - Roadmap for Future Scaling.

7 GEO-Sandbox Management Plan

Following the GEO-Sandbox roadmap, the ongoing management structure ensures effective governance, operational efficiency, and continuous innovation. The plan establishes clear oversight, streamlined resource allocation, and security protocols while integrating performance tracking and emerging technology evaluation.

7.1 Governance and Oversight

GEO-Sandbox governance aligns with the national geospatial governance framework [3].

1. Steering Committee
    - Composed of GEOSA leadership and other government representatives to provide high-level guidance.
    - Provides high-level guidance on policy alignment, regulatory compliance, and national geospatial strategy [8] integration.
    - Evaluates emerging technology readiness (ETRI KPIs [6, 7]) and approves major sandbox initiatives.
    - Meets periodically to review performance, approve major expenditures, and align sandbox activities with GEOSA strategy and the national geospatial.
2. Project Management Office (PMO)
    - Day-to-day oversight of sandbox operations.
    - Develops and enforces standard operating procedures (SOPs) for data collection, processing, and QA/QC.
    - Tracks KPIs (Section 9) and reports progress to the Steering Committee.
3. Technical Working Groups
    - Specialized teams for cartography, remote sensing, marine surveying, AI/ML analytics, cybersecurity, and cloud infrastructure.

- Responsible for overseeing pilot projects, Technical validation, maintaining technical standards, and troubleshooting operational issues.

Key Outputs:

- Governance Charter (updated annually).
- Periodically Performance Reviews with ETRI-based readiness tracking..
- Consolidated KPI Dashboards and risk assessment updates.

7.2 Operational Processes

1. Data Management and Security
    - All datasets undergo quality assurance checks, ensuring alignment with the framework.
    - Implement cybersecurity protocols for encryption, access control, and intrusion detection.
2. Resource Allocation
    - PMO balances resource demands across multiple pilots (drones, staff time, computing power).
    - Assign “Technical Leads” to each pilot for accountability and timely milestone achievement.
3. Continuous Risk Management
    - Maintain a live risk register, and update regularly with identified threats (budget shortfalls, data breaches, regulatory changes).
    - Integrate risk monitoring into weekly or monthly operations meetings.
4. Stakeholder Engagement
    - Schedule periodic workshops with private partners, academic institutions, and local communities to gather feedback, share knowledge, and refine sandbox objectives.

7.3 Human Resources and Capabilities

1. Geospatial Analysts
    - Responsible for analyzing geospatial data (e.g., satellite imagery, panoramic imaging, bathymetric data).
    - Typical profile: master's in geomatics, geography, or a related field, plus specialized software training (e.g., GIS platforms, remote sensing tools).
2. Data Scientists / AI Specialists
    - Focus on advanced analytics, such as machine learning for feature extraction or predictive modeling.
    - Collaborate with geospatial analysts to integrate AI algorithms into data workflows.
3. IT and Cloud Infrastructure
    - Manage server environments, data storage, and cybersecurity protocols.
    - Ensure compliance with in-country hosting requirements and national data laws.
4. Project Managers / Coordinators
    - Oversee timelines, budgets, and deliverables for each pilot.
    - Serve as the primary interface with the Steering Committee and external partners.
5. Support Staff
    - Handle administrative tasks, procurement, workshop logistics, and documentation management.

Note: The size of each team expands, or contracts based on pilot scope and overall sandbox maturity.

7.4 Budget: Establishment and Operational Costs

A high-level view of initial setup (CAPEX) and ongoing operational (OPEX) costs are below:

1. Capital Expenditures (CapEx)
    - Equipment:
        - Drone fleets, LiDAR sensors, panoramic imaging rigs, and hydrographic instruments.
        - Estimated Range (Year 1).
    - Infrastructure Setup:
        - Securing or building physical workspace (including server rooms) and purchasing networking equipment.
        - Estimated Range (Year 1).
2. Operational Expenditures (OpEx)
    - Human Resources:
        - Salaries for 10–20 specialized staff (geospatial analysts, AI experts, PMs, etc.).
        - Estimated Range (Annual).
    - Software and Cloud Services:
        - GIS licenses, AI/ML frameworks, cloud processing fees, data security solutions.
        - Estimated Range (Annual).
    - Maintenance and Support:
        - Regular upkeep of drones, surveying equipment, and ongoing training initiatives.
        - Estimated Range (Annual).
3. Contingency and Scalability
    - Recommended 10–15% contingency for unanticipated costs (e.g., new pilot expansions, emerging technologies).
    - A dedicated R&D allocation (5–10% of the total annual budget) can drive continuous innovation, ensuring the sandbox remains current with evolving geospatial technologies.

8 Key Guidelines for Geospatial Projects

The GEO-Sandbox is committed to ensuring that all geospatial projects are designed and executed in alignment with global and national best practices, with a focus on emerging technologies and scalability. This section outlines the key guidelines for the successful implementation of geospatial projects, ensuring their alignment with emerging technology readiness and national geospatial priorities.

8.1 Alignment to emerging technology readiness index

The GEO-Sandbox will closely follow the recommendations from the Emerging Technology Readiness Index (ETRI) [6, 7] to ensure that each geospatial project aligns with global technological trends and Saudi Arabia's national readiness. Key factors from the ETRI methodology will be integrated into the design, testing, and implementation phases of geospatial projects:

a. Evaluation of Technology Readiness:
    a. Projects will be evaluated based on their readiness level, including the adoption potential, scalability, and integration capacity with existing national geospatial frameworks.
    b. KPIs will track the maturity level of emerging technologies, such as AI-powered geospatial analytics and digital twin applications.
b. Impact on National Geospatial Data Infrastructure:
    a. Projects will be assessed based on how they contribute to the growth and maturity of Saudi Arabia's National Geospatial Data Infrastructure (NGDI).
    b. Emphasis will be placed on interoperability with existing national geospatial systems.
c. Technology Adoption Roadmap:
    a. Each project will align with a structured roadmap for integrating emerging technologies, ensuring their smooth transition from pilot to large-scale deployment.
d. Scalability Assessment:
    a. All projects will be evaluated on their ability to scale, considering data processing needs, cloud infrastructure, and regulatory compliance.

8.2 Data Collection and Acquisition

- Implementing standardized methodologies for aerial, terrestrial, and marine geospatial data collection to ensure uniform quality.
- Ensuring high-resolution imagery and accurate spatial data across different collection platforms (satellites, drones, ground surveys, and marine sensors).
- Utilizing AI-powered automation and IoT-enabled sensors for real-time data acquisition.
- Establishing best practices for integrating multi-source geospatial datasets to improve accuracy and coverage.
- Storage and Accessibility: Leverage in-country cloud platforms to store imagery for easy access, sharing, and integration with other systems.

8.3 Geospatial Data Processing and Quality Assurance

- Applying rigorous validation techniques to ensure the accuracy, completeness, and reliability of collected data.
- Standardizing geospatial data formats and classification schemes for interoperability.
- Enforcing national and international geospatial data quality standards stated in the National Geospatial Data Standards [1].

8.4 Geospatial Data Management and Integration

- Developing structured geospatial databases to store and manage large-scale datasets.
- Ensuring seamless integration of different data types (raster, vector, 3D models, point clouds, etc.) within GIS platforms.
- Following data governance guidance on data integration frameworks from the National Geospatial Data Standards [1], ensuring consistency across sandbox projects
- Establishing data governance policies to regulate ownership, access, and sharing of geospatial data, and compliance adhere to international geospatial mapping standards and GEOSA's regulatory framework.

Ensuring alignment with the phase one geospatial economic activities while maintaining scalability for future phases

- Utilizing cloud-based infrastructure for scalable geospatial data storage and real-time analytics.
- Storage and Accessibility: Leverage in-country cloud platforms to store imagery for easy access, sharing, and integration with other systems.
- all GEO-sandbox datasets must align with the national metadata profile [5].

8.5 Designing Scalable and Reliable Navigation Apps

- **User Experience (UX):** Focus on intuitive interfaces, real-time responsiveness, and multilingual support.
- **Routing Algorithms:** Develop algorithms optimized for shortest paths, traffic conditions, and user preferences.
- **Integration with Local Data:** Incorporate local landmarks, infrastructure details, and cultural considerations to enhance relevance.
- **Offline Functionality:** Design features for offline access, ensuring functionality in areas with limited connectivity.
- **Testing and Validation:** Rigorously test navigation applications in diverse conditions, including urban congestion and rural settings.

8.6 Mapping, Visualization, and Digital Twin Development

- Creating advanced cartographic products, including topographic, thematic, and marine maps.
- Utilizing 3D modeling and digital twin technology to enhance spatial analysis and decision-making.
- Adopting AR/VR visualization tools for interactive geospatial exploration.
- Implementing dynamic mapping solutions that update in real-time based on live sensor data.

8.7 Adapting to Local Geographical and Urban Contexts

- **Cultural Sensitivity:** Ensure that geospatial solutions respect cultural and religious norms in KSA.

- **Urban Development Alignment:** Coordinate with urban planning authorities to align projects with ongoing infrastructure development.
- **Environmental Considerations:** Minimize environmental impact during data collection and processing and incorporate sustainability measures.

8.8 Ensuring Data Privacy and Security

- Data Anonymization: Protect user and community privacy by anonymizing sensitive data during collection and processing.
- Compliance with Regulations:
    - data encryption, anonymization policies, and access control for geospatial datasets must comply with the National Geospatial data policies [2].
    - Adhere to KSA's data privacy laws, ensuring secure storage, sharing, and usage of geospatial data.
- Security Protocols: Implement robust encryption and cybersecurity measures to safeguard data from unauthorized access.

8.9 Documentation and Knowledge Sharing

- Project Reports: Maintain detailed documentation of methodologies, challenges, and solutions for each project.
- Case Studies: Publish insights and lessons learned to inform and guide future geospatial projects.
- Training and Workshops: Conduct training sessions for stakeholders to share knowledge and build local capacity.

9 KPIs for Project Success

The GEO-Sandbox will use Key Performance Indicators (KPIs) to measure the success of its projects and ensure alignment with both emerging technology readiness and national geospatial priorities. These KPIs will focus on technical performance, user satisfaction, scalability, and impact assessment, while integrating the ETRI evaluation factors for comprehensive assessment.

9.1 General KPIs for the GEO-Sandbox

- **Project Completion Rate**: Percentage of projects successfully completed within the planned timeline and budget.
- **Stakeholder Satisfaction**: Positive feedback from participating stakeholders, including government entities, private companies, and end-users.
- **Scalability of Solutions**: Number of projects replicated or implemented in other regions across phase one priority areas and broader geospatial economic activities.
- **Knowledge Transfer**: Quality and number of published case studies, guidelines, and training sessions derived from sandbox projects.

9.2 Data Collection and Accuracy KPIs

- **Positional Accuracy:** Measurement of geospatial data accuracy compared to ground truth (e.g., centimeter-level precision for land surveying).
- **Data Completeness:** Percentage of target areas successfully covered by aerial, terrestrial, or marine data collection efforts.
- **Real-Time Data Acquisition Efficiency:** Speed and frequency of real-time data updates from IoT sensors and remote sensing systems.
- **AI-Powered Data Processing Efficiency:** Reduction in processing time due to automation and AI-driven analytics.
- **standards for metadata:** all sandbox datasets must align with the national metadata profile [5].

9.3 Geospatial Data Quality and Processing KPIs

- **Data Integrity and Consistency:** Percentage of datasets meeting predefined quality standards.
- **Error Rate in Automated Feature Extraction:** Accuracy of AI models in detecting, classifying, and mapping geospatial objects.
- **Data Update Frequency:** Timeliness of geospatial dataset updates to reflect changes in infrastructure, environment, or urban expansion.
- **Processing Efficiency:** Average time required to convert raw geospatial data into a final, validated product.

9.4 Mapping, Visualization, and Digital Twin KPIs

- **3D Model Precision:** Accuracy of digital twins and 3D models in representing real-world structures.
- **Map Detail and Layer Integration:** Number and quality of integrated geospatial layers (e.g., transportation networks, topography, hydrography).
- **Geospatial Dashboard Utilization:** User engagement and adoption rates for geospatial visualization tools.
- **AR/VR-Based Data Accessibility:** Effectiveness of immersive visualization tools in enhancing spatial understanding and decision-making.

9.5 Broader Impact KPIs

- **Economic Impact**: Contribution of geospatial projects to local economic growth, such as job creation or increased investment in geospatial technologies.
- **Environmental Impact**: Reduction in resource consumption or environmental disruption during data collection and implementation.

9.6 Monitoring and Reporting KPIs

- **Reporting Compliance**: Percentage of projects submitting periodic reports as per the agreed schedule.
- **Data Quality**: Percentage of datasets generated in the sandbox meeting predefined quality benchmarks.

- **Error Mitigation**: Frequency and effectiveness of corrective actions taken during project execution.

9.7 ETRI-Based Readiness Evaluation Factors

To ensure alignment with the Emerging Technology Readiness Index (ETRI) [6, 7], additional KPIs will evaluate projects across the key readiness factors:

9.7.1 Research Capabilities

- **Assessment of R&D Investment:** Tracking funding, resources, and efforts focused on innovation in AI-driven geospatial technologies, real-time data integration, and IoT-powered solutions.
- **Innovation Benchmarking:** Comparing technological advancements to global trends in emerging geospatial solutions.

9.7.2 Communication and Interoperability

- **Integration Success Rate:** Percentage of successful integration with national geospatial data systems and interoperability with global GIS platforms.
- **Data Sharing Efficiency:** Speed and effectiveness of data exchange between public, private, and academic entities.

9.7.3 Evidence and Standardization

- **Data Standardization Score:** Degree of standardization in geospatial data formats, AI model outputs, and processing workflows for consistent quality across sandbox projects.
- **Validation and Testing Compliance:** Percentage of projects successfully passing ETRI-based testing protocols, ensuring readiness for wider national adoption.

9.7.4 Integration and Scalability

- **Project Scalability Index:** Measuring how well sandbox solutions scale across regions and different geospatial domains, ensuring solutions are adaptable across urban, rural, and environmental contexts.
- **Technology Maturity Rating:** ETRI readiness levels of sandbox projects based on real-world trials and pilot evaluations.

10 Lessons Learned and Best Practices

The GEO-Sandbox aims to extract valuable insights and establish best practices from each project undertaken. These lessons will serve as a foundation for future geospatial initiatives, ensuring continuous improvement and greater impact.

10.1 Challenges Faced and Solutions

- Technical Challenges:
    - Lesson: Incomplete or inconsistent data collection can result in delays and inaccuracies.
    - Best Practice: Standardize data collection protocols and use advanced tools like drones, LiDAR, and IoT sensors to ensure quality and consistency.
    - Lesson: Real-time processing of large datasets poses significant challenges.
    - Best Practice: Leverage cloud computing and parallel processing techniques to handle high data volumes efficiently.
- Regulatory Challenges:
    - Lesson: Navigating compliance with data privacy laws can delay project execution.
    - Best Practice: Engage regulatory bodies early to align project goals with local laws and ensure adherence throughout the project lifecycle.
- Collaboration Challenges:
    - Lesson: Limited coordination between stakeholders can lead to misaligned objectives.
    - Best Practice: Establish clear roles, responsibilities, and communication channels for all participants from the outset.

10.2 Key Insights from the Sandbox

- Adaptation to Local Context: Projects in KSA demonstrated the importance of tailoring geospatial solutions to unique urban, cultural, and geographical factors.

- **Stakeholder Engagement**: Early involvement of local authorities and community stakeholders significantly improved project acceptance and utility.
- **Incremental Scaling**: Starting with small-scale pilots allowed for risk mitigation and easier adaptation of processes before scaling up to larger deployments.
- **Cross-Disciplinary Expertise**: Collaboration between geospatial experts, data scientists, and local urban planners enhanced the quality and relevance of project outputs.

10.3 Best Practices for Geospatial Data Collection and Acquisition

- **Standardized Data Quality:** Define and enforce resolution, accuracy, and consistency benchmarks for all geospatial data types, including aerial, terrestrial, and marine sources.
- **Multi-Platform Data Acquisition:** Utilize drones, satellites, mobile mapping systems, and IoT sensors to ensure comprehensive and real-time data collection.
- **Advanced Imaging and Sensor Integration:** Leverage LiDAR, multi-spectral, and hyperspectral imaging for enhanced data precision and expanded analytical capabilities.

10.4 Best Practices for Geospatial Data Processing and Management

- **Automated Data Cleaning and Validation**: Implement AI-powered workflows to detect anomalies, correct errors, and enhance data accuracy.
- **Multi-Layered Data Fusion**: Integrate geospatial datasets across different domains to create comprehensive and dynamic spatial models.
- **Iterative Data Updates**: Establish regular update cycles to reflect real-time environmental changes, infrastructure development, and evolving spatial datasets.

10.5 Best Practices for Geospatial Analytics and Decision Support

- **User-Centric Geospatial Applications**: Design platforms with intuitive interfaces, real-time interactivity, and customizable visualization tools.

- **Predictive Analytics and AI Integration**: Use machine learning to enhance spatial forecasting, trend analysis, and risk assessment for urban planning, mobility, and environmental management.
- **Scalability and Adaptability**: Ensure that geospatial solutions are flexible, expandable, and able to integrate with future technologies and datasets.

10.6 Recommendations for Future Geospatial Projects

- **Early Risk Identification**:
  - Develop a comprehensive risk assessment framework at the beginning of each project, incorporating ETRI readiness evaluation factors to identify potential technological, regulatory, and scalability risks early.
  - Assess data integrity, cybersecurity risks, and interoperability challenges as part of emerging technology adoption in the initial project planning phase.
- **Knowledge Sharing**:
  - Document and disseminate methodologies, successes, and challenges to build a knowledge repository that incorporates ETRI readiness assessments and feedback loops from project pilots.
  - Share best practices for scalability and interoperability, enabling others to learn from sandbox implementations and support technology adoption.
- **Sustainability**:
  - Incorporate environmentally friendly practices, such as minimizing disruption during data collection and optimizing energy use in data processing.
- **Interoperability Standards**:
  - Ensure that geospatial solutions adhere to global interoperability standards and integrate seamlessly with national systems such as Saudi Arabia's NGDI.
  - Align technology development with ETRI integration factors, ensuring that new solutions are scalable and can be adapted for use in other regions or geospatial domains.

- Ensure that geospatial solutions can integrate seamlessly with other systems, enhancing their scalability and utility.

10.7 Long-Term Vision

- Refining Project Frameworks for Expansion:
  - Use lessons learned from the GEO-Sandbox to refine project frameworks, ensuring the scalability of geospatial solutions and integration of emerging technologies as assessed in the Emerging Technology Readiness Index (ETRI) [6, 7].
  - Expand the sandbox concept to other regions in KSA, focusing on regional adaptation of AI-based geospatial tools, data governance standards, and cloud infrastructure solutions for seamless national implementation.
- Fostering a Culture of Innovation:
  - Encourage public and private sector entities to adopt best practices and emerging geospatial technologies developed in the sandbox.
  - Promote AI-powered geospatial intelligence, digital twin modeling, and sustainable data processing techniques within KSA's geospatial ecosystem.
  - Support continuous innovation by allocating resources to AI and IoT solutions, cloud-based spatial platforms, and automation in geospatial workflows.
- Strengthening International Collaboration:
  - Align sandbox methodologies with global geospatial standards, ensuring ETRI-based evaluations for global interoperability.
  - Foster international partnerships by sharing GEO-Sandbox methodologies, data standards, and project outcomes to ensure global collaboration in areas such as smart cities, autonomous mobility, and environmental monitoring.
  - Participate in global geospatial forums and collaborative R&D efforts, integrating global advancements in AI-driven geospatial data analytics and cloud-based platforms.

11 Documentation

Comprehensive documentation is a critical component of the GEO-Sandbox initiative. It ensures transparency, facilitates knowledge transfer, and provides a foundation for replicating and scaling geospatial projects across KSA and beyond. It also supports the localization and empowerment of geospatial technologies, attracts investments, opens broader opportunities for innovation and research in the sector, and enhances national knowledge and capabilities. This section outlines the documentation practices that will be implemented throughout the lifecycle of the GEO-Sandbox projects.

11.1 Importance of Documentation

- **Knowledge Sharing**: Documenting methodologies, processes, and outcomes creates a knowledge base that can guide future geospatial projects.
- **Transparency**: Maintaining detailed records ensures accountability and provides a clear audit trail for stakeholders.
- **Replicability**: Well-documented processes enable other teams or regions to replicate successful projects and adapt them to their unique contexts.

11.2 Types of Documentation

- **Project Planning Documents**:
  - Project charters outlining objectives, scope, and deliverables.
  - Resource allocation plans, including budgets and team structures.
- **Implementation Records**:
  - Detailed workflows and step-by-step processes followed during project execution.
  - Logs of tools, technologies, and equipment used in the sandbox.
- **Technical Specifications**:
  - Schematics of panoramic imagery systems, HD mapping frameworks, and navigation app architectures.
  - Algorithms and coding standards applied in geospatial solutions.

- Performance Reports:
    - Periodic reports evaluating progress against KPIs, milestones, and predefined goals.
    - Analysis of project outcomes, highlighting successes and areas for improvement.
- Regulatory and Compliance Documentation:
    - Proof of adherence to local laws, GEOSA guidelines, and international geospatial standards.
    - Records of data privacy, security protocols, and risk mitigation measures.

11.3 Documentation Processes

- Standardized Formats:
    - Use predefined templates for consistency across projects (e.g., project plans, reports, and technical manuals).
- Regular Updates:
    - Maintain logs and records in real-time, ensuring accuracy and relevance.
    - Schedule periodic reviews to update documentation as the project progresses.
- Version Control:
    - Implement version control systems to track changes and maintain the integrity of documents over time.

11.4 Stakeholder-Specific Documentation

- For Internal Teams:
    - Detailed technical guides and process manuals for team members involved in project implementation.
- For Regulatory Bodies:
    - Comprehensive reports demonstrating compliance with GEOSA standards and legal requirements.

- For the Public and Other Stakeholders:
    - Summarized case studies, success stories, and infographics showcasing the impact and scalability of sandbox projects.

11.5 Documentation for Knowledge Transfer

- Case Studies:
    - Develop detailed case studies highlighting the methodologies, tools, challenges, and outcomes of sandbox projects.
- Best Practices Guides:
    - Publish guides on projects based on sandbox experiences.
- Training Materials:
    - Create training materials, including videos, tutorials, and step-by-step manuals, to educate teams and stakeholders.
- Workshops and Seminars:
    - Host knowledge-sharing events to present key insights and lessons learned from GEO-Sandbox projects.

11.6 Archiving and Accessibility

- Digital Repository:
    - Establish an online portal to house all GEO-Sandbox documentation, making it easily accessible to stakeholders.
- Open Access Policy:
    - Provide open access to non-sensitive documentation to promote collaboration and innovation across the geospatial industry.

12 Conclusion

The GEO-Sandbox initiative represents a transformative step towards advancing geospatial technology in Saudi Arabia, positioning the Kingdom as a global hub for innovation and technological excellence. By fostering a dynamic, structured environment, the sandbox enables the design, testing, and execution of cutting-edge geospatial projects, driving creativity, collaboration, and technological growth. It serves as a catalyst for localizing technologies, enhancing national capabilities, and expanding opportunities for research, investment, and economic growth within the geospatial sector.

12.1 Positioning KSA as a Geospatial Innovation Leader

Through the GEO-Sandbox, Saudi Arabia is poised to become a national and regional leader in geospatial innovation. The sandbox leverages KSA's unique geographical and cultural significance, combined with its state-of-the-art infrastructure, to drive the development of cutting-edge geospatial solutions. These innovations will not only address local needs but also set a benchmark for other regions within the Kingdom. The sandbox's alignment with the Emerging Technology Readiness Index (ETRI) [6, 7] ensures that global technologies are localized effectively, with an eye toward scalability and regional integration.

12.2 Contribution to GEOSA Strategy

The GEO-Sandbox is fully aligned with GEOSA's Strategy and contributes significantly to national geospatial ecosystem growth and digital transformation. By supporting economic diversification and the development of smart cities, the sandbox acts as a key enabler in advancing geospatial technologies for urban planning, mobility, and environmental sustainability. Through innovation, the sandbox attracts collaboration from both the public and private sectors, strengthening the resilience and forward-looking capabilities of the geospatial ecosystem.

12.3 Enabling Knowledge Sharing and Growth

A key outcome of the GEO-Sandbox will be the creation of a robust knowledge base capturing lessons learned, best practices, and replicable methodologies from projects. This knowledge base will provide a comprehensive guide for future geospatial initiatives, ensuring that successful solutions are scalable and can inspire the development of geospatial solutions across the Kingdom and internationally. As part of this effort, the ETRI-based evaluation will continue to

serve as a foundation for assessing the maturity and scalability potential of future geospatial projects.

12.4 Call for Collaboration

The success of the GEO-Sandbox is dependent on the active collaboration of all stakeholders—government bodies, private sector entities, academic institutions, and the local community. By working together, these stakeholders can overcome challenges, share expertise, and unlock the full potential of geospatial technologies. With active participation and the integration of emerging technologies, collaboration will drive the successful scaling of projects, ensuring that geospatial innovations benefit all sectors.

12.5 A Vision for the Future

The GEO-Sandbox is not only about developing individual projects; it's about creating a sustainable framework for innovation. By continuously refining processes, integrating emerging technologies, and scaling successful solutions, the sandbox will ensure that KSA becomes a global leader in geospatial technologies. With an eye toward continuous ETRI-based evaluation, the sandbox's future vision will include the national adoption of successful pilots and the integration of next-generation geospatial solutions, positioning Saudi Arabia as an international leader in geospatial innovation.

13 References

[1] "معايير البيانات الجيومكانية الوطنية", 2025, url: https://www.geoportal.sa/Geoportal/pdf/%D9%85%D8%B9%D8%A7%D9%8A%D9%8A%D8%B1%20%D8%A7%D9%84%D8%A8%D9%8A%D8%A7%D9%86%D8%A7%D8%AA%20%D8%A7%D9%84%D8%AC%D9%8A%D9%88%D9%85%D9%83%D8%A7%D9%86%D9%8A%D8%A9%20%D8%A7%D9%84%D9%88%D8%B7%D9%86%D9%8A%D8%A9.pdf

[2] "سياسات البيانات الجيومكانية الوطنية", 2025, url: https://www.geoportal.sa/Geoportal/pdf/%D8%B3%D9%8A%D8%A7%D8%B3%D8%A7%D8%AA%20%D8%A7%D9%84%D8%A8%D9%8A%D8%A7%D9%86%D8%A7%D8%AA%20%D8%A7%D9%84%D8%AC%D9%8A%D9%88%D9%85%D9%83%D8%A7%D9%86%D9%8A%D8%A9%20%D8%A7%D9%84%D9%88%D8%B7%D9%86%D9%8A%D8%A9.pdf

[3] "إطار حوكمة البيانات الجيومكانية الوطنية", url: https://www.geoportal.sa/Geoportal/pdf/%D8%A5%D8%B7%D8%A7%D8%B1%20%D8%AD%D9%88%D9%83%D9%85%D8%A9%20%D8%A7%D9%84%D8%A8%D9%8A%D8%A7%D9%86%D8%A7%D8%AA%20%D8%A7%D9%84%D8%AC%D9%8A%D9%88%D9%85%D9%83%D8%A7%D9%86%D9%8A%D8%A9%20%D8%A7%D9%84%D9%88%D8%B7%D9%86%D9%8A%D8%A9.pdf

[4] "دليل تأسيس وتشغيل وحدة المعلومات الجيومكانية بالجهات الحكومية", url: https://www.geoportal.sa/Geoportal/Geospatial-Governance

[5] "KSA National Geospatial Metadata Profile", GEOSA, url: https://www.geoportal.sa/Geoportal/pdf/%D8%A7%D9%84%D9%86%D9%85%D9%88%D8%B0%D8%AC%20%D8%A7%D9%84%D9%88%D8%B5%D9%81%D9%8A%20%D9%84%D9%84%D8%A8%D9%8A%D8%A7%D9%86%D8%A7%D8%AA%20%D8%A7%D9%84%D8%AC%D9%8A%D9%88%D9%85%D9%83%D8%A7%D9%86%D9%8A%D8%A9.pdf

[6] "جاهزية تبني التقنيات الناشئة في الجهات الحكومية", 70 pages, 2025, KSA.

[7] "جاهزية تبني التقنيات الناشئة - التقرير التفصيلي للهيئة العامة للمساحة والمعلومات الجيومكانية", 37 pages, 2025, KSA.

[8] "الاستراتيجية الجيومكانية الوطنية", url: https://saudipedia.com/article/14541/%D8%AD%D9%83%D9%88%D9%85%D8%A9-%D9%88%D8%B3%D9%8A%D8%A7%D8%B3%D8%A9/%D8%A7%D9%84%D8%

AD%D9%83%D9%88%D9%85%D8%A9-%D8%A7%D9%84%D8%B1%D9%82%D9%85%D9%8A%D8%A9/%D8%A7%D9%84%D8%A7%D8%B3%D8%AA%D8%B1%D8%A7%D8%AA%D9%8A%D8%AC%D9%8A%D8%A9-%D8%A7%D9%84%D8%AC%D9%8A%D9%88%D9%85%D9%83%D8%A7%D9%86%D9%8A%D8%A9-%D8%A7%D9%84%D9%88%D8%B7%D9%86%D9%8A%D8%A9

Versioning Table

Version	Date
1.0	Jan-2025
1.1	Feb-2025
1.2	Feb-2025
1.3	Feb-2025
1.4	Feb-2025
1.5	Mar-2025
1.6	Mar-2025
1.7	Mar-2025
1.8	Mar-2025

GEOSA
الهيئة العامة للمساحة والمعلومات الجيومكانية
General Authority for Survey and Geospatial Information

www.geosa.gov.sa