

# Activating Geospatial Information for Sudan's Sustainable Investment Map

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## ABSTRACT

Sudan is witnessing an acceleration in the processes of development and transformation in the performance of government institutions to raise the productivity and investment efficiency of the government sector. The development plans and investment opportunities have focused on achieving national goals in various sectors. This paper aims to illuminate the path to the future and provide geospatial data and information to develop the investment climate and environment for all-sized businesses, and to bridge the development gap between the Sudan states. The Sudan Survey Authority (SSA) is the main advisor to the Sudan Government in conducting surveying, mappings, designing, and developing systems related to geospatial data and information. In recent years, SSA made a strategic partnership with the Ministry of Investment to activate Geospatial Information for Sudan's Sustainable Investment and in particular, for the preparation and implementation of the Sudan investment map, based on the directives and objectives of the Ministry of Investment (MI) in Sudan.

This paper comes within the framework of activating the efforts of the Ministry of Investment to develop technical investment services by applying techniques adopted by the Ministry and its strategic partners for advancing investment processes in the country.

**KEYWORDS:** SNBS = Sudan National Base Map System; SSA = Sudan Survey Authority; GGRF = Global Geodetic Reference Frame; IGIF = Integrated Geospatial Information Framework; UN GGRF = United National Global Geodetic Reference Frame; UNGGIM = United Nations Initiative on Global Geospatial Information Management

## 1. INTRODUCTION

The Sudan Survey Authority (SSA) is the advisor to the Sudan Government in conducting surveying, mappings, designing, and developing systems related to geospatial data and information. In recent years, SSA has made a strategic partnership, with the Ministry of Investment to activate Geospatial Information for Sudan's Sustainable Investment, and for the preparation and implementation of the Sudan investment map, based on the directives and objectives of the Ministry of Investment (MI) in Sudan.

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advancing investment processes in the country. In this regard, the SSA participated seriously with immense efforts and endeavors that aim to raise the country's standing, by creating a scientific breakthrough, exchanging technical expertise, and exchanging geospatial information knowledge. The Authority hopes to fulfill the required data and information and share and integrate them, through the federal and State government departments to achieve the basic objectives of the investment map. The SSA will provide the Ministry of Investment with the basic information and the digital national base map to become a basic base for all geospatial information provided by the Ministry of Investment and all strategic partners from the public and private sectors.

This confidence stems from the willingness of SSA during the previous years to prepare the base map in a way that meets the needs of all national parties in this matter, getting use of its technical expertise, which has exceeded one hundred years in surveying and map productions of all kinds and geospatial services.

To achieve the Sudan, Investment Map (SIM) objectives, the general framework is summarized with a focus on the following: 1. Basic directives of the Ministry of Investment for preparing the investment map. 2. Work Plans in coordination with partners and relevant authorities. 3. Work outputs and final products of provision of geospatial data, information, and data models. 4. Timeline of activities according to the agreed-upon stages. 5. The work team entrusted with implementing the geospatial information system in terms of study, design, and operation. 6. Business quality control (QA/QC), providing technical support, training program, and system activities. 7. Communication and coordination plan during the stages of implementing the national base map and inventorying the data of the Ministry of Investment's partners. 8. Hardware and software specifications required to operate and activate the system (System Specifications). 9. The financial cost of completing the geospatial information system in terms of providing basic data to the Ministry, and modeling the data of the Ministry's strategic partners.

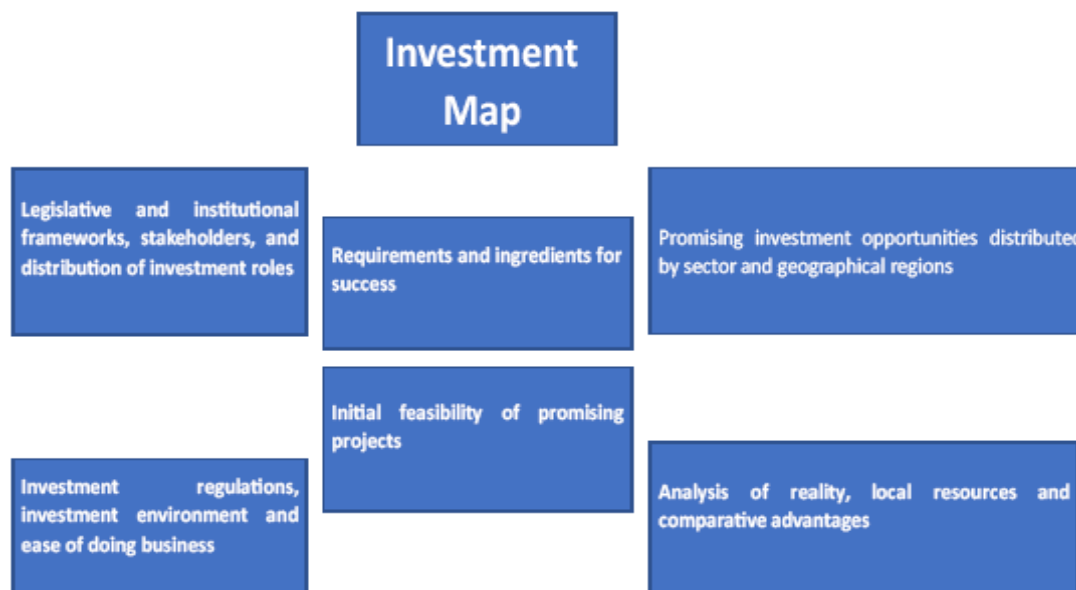
As well known, the geospatial data infrastructure and geospatial systems of today, necessitate the use of accurate reference frames and spatial data infrastructure, standards, and specifications [3, 9] for most applications and implementation of information systems. This will be essential for geospatial data sharing, integration, and mitigations. The unification of the geo-referencing systems of all geospatial data in Sudan assisted the Sudan Survey Authority in taking advanced steps in the implementation of enterprise geospatial solutions and the exchange of information. The devise of geospatial data infrastructure standards and specifications will increase the integration capabilities of databases between different organizations in the country, and in performing several operations in cost cost-effective and manageable manner. The SSA already completed

with an association with its partners most of the required geospatial standards and specifications in Geomatics and the preparation of data models and geospatial data dictionaries, Metadata, and feature coding for map production. This will assist all organizations in Sudan to expand their capabilities for the enhancement of their data collection, and management, and raising the level of support for geospatial data activities and provision of solutions that enable the effective delivery of geospatial information.

Contributions from Sudan Federal Departments and States government Spatial Data Infrastructure (SDI) are to be used to define the matrix of technologies, policies [8, 9], and institutional arrangements that will facilitate the availability and access of geospatial data at all levels of government, the private sector, and academic organizations. For MI and SSA the importance of SDI [8] can be considered crucial in creating the Sudan Investment map, supporting all terrestrial applications, decision-making processes, and management of resources at the growing national and regional levels. Because geospatial data is an expensive resource, has increased the need for cooperation between various MI partners in the acquisition of geospatial data, and the establishment of programs and projects to obtain and access the geospatial data, promote its use, and ensure that continuous additional investment in geospatial information [4].

## **2. Ministry of Investment and Sudan Survey Authority**

The Ministry of Investment has developed its directives for the development of the Sudan Investment map as a framework (Figure 1) for activating its efforts to advance investment in Sudan and to develop policies, regulations, and technical services by applying techniques adopted for the investment processes in the country. In recent years, SSA has become a strategic partner to the Ministry of Investment for activating Geospatial Information for Sudan's Sustainable Investment and in particular, for the preparation and implementation of the Sudan investment map.



**Figure 1: General features of the components and capabilities of the investment map**

The Sudan Survey Authority (SSA), is a national leader in geospatial data, information, and technology, and is the official surveying and mapping authority in Sudan. SSA is the nation's primary geospatial base map, and reference frame enabler. Since 1998 and in the years to follow, Sudan's government, the general public, and enterprises have relied on the Sudan Survey Authority as a legal and regulatory authority for accurate and up-to-date geospatial information. Currently, the Sudan Survey Authority has shaped the geospatial business and assisted the Sudan government in becoming one of the top digital nations in the region, by setting the bar for data collection, data management, and planning for innovative services, as demonstrated in the Sudan Survey Act. The Sudan Survey Authority is also in charge of developing a geodetic network, processing and mapping, aerial photography, and planning the design of national geospatial information that could become a crucial component of Sudan's geospatial system and infrastructure.

The Sudan Survey Authority (SSA), also, serves as the country's central organizing body for the national and regional implementation of UNGGIM geospatial information management to empower and advance geospatial information for sustainable national development [4]. SSA began by urging the Sudan government and regional partners for the unification of global reference frames to implement the United Nations initiative related to UNGGIM with its two mainframes, i.e. The National Global Geodetic Reference Frame (NGGRF) and National Integrated Geospatial Information Frame (IGIF). The Sudan Survey Authority planned for the Federal and State governments to establish the Sudan National Basemap System (SNBS). The SNBS has been developed and is currently in the implementation stage for the establishment of the Sudan National Basemap Center on SSA premises. To create the National Integrated Geospatial Frame following UNGIM resolutions, plans, rules, and strategies, the SNBS must be integrated with the numerous Sudan entities including the Ministry of Investment, and the existing GIS and geospatial systems in Sudan. With the cooperation of all of its strategic partners and stakeholders, SSA become the primary SNBS implementer in Sudan. Knowing that the SSA has been working as a government agency responsible for surveying and mapping in Sudan for more than a century. It currently offers mapping and surveying services for the entire nation, and as of 2020, the Sudan Translational government has directed it to offer geospatial services to all government organizations in Sudan [10]. Now SSA is the official geospatial Partner of the Ministry of Investment and has developed solid connections with numerous organizations and entities across Sudan to enable national information architectures to improve access, sharing, and integration of geospatial information and services for decision and policy-making,

### 3. United Nations Global Geospatial Information Management

The United Nations uses geospatial information to better understand global issues and to carry out its decision-making work, which led the United Nations to develop the Global Geospatial Information Management (GGIM) initiative that seeks to improve access to geospatial information for all countries. The United Nations Global Geospatial Information Management (UNGIM) is a platform that aims to promote the use of geospatial information for sustainable development [5, 9]. UNGGIM works to improve the utilization, accessibility, and quality of geospatial data and information globally. It also guides best practices, standards, and policies related to geospatial information management [3]. The UN-GGIM consists of two major sectors: The United Nations

Integrated Geospatial Information Framework (UN-IGIF) and the United Nations Global Geodetic Reference Frame (UN-GGRF).

### **3.1. The United Nations Integrated Geospatial Information Framework:**

The United Nations Integrated Geospatial Information Framework (UN-IGIF) provides a basis and guide for developing, integrating, strengthening, and maximizing geospatial information management and related resources in all countries. It will assist countries in bridging the geospatial digital divide, secure socio-economic prosperity, and leave no one behind. The IGIF comprises three parts as separate [6], but connected, documents: Part 1 is an Overarching Strategy; Part 2 is an Implementation Guide; and Part 3 is a Country-level Action Plan. The three parts comprise a comprehensive Integrated Geospatial Information Framework that serves a country's needs in addressing economic, social, and environmental factors; which depend on location information in a continually changing world. The Implementation Guide communicates to the user what is needed to establish, implement, strengthen, improve, and/or maintain a national geospatial information management system and capability. The IGIF focuses on location information that is integrated with any other meaningful data to solve societal and environmental problems, acts as a catalyst for economic growth and opportunity, and understands and takes benefits from a nation's development priorities and the Sustainable Development Goals.

### **3.2. UN-GGRF:**

The global geodetic reference frame (GGRF) is a system of coordinates and measurements used to describe the shape and position of the Earth. It is a fundamental tool for geodesy, which is the science of measuring and understanding the Earth's physical properties. The GGRF is based on a network of ground-based stations that use precise instruments to measure the Earth's rotation, gravity, and other properties. These measurements are combined with data from satellite-based systems such as Global Navigation Satellite Systems (GNSS) to create a highly accurate and detailed model of the Earth's surface.

The GGRF is essential for a wide range of applications [6, 7], including navigation, surveying, mapping, and scientific research. It provides a common reference point for countries around the world to use in their geodetic activities, ensuring consistency and accuracy in measurements across borders. One important aspect of the GGRF is its ability to track changes in the Earth's shape and position over time. This information can be used to monitor natural phenomena, as well as human-induced changes such as land subsidence or sea level rise.

### **3.3. Country-level Action Plan**

Sudan-level Action Plan (SAP) for investment, has to be developed, specifically to the Sudan investment map and details 'how' the guidance, policies, options, and actions are to be outlined in the Ministry of Investment implementation guide which will be carried out, by the MI stakeholders. This action plan should contain the processes, resource materials, geospatial data, templates, and examples that are available and helpful to first develop a national action plan, and then operationalize the national IGIF through its subsequent implementation, aligned with national priorities and cognizant of national circumstances.

For SSA operationalize the IGIF with the Sudan Action Plan (SAP) that aligns with the county priorities and circumstances. An SAP addresses all strategic pathways while considering the strategic and operational needs of the country when operationalizing the IGIF. The SAP is unique, as it determines where they currently are in their capacity and capabilities and reflects decisions made to advance and enhance national geospatial capabilities to serve the investment within Sudan, and for the integrated geospatial information management.

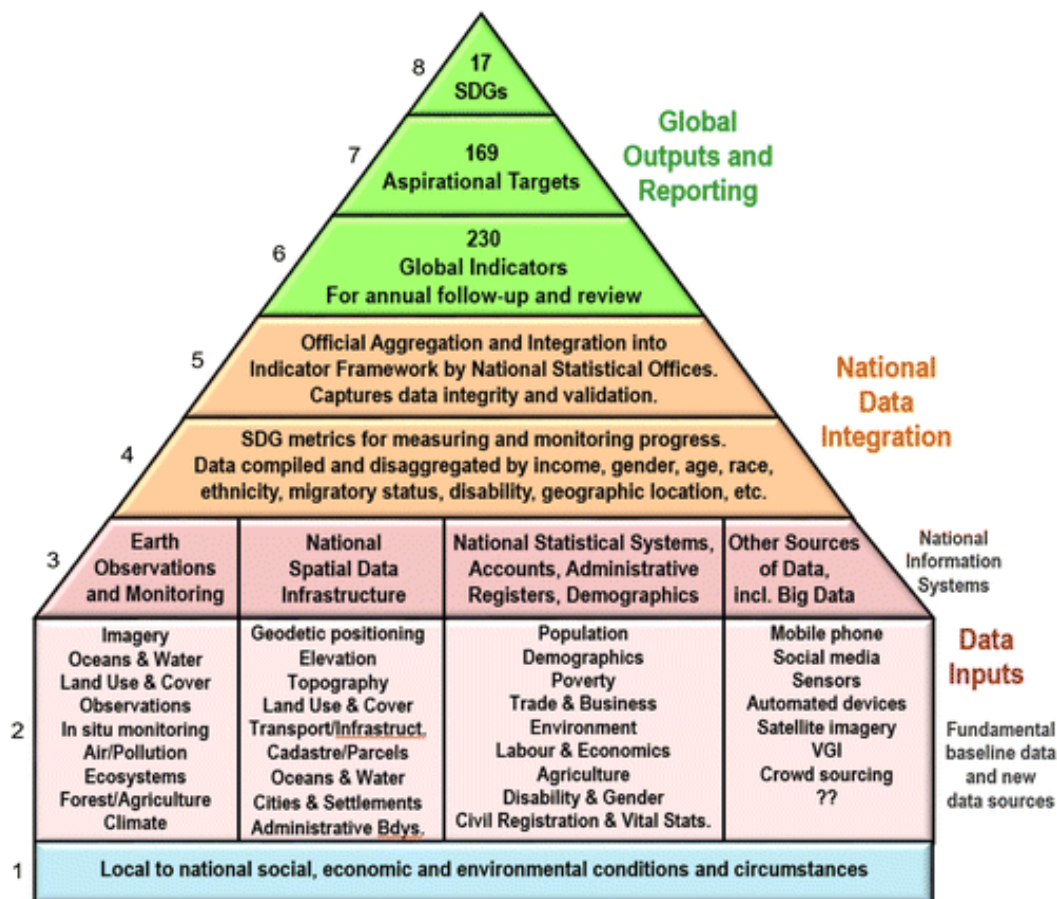
### **3.4. Sustainable Development Goals:**

Sustainable development goals have to be progressed in a parallel time frame to geospatial information; all of the issues impacting sustainable development goals can be integrated into the Sudan geospatial information system after being analyzed, mapped, and modeled within a geospatial context. One of the main goals of the UN-GGIM is to support and achieve the 17 sustainable development goals (Figure 2). The 17 Sustainable Development Goals (SDGs), which is an urgent UN call for action by all countries - developed and developing - in a global partnership. SDGs are to be recognized in Sudan as a means for ending national poverty, hunger, and other deprivations must go hand-in-hand with strategies that improve health and education, reduce inequality, and spur economic growth – all and/while tackling climate change and work to preserve Sudan land uses and forests.



**Figure 2: The 17 Sustainable Development Goals [5]**

Figure 3, shows the general national information systems sustainable development framework, that provides the building blocks and processes for any given country to measure and monitor the SDGs from local real-world conditions through to global harmonized reporting [5].



**Figure 3. A general national information systems sustainable development [5]**

#### 4. Definition of investment map:

The investment map (Figure 4) can be defined as a document that specifies a list of potential investment ideas and opportunities, and an integrated geographical, legislative, and procedural guide that provides the investor with all the data and information that helps in completing investment decisions efficiently and accurately, in addition to reviewing investment opportunities at the federal and state levels in Sudan. Therefore, the investment map is a strategic indicator, to highlight specific projects in all sectors.

The investment map requires planning, coordination, and joint work between the Ministry of Investment and its strategic partners [6, 11]. One of the possibilities for effective planning is that there is a pivotal role for the government and the participation of all parties at the national level in determining the frameworks and goals of investment, and the ability to mobilize human and technological resources to support investment and provide data and information. The adequacy, quality, and modernity of databases and information available for investment work [11]. Therefore, it has become necessary to prepare an integrated investment map that includes all the necessary indicators and guidance to guide investors and acquaint them closely with the investment opportunities in the various sectors of the country systematically and scientifically, and enhancing the ability of the Ministry of Investment to address challenges and find effective smart solutions.

The Sudan investment Map required the geospatial information and its processes of collecting, organizing, and managing geospatial data from a variety of sources. It involves the integration of geospatial data from different sources into a single investment map, allowing for analysis and visualization of the data. This type of geospatial information is used to support decision-making in all areas and resource management, using geospatial Information data Sources (geospatial data is any data with a direct or indirect reference to a specific location or geographical area) and is often referred to as geospatial data or geographic information, such as: -

- A. Satellite Imagery: Satellite imagery data source that provides information about the Earth's surface from aerial or orbital satellites. This type of data can be used to create detailed maps, analyze land use, and monitor environmental changes.
- B. Aerial Photography: Aerial photography data source that captures images from the air using either manned or unmanned aircraft. This type of data can be used to create detailed maps, analyze land use, and monitor environmental changes.
- C. GIS Databases: GIS database data source that stores geographic information in a digital format. This type of data can be used to create detailed maps, analyze land use, and monitor environmental changes.
- D. GNSS Data: GNSS data is a type of data source that uses satellite signals to determine the location of an object or person on Earth's surface. This type of data can be used for positioning and creating detailed maps, analyzing land use, and monitoring environmental changes.

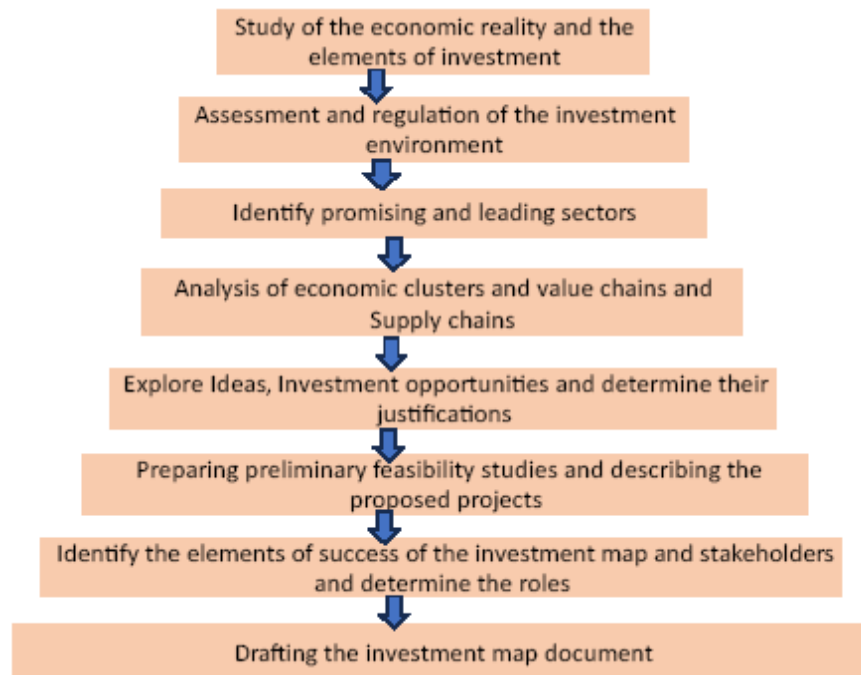
#### 5. Basic Sudan Investment Map Requirements

Based on the existing cooperation and coordination between the Ministry of Investment and all partners for preparing, designing, and implementing the investment map system for Sudan. The Sudan Survey Authority realizes the importance of the investment map, its terms of reference, and the great challenge to accomplish this work and the resulting activities during the stage of preparation and the activation of geospatial information and over an ongoing period to ensure the sustainability of the investment process in Sudan. In this context, the Sudan Survey Authority will rely, during the implementation stages of the investment map, on the following guidelines:

1. The basic Ministry of Investment guidelines.
2. Objectives and determinants of investment work in Sudan.
3. Policies and Laws that govern and frame the investment process in Sudan.
4. Specifications and requirements for the investment process issued by the Ministry of Investment.
5. The nature of the work of relevant authorities (local and international).
6. The basic objectives of the investment map.
7. Previous relevant efforts and technical works prepared by the Ministry of Investment.
8. Outputs of the initial report (Inception Report) that will be prepared during the system analysis phase.
9. Use cases that will be extracted from the content of the initial report and whose scenarios and policies will be built in the conceptual model and completed in the description of the logical model.
10. A set of data and concepts that will be extracted from the Conceptual Model that will be prepared during the analysis phase [1, 12].
11. The structures that will be designed during the stage of preparing the logical model.
12. The needs of decision makers and the end user, according to what was stated in the initial report referred to above.
13. Basic requirements and specifications for preparing geospatial information systems and digital maps.
14. Technical and timing caveats or a notice, that certain actions may not

be taken without informing the entity who gave the notice. 15. Previous experiences in the relevant field in the local, regional, and international contexts.

The stages of preparing investment opportunity maps (figure 4), are to define and determine the geographical scope of the national investment map, study and analyze the current investment situation, study and analyze needs and global best practices in the field of investment, define the framework and objectives of the national investment map, devise investment opportunities and how to finance, the strategic plan to achieve investment goals and opportunities. Recognizing the challenges, qualifying and raising administrative and technical capabilities in investment management, determining the baseline for all components of the investment map in its various sectors, preparing key performance indicators, and managing quality and change. The process of preparing investment maps involves a set of procedures and steps that must be implemented efficiently and accurately. This requires the availability of the necessary total and sectoral data and statistics, in addition to the cooperation of the concerned investment parties, the most important of which are investment authorities, the ministries of planning, industry, trade, local and financial development, the statistics department, the banking sector, financial institutions, and business Development.



**Figure 4: Stages of preparing investment opportunity maps**

## 6. Activating geospatial information

The basic geospatial data and information provided by the Sudan Survey Authority is considered a key success factor for the sustainability of the investment map in Sudan, in which the reference system for geospatial information is defined and unified, the national base map of Sudan is to be activated with the investment map, inventory of investment data and information across sectors, modeling and preparation of databases, and inventory technical teams and agencies concerned with geospatial information in investment sectors. During the previous years, a cooperation and partnership agreement was reached between the Ministry of Investment and the Sudan Survey Authority to enhance the role of geospatial information systems for the success of investment sustainability in Sudan, contribute to building or developing a national geospatial information device, establish a national network to collect and process investment data, build integrated investment databases, create mechanisms for updating investment data and information for the Ministry and its partners, defining roles and responsibilities between the Ministry of Investment and the various investment sectors, and devising smart methods for organizing meetings and workshops between investment partners.

The national base map of Sudan will be the core of geospatial information, which was approved by the Government of Sudan to be implemented at the federal and state levels. The base map is considered an important component of the investment map to provide spatial data infrastructure and land information from its various official and public sources. It represents a national strategy aimed at framing foundations in which the benefits of spatial data infrastructure and land users are shared to build geographic information infrastructure (Figure 5) at the national level. The concept of the base map represents a very important objective axis for the investment

map, for modeling real reality and finding solutions to problems related to reality. Bearing in mind that, it should be consistent with the United Nations programs for providing the required geospatial information to achieve sustainable development goals.



**Figure 5: Basic components of the national base map system [17]**

The base map is considered a representative model that frames and reflects the facts of things in natural reality and their interactions. Thus, it represents a key element in providing geographical information that enables managing, monitoring, and tracking the changes occurring on the land in Sudan and hence in the investment map. In addition to forming communication, circulation, and exchange links for the geospatial information system between the Ministry of Investment and the relevant sectors in an integrated framework that provides the opportunity to find the complex intersections and interrelationships of the spatial information infrastructure (which represents more than 80% of the land information required for investment and decision-making work). Figure 6, shows the basic layers of the national base map system.

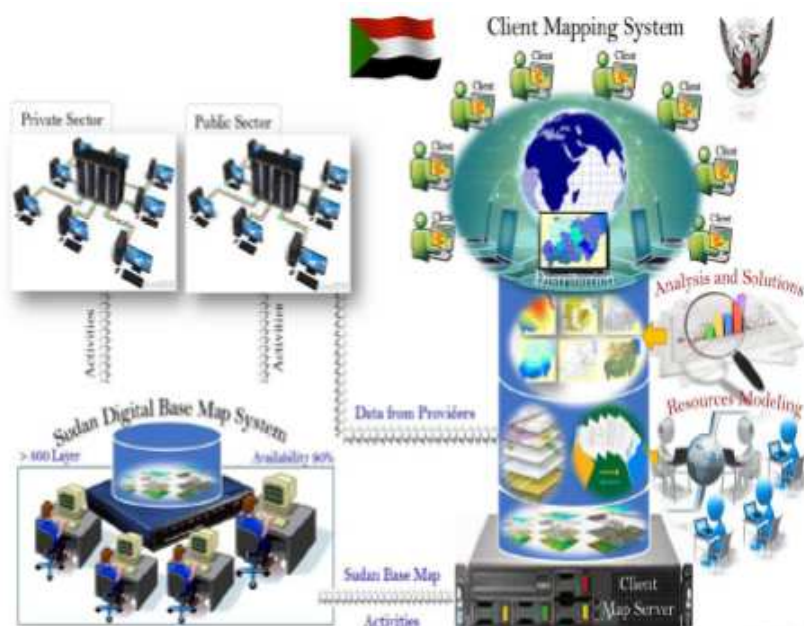
Serial No.	Use Case	Partial No.	Theme	Coverage	Serial No.	Use Case	Partial No.	Theme	Coverage	Serial No.	Use Case	Partial No.	Theme	Coverage	Serial No.	Use Case	Partial No.	Theme	Coverage
1	Administrative Boundary	1	International	Globe	36	Transportation	8	Water Stations	Country Territory	72	Transportation	36	Wad Madani	Country Territory	109	Energy	1	Railways	Country Territory
2		2	Regional	Sudan Region	37		1	Highways	Country Territory	73		37	Kamleen	110	2		Bridges	Country Territory	
3		3	State	Country Territory	38		2	Tracks	74	38		Heseheesa	111	3	Airports		Country Territory		
4		4	Districts		39		3	Town Roads	75	39		Rafaa	112	4	Runways (Airports)		Country Territory		
5		5	Administrative Units	Country Territory	40		4	Omdurman	76	40		Arbiji	113	1	Villages		Country Territory		
6		6	Urban Areas		41		5	Bhri	77	41		El Managil	114	1	Vegetation		Country Territory		
7	Elevation (Topographic & Relief)	1	Contour 10m	Country Territory	42	6	Jabel Awlia	78	42	El Madina Arab	115	2	Forests (Woodland)	Country Territory					
8		2	Country Territory	43	7	Tuti Island	79	43	El Maseed	116	1	Agricultural Projects	Country Territory						
9		3		Khartoum	44	8	Port Sudan	80	44	Ad Damazeen	117	4	Agricultural Land	Country Territory					
10		4		Dongola	45	9	Arkawit	81	45	Rabak	118	5	Sandy Land	Country Territory					
11		5		Damir	46	10	Town Roads	82	46	Kosti	119	1	Geological Structures	Country Territory					
12		6		Port Sudan	47	11	Ed Daba	83	47	Ed Dweim	120	2	Geological Eon	Country Territory					
13		7		Kassala	48	12	El Gaba	84	48	Sinnar	121	3	Geological Era	Country Territory					
14		8		Qadarif	49	13	El Gold	85	49	El Obeid	122	4	Earthquakes	Country Territory					
15		9		Wad Madani	50	14	Karti	86	50	El Fouta	123	5	Volcanics	Country Territory					
16		10		Sinnar	51	15	Wadi Halfa	87	51	Lagowa	124	1	Oil Concession Blocks	Country Territory					
17		11		Rabak	52	16	Marewei	88	52	Kadogli	125	2	Pipeline	Country Territory					
18		12		Damazeen	53	17	Kerinya	89	53	El Rahad	126	3	Refiners & Mines	Country Territory					
19		13		El Obeid	54	18	Karma	90	54	El Fashir	127	1	Tourism Sites	Country Territory					
20		14		El Fashir	55	19	Abu Hamad	91	55	Umm Kodada	128	1	Sewers	Country Territory					
21		15		Nyala	56	20	Atbara	92	56	El Tyne	129	2	Water Net	Country Territory					
22		16		Zalingi	57	21	Damir	93	57	Kutuk	130	3	Electrical Net	Country Territory					
23		17		Eljummayna	58	22	Berber	94	58	Nyala	131	4	Elect. H. T. Towers	Country Territory					
24		18		El Dein	59	23	Shendi	95	59	Kass	132	5	Telecom Net	Country Territory					
25	19	Drainage		60	24	Abu Zabad	96	60	El Geneina	133	6	Telecom Towers	Country Territory						
26	20	Country Territory	61	25	Kassala	97	61	Zalingi	133	6	Telecom Towers	Country Territory							
27	21		Spa. Heights	62	26	Aroma	98	62	Kabbabiyia	133	6	Telecom Towers	Country Territory						
28	Water Bodies	1	Hydrosphere	Globe	63	Water Bodies	27	Kashm ElGerba	Country Territory	63	Water Bodies	63	Meleit	Country Territory					
29		2	Rivers	Country Territory	64		28	New Halfa	100	64		El Geneina	Country Territory						
30		3	Islands		65		29	Qaderif	101	65		El Dein	Country Territory						
31		4	Water Basin	66	30		El Dindir	102	66	Garrilla		Country Territory							
32		5	Ground Water	67	31		El Kurmuk	103	67	Asalaia		Country Territory							
33		6	Water Resources	68	32		El Fao	104	68	Habiya		Country Territory							
34		7	Lakes	69	33		El Shoui	105	69	Umm Rowaba		Country Territory							
35			70	34	El Soaki	106	70	Bara	Country Territory										
			71	35	Singa	107	71	El Semelh	Country Territory										
			72			108	72	El Nihoud	Country Territory										
Sum																		133	

**Figure (6): The basic layers of the national base map system [1]**

The national base map is a digital map that should be circulated within Sudan's various entities via the national communication network between federal ministries and state institutions. It includes more than (800) layers of land information such as terrain, rivers, and international and state borders. It contains more than (700) large

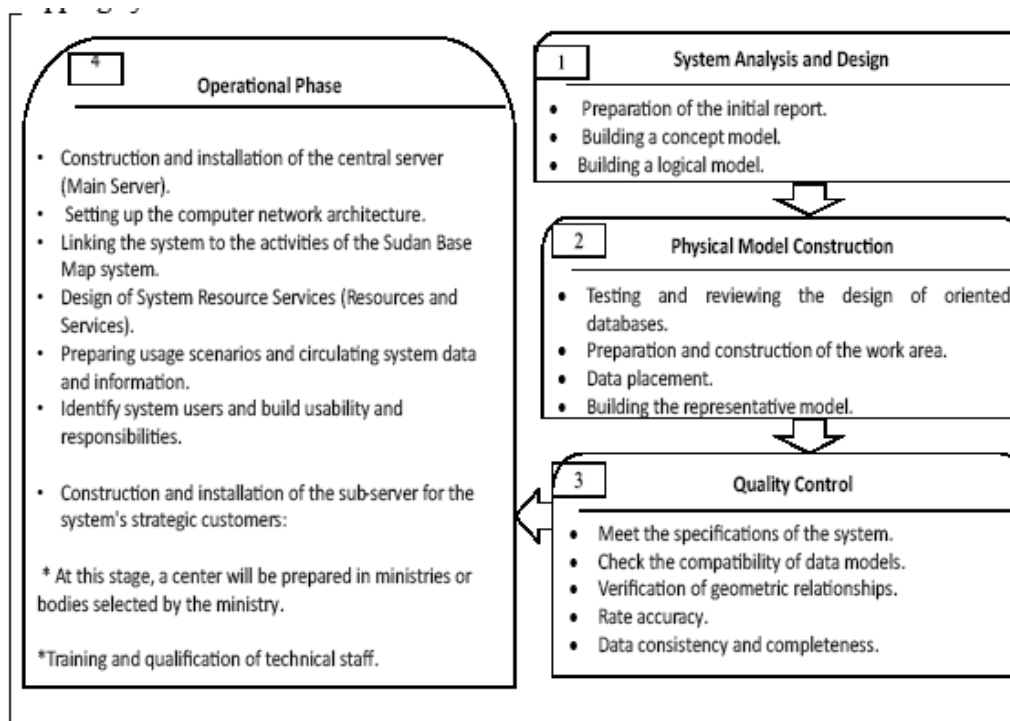


cities and villages at the household level, with a population estimated at more than three-quarters of the population of Sudan. It serves as a base for electronic government and the (digital) population census and then later integrates statistical information and civil registry with geospatial information as a unified system that serves all investment work. These layers included in the base map also serve as a unified basis and frame of reference [13, 14] for documenting data for all investment sectors in ministries, national institutions, private sector institutions, and investment information, as well as information about public services and facilities such as information about states, localities, administrative units, general information, mining, oil, agriculture, forestry, livestock, geological information, tourism, and others. As mentioned previously, the Sudan government issued a decision to apply the base map at all federal and state levels in the country. Figure 7, illustrates how the base map interactions between the Sudan Survey Authority and all stakeholders and clients including the invest map parties.



**Figure 7: Base map interactions between the Sudan Survey Authority and the Clients**

Figure 8, illustrates the work plan in four basic stages, each of which is subdivided into sub-stages according to principles of preparing, building, and developing investment mapping systems.



**Figure 8: The general framework of the action plan**

## 7. Sudan National Basemap System

The Sudan National Base map offers effective and efficient solutions for the collection, editing, storing, and delivery of geospatial data and information. SNBS will implement an improved information management system that will significantly increase the level of support for the activities of SSA and the Sudan geospatial community. SNBS will deliver the geospatial information management system to an acceptable level of confidentiality, availability, and performance. SSA has planned and outlined the requirements of the IT system and its components as well as any upgrades and additions to the current IT infrastructure. To gather requirements for SSA Departments and Unit business processes, the SSA technical teams must undertake and amend the prior needs assessment. It is acknowledged that the base map and spatial data provision, in addition to the following, will impact this plan: (1) Hardware, end-user computers, servers, and physical security. (2) Local Area Network and Internet addressing in networks and telecommunications (3) Observations on the Data Volumes and Current Infrastructure. (4) Database solutions, merging, and architecture. (5) Application Development; which relates to the ability to model business processes by creating specialized open-source software programs. (6) Software Licensing; the SSA will outline the system's potential implications for operating system licensing, particularly, a description of the prerequisites for access licenses resulting from system implementation, stating versions and desired licensing model, with a description of the licensing structure to be purchased as part of the final system. SSA must use quality control methods and procedures, including formal system and user acceptance testing, for sustainable adoption. The SSA Basemap Center team will then put selected trainers through training and make sure lead users are trained to support the system at a departmental level with enough supervision at all phases of implementation. Post-implementation support must be organized and provided in a logical and organized way. The task of spreading the usage of the new system will be specifically assigned to it, and it will be addressed with a strategy for involving the employees. Here it may be concluded that complete user needs analyses should be carried out inside the SSA organizational structure for the full implementation of SNBS in all departments based on the investigations and understanding of the SSA conditions [16].

SSA also understands that achieving sustainable development presents all countries and the global policy community with a set of significant development challenges that are almost entirely

geographic. Many of the issues impacting sustainable development can be analyzed, modeled, and mapped within a geographic context, which in turn can provide the integrative framework necessary for global and regional collaboration [10, 15], consensus, and evidence-based decision-making. However, despite significant advances in geospatial information technologies, there is a lack of awareness in Sudan, understanding and uptake, particularly at the policy and decision-making level, of the vital and integrative role of geospatial information and related enabling architectures such as National Basemap Infrastructure.

The global geospatial community now has a unique opportunity to integrate and connect geospatial information into the global development agenda [11] in a sustainable manner, specifically in contributing their data resources toward measuring and monitoring the 17 Sustainable Development Goals, and their 169 associated targets, through the global indicator framework that anchors the 2030 Agenda for Sustainable Development.

## 8. Activating Investment Map parties' geospatial information

Activation of the geospatial information of the Investment Map parties can be done in the following stages:

**The first stage** involves the System Analysis and Design which is concerned with devising the basic requirements, extrapolating the specifications of the required work, and understanding the use cases and user needs through careful and precise analysis, which aims to prepare the Inception Report [12] and build the Conceptual Model and the Logical Model to ensure that the work meets all requirements of the Sudan investment map. This stage is considered to be the basic focus of all subsequent work stages, and it serves as an establishment of the methodology that must be followed to complete the required work. The steps of this stage are further outlined as:

1. Preparation of the Inception Report for a. Familiarity with the guidelines and objectives of the investment map for Sudan. b. Derivation of basic system specifications. c. Analyzing and evaluating user needs (Needs Assessment) and defining the strategic clients of the system. d. Studying use cases for investment entities and building their scenarios.
2. Building a conceptual model for; a. Extrapolating and extracting concepts for the system structure. b. Determine the number and specifications of the concepts that have been proposed. d. Defining and determining the fundamental datasets that must be included in the system and preparing and

designing a data dictionary. d. Identifying and describing relationships and intersections between data sets.

3. Building a logical model for
  - a. Designing the system's relational databases.
  - b. Identify the specifications of data models related to system concepts by studying the data index.
  - c. Studying the structural structure of targeted geographic/geospatial databases.

**The second stage is building** the physical model of the system, the physical model will be built, which aims to translate the outputs of the design stage from the abstract level to the application level, by building targeted geographic/geospatial databases and placing data in them so that the layers of data and information are organized; in the form of feature classes within a data set according to what was stated in the design model so that it matches the reality and use cases [1]. This stage is also concerned with a description of the data of the physical model for all data layers through preparing metadata. One of the main objectives of this stage, is also, to prepare a representational model for the system, where the physical model will be activated in an institutional geospatial information system environment that achieves joint and secure circulation of system information and works to provide solutions to problems and inquiries related to the investment process in the country. The methodology for implementing this stage is outlined as: 1. Testing and reviewing the design of targeted databases. 2. Preparing and building the workspace and establishing the skeleton of the targeted geographic/geospatial database. 3. Geodatabase populating by implementing the following stages:

- A. Providing data (Data Acquisition) from various sources. It is considered one of the critical stages that requires a lot of time and effort. This stage includes:
  - i. Testing the available data (Inventory of Existing Data) in terms of accuracy, required drawing scales, level of coverage, and compatibility of its graphical structures according to what was stated in the Data Dictionary during the design phase.
  - ii. Correcting and refining errors in the available data (Data Refining).
  - iii. Complete missing data.
- B. The data management stage, which includes the following:
  - i. Providing coordinates of horizontal and vertical control points to unify the datum, adjust the ground reference, and determine geometric accuracy during the quality control stage.
  - ii. Assigning ground coordinate systems to all data layers.
  - iii. Editing data to convert its forms into digital forms that can be circulated on the computer.
  - iv. Correcting errors in the data

editing phase. v. Converting digital data bodies into bodies that meet the specifications and standards of digital mapping systems. vi. Applying various procedures and treatments to satellite images and aerial images to extract spatial data [7] and objective and descriptive information.

- C. Loading data into feature-class structures.
- D. Metadata description of all geospatial data layers.

**The third stage:** is concerned with quality control verifying the technical quality of the system and ensuring that the basic specifications and requirements for the work are met through the planned tests, statistical analysis, and standard comparisons to verify:

1. Fulfilling the specifications of the data set in terms of the number, the domain and coverage.
2. Data Model Conformance.
3. The structure of topology relationships in terms of connection and matching.
4. Absolute and relative accuracy.
5. Data consistency and completeness.

**The fourth stage:** In this stage, the system will be activated based on the system work plan, the operating environment for the system will be built by establishing the central headquarters of the system, installing the main server, and building the network infrastructure. Also, preparing user specifications under the policies that will be agreed upon to access and exchange geospatial data and information in various ways.

## 9. Conclusion

Sudan is witnessing an acceleration in the processes of development and transformation in the performance of government institutions to raise the productivity and investment efficiency of the government sector. This is what development plans and investment opportunities have focused on to achieve national goals in various sectors, within performance measurement indicators, follow-up, and adjustment according to changing priorities. This paper aims to illuminate the path to the future and provide geospatial data and information to develop the investment climate and environment for all-sized businesses, especially to bridge the development gap between the Sudan states.

For the Sudan Survey Authority to be able to take into account the views of the Authority's main partners, in addition to the challenges and aspirations of the various parties, the Sudan Survey Authority held a

large number of meetings and brainstorming sessions with the senior departments of the ministries and state governments and held a group of workshops with the Investment Map Team.

The first stage is connecting and activating the digital base map to the National Investment Map Center, supplying and installing services, and building the network for the National Investment Map Center. The second phase is supplying and installing the services and building the network for the National Investment Map Center and all software systems.

The objectives of this paper were also to provide insights into global sustainable development challenges and processes, how they are closely interrelated with geography, and to demonstrate that the global geospatial information community, through national geospatial information agencies, has a unique opportunity to integrate and connect geospatial information into sustainable global and regional development agenda.

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