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On the Prospects of Developing Khartoum Sustainable Geospatial System

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ABSTRACT

For the development of sustainable geospatial system Khartoum State has to initiate an strategy to implement an enterprise GIS solutions, which necessitate the development and utilization of Spatial Data Infrastructure, as well as the unification of geomatics standards, specification and referencing systems, By fully implementing SDI based on well approved roadmap that enable the State to produce efficiencies and higher customer satisfaction based on geospatial solutions and to open a new era in the provision of government services to the general public. For the successful implementation of the geospatial system in Khartoum State, the Survey Directorate has to be considered as the focal point for spatial data acquisition, access and delivery and to play its important role in GIS and geospatial implementation.

KEYWORDS: *Geospatial, GIS, Geomatics, SDI, Standards, Enterprise, strategy*

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1. INTRODUCTION

The Survey Directorate (SD) of Khartoum State, maintains base mapping and spatial data and employed independent plans to achieve accurate and up-to-date base mapping by the aid of periodic digital mapping projects and transactional updating. Periodic updating of the topographic Basemap is project-based and typically involves contracting for the update service. The transactional updating is a strategic approach for continuous database maintenance that embeds the update of geospatial data within existing transactions that impact on data elements contained in the topographic base map layer. Now the Directorate strategically aiming the transactional update of spatial data to include all data related to roads and utilities infrastructure, and building permits, and construction permits. Re-engineering processes for the transaction-based updating has to be made and applied, which shall be considered in the very near future, as one of the major successes in Basemap and geospatial updating in Khartoum State.

Major geo-spatial datasets maintained by the Directorate can be classified into: Geodetic Network Data, Topographic Base Mapping Data, Cadastral and Property Mapping Data, and Utility Mapping Data. The GIS Section of the Directorate, supports processes of the services, such as maintaining a comprehensive geo-spatial database of Basemap layers, land plots, utilities and service corridors, roads, imagery, and other datasets. For all construction and infrastructure works, the GIS Section can work closely with other State Departments to perform updates on GIS layers based on the daily survey works. This indicates that SD is primarily aiming to update with as-built drawings after being approved and facilitates that to other capable custodian business units at Khartoum State. The Detailed Urban Planning Section on the other hand utilizes GIS to update land details. The GIS Section has to deliver geo-spatial data updates to other external stakeholders either through on-line FTP links or off-line on portable storage media. The Ministry of

Urban Planning should continuously aim to improve the geospatial data to map all the assets with special consideration to the completeness and positional accuracy and to govern the land use processes.

The spatial data Infrastructure in Khartoum State, can be practically obtained from many sources including, land surveying, digitized or scanned digital data, land records, photogrammetry and remote sensing images, and Global Positioning System data as well as from various State Departments. Many of other Department geospatial data is not ready and may not be useful in terms of data sharing due to the fact that the data is based on different georeferencing systems. This and the continuing rapid growth of human settlements, urbanization and developments in Khartoum as a capital city, has increased the demand of national and State spatial data infrastructure, which certainly require the development of large partnerships between various organizations in Khartoum state as well as private and public sectors at local, and national levels [15], [16]. The Spatial data Infrastructure can be considered as national or local assets and many of its components are used by the government's authorities for planning and development of basic infrastructures and utility services as well as for fundamental and strategic research for exploitation of natural resources, and environmental impact assessments. The range of SDI products developed in many countries include [15]: cadastral maps, large scale and topographic maps, national base maps and small-scale maps but all referenced to one unified spatial reference system. Logically, most of the other mapping products should use these main basic maps as a common reference and building upon their basic information, and all required thematic data and applications.

On the other hand, interoperability complications here in Khartoum between State departments and Federal Departments are expected to exist in the beginning at different levels, including: use of different Survey and GIS standards and specifications, different datum and reference systems, mapping sources, edge matching problems between data sets and overlap of some features obtained from different sources and processes, in addition to the use of different data models and features coding. To resolve such complications a mixture of many ingredients are required, such as technology, adoption of a common concept for spatial data, standards and policies as well as political support to help in resourcing the necessary key implementations of National Spatial Data Infrastructure. The Spatial Data Infrastructure in the world of today considered to be as a driving force for services and economic development. This indicates that it is a high time for Khartoum State and Sudan in general to create its own information society and to build the Sudan strategic SDI imitative that will lead to knowledge economy based on information technology.

2. Spatial data Infrastructure

The spatial data infrastructure and geospatial systems of today, require integration and adoption of an accurate reference frames and spatial data infrastructure standards [12], [13], and specifications for most applications and implementation of information systems, this is crucial for spatial data sharing, integration and mitigations. The unification of the geo-referencing systems of all spatial data in Khartoum State in particular and Sudan in general will assist in implementation of enterprise GIS and geospatial solutions and in the spatial data integration, data sharing and exchange of information [3], [6], [7].

The adoption of spatial data infrastructure standards and specifications will be a must and also help in increasing the integration capabilities of databases between different organizations in the country, and in performing a number of operations in cost effective and manageable manner. The Survey Directorate of Khartoum State has already drafted its strategy and started to create and associate it with its partners including all GIS required standards and specifications in Geomatics and preparation of data models and spatial data dictionaries, Metadata and feature coding for map production. This shall assist all organizations in Khartoum State to expand their capabilities for the enhancement of data collection, management and improvement of the level of support for spatial data activities and provision of solutions that enable the effective delivery of spatial data throughout the State.

The contributions of other stakeholders of Spatial data infrastructure (SDI) can be used to define the matrix of technologies [11], [14], policies and institutional arrangements that will facilitate the availability and access of spatial data at all levels of government, the private sector, and academic organizations [1], [3] and [5]. For the Khartoum State, the importance of SDI can be considered as crucial in supporting all terrestrial applications, many decision-making processes and management of resources in the growing national and regional levels. Due to the fact that Spatial data is an expensive resource, this has increased the need for corporation between various organizations in the acquisition of spatial data, and the establishment of programs and projects to obtain and access the spatial data, promote its use and ensure that continuous update and additional investment in spatial data and its usages.

3. Ministry of Urban Planning Spatial Data

The Ministry of Planning acts as the main focal point of all Khartoum State Urban planning and to oversee public works in the State. Khartoum State aims to produce efficiencies and higher customer satisfaction in accordance with the national Policy and the State Strategy that will represent a new era in government services to the general public. Based on this and on the State strategy, SD plans are to provide inputs to the development of an enterprise geospatial strategy that considers not only current needs based on existing government business practices, but also looks to the rest of the world for new, creative and progressive ideas and methods that could be of benefit to Khartoum State. These plans also strive to identify a common understanding and thereby ensure some level of consistency and uniformity in the application of business capabilities and functions within the State.

This section is not meant to prescribe what the Ministry must do, but to provide a set of reference best practices and ideas adopted by leading governments managing geospatial information, technology and services around the world as part of a digital strategy. The SD and its stakeholders have progressively been expanding their use of and expectations of their geospatial systems from applications that deliver asset, location and Basemap information. Now geospatial systems are looked upon as full-function enterprise systems with the ability to deliver a full range of geographical information capabilities on a variety of platforms, with the ability to share and exchange data with any other internal and external systems. GIS and its inherent ability to provide spatial context-awareness are observed as an important component of leading enterprise geospatial strategies. Through the use of GIS as an enterprise system coupled with emerging technologies the goal of geographic information systems providing a user experience that is intuitive, simple without the user caring how it was implemented and performs something fundamentally useful to the customer. As one component of a digital ecosystem, enterprise geospatial enables and provides new methods of interaction, engagement and service delivery methods to other accessible digital infrastructures and open government ecosystems for delivery of services that unlike traditional e-Government strategies of the past, Transformational Government (t-Government) begins with citizen engagement to assure greater use and return on investment

The purpose of this paper also to highlight a number of function-specific best practices (operational capacity) in the local government geospatial domain. Identify local governments that exhibit an innovative and functional use of GIS across the enterprise and obtain from those operational capacity that either exhibit a best practice or support/use a best practice. Thus, this paper, highlights the importance of the process of innovation as much as the product of innovation and organization within a local government enterprise GIS. The best practices within local government enterprise GIS in many case studies presented and focused on the operational use of GIS. The use of innovative geospatial, information, technology and services are playing an increasing key role within local governments, through seamlessly integrating business processes and transactional updating, geospatially enabling nearly all applications in an integrated environment, governments are working to apply the spatial context-awareness across their organizations.

An operational capability itself is defined as a process that supports the overall operational vision of the local government and being a customer focused value propositions that are coupled with the ability of the Locality or State Ministry to deliver these processes effectively and efficiently.

If we look closely at leading Local government's approaches to e-Government and its use of geospatial information, technology and services: the aim is to provide a window into trends that will influence public expectations of the Local government over the next decade.

4. Survey Directorate Spatial Data

In Khartoum State, the Survey Directorate (SD) has to be considered as the focal point for spatial data acquisition, access and delivery. An awareness of the benefits of spatial data started to grow in Sudan, while the Survey Directorate is seeking to meet the State development requirements and the demands for digital base maps [8]. The characteristics of the spatial data in SD can be described as:

- Common base map.
- Plans and planning Layer.
- Cadastral information and land files.
- Utility maps and setting out information.
- Aerial photographs and satellite imageries and ortho photos (Fig. 1).

Figure 1: Shows sample of Khartoum Aerial Photography

Khartoum State base map is a vector map (Fig. 2), which contents are identified by the Survey Directorate, which is the sole responsible for Basemap production and updating in Khartoum State.

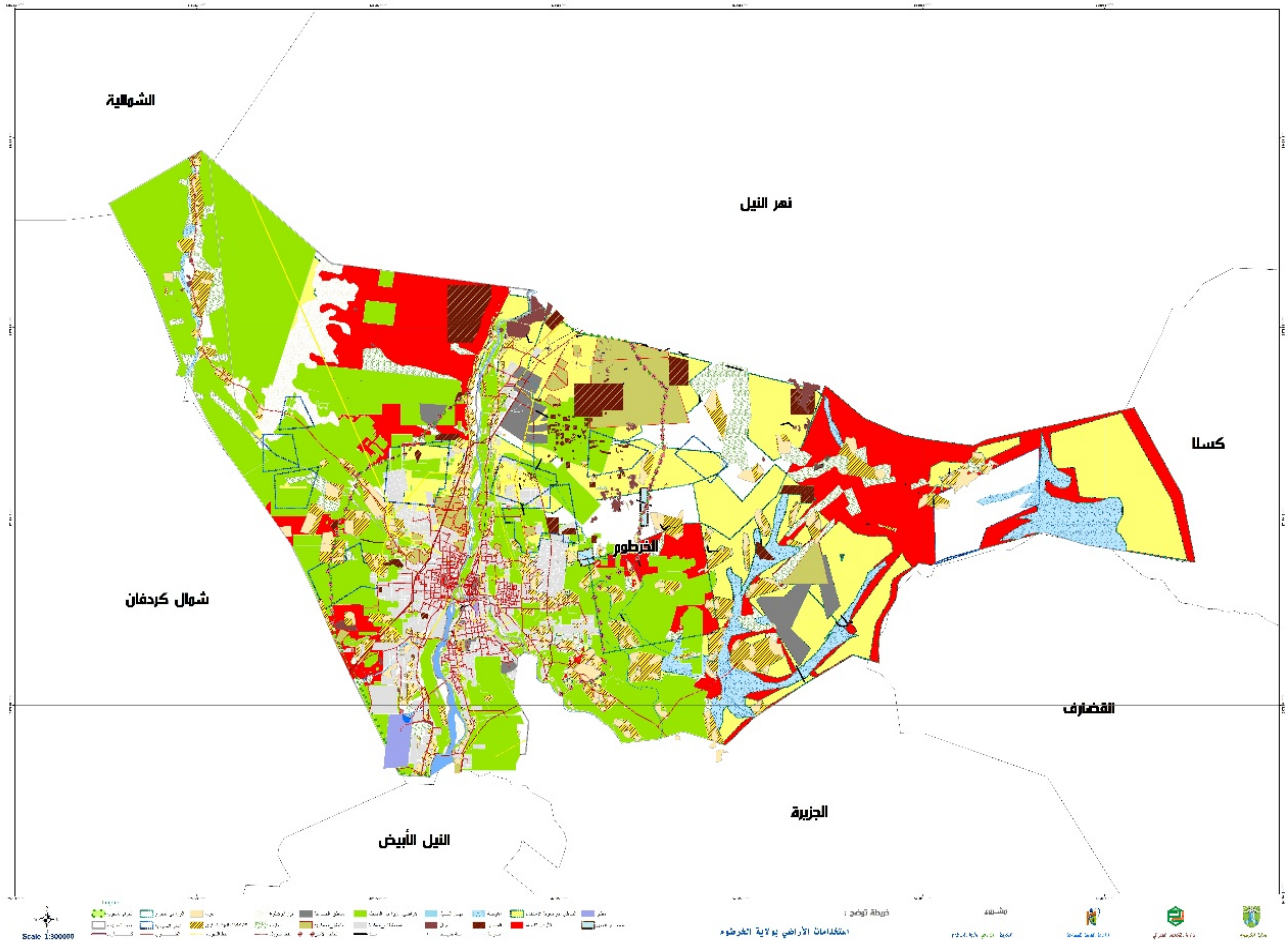

Figure 2: Sample of Khartoum State Basemap

Various implications of base maps can be defined including:

- Topographic Mapping: A topographic map is a type of map characterized by large-scale detail and quantitative representation of relief, usually using contour lines and DTM. A topographic map contains both natural and man-made features. A topographic map is typically published as a map covering a township, a city, a country or an entire State. Topographic maps are essential for design and engineering applications and for many kinds of services. But in practice there was a very limited use of the SD Basemap and unfortunately many Departments produced their own Basemap which are not standardized.
- Base Map Update: Base Map update is the process where a base map layer is maintained and updated on a regular basis to reflect the current state of the infrastructure in an area. In SD Basemap update is currently produced from aerial photogrammetry processes and ground topographic surveys. Satellite imagery can be used for completeness, detecting and checking the missing features. Base map information is to provide the spatial frame of reference for all other geographic data, these include horizontal and vertical geodetic control, topographic and bathymetric contours, spot elevations, planimetric features, coordinate grids, and similar information [8]. The Basemap includes the following data themes: Geodetic Framework, land properties, elevations, Hydrography, Imagery and Remotely Sensed Data, Scanned Basemaps, Planimetric Features, Structures etc.
- ***Positional Accuracy***: Positional (horizontal and vertical) accuracy can be of crucial importance, as there is a relationship between this and scale, whereby the level of accuracy applied often increases at larger scales. As well of equal or greater importance to accuracy is completeness, both in spatial and descriptive terms. Spatial completeness refers to whether or not a data set covers the entire territory that it ought to, in addition to ensuring that all features within that territory have been captured. Descriptive or attribute completeness typically relates to ensuring that all information for a given feature has been recorded.
- ***Map Projections and Datums:*** Map projections are the systems used to represent all or part of the earth's spherical surface as a flat map. A GIS can project units of measurement for a geodetic coordinate system (such as latitude and longitude) into a flat, planar coordinate system using a map projection. Both raster and

vector data structures utilize UTM map projection that store data in E, N plane coordinate system. In surveying and geodesy, a datum is a set of reference points on the earth's surface against which position measurements are made [4], and (often) an associated model of the shape of the earth (ellipsoid) to define a geographic coordinate system. Traditionally, horizontal datums are used for describing a point on the earth's surface, in latitude and longitude or another coordinate system. Vertical datums measure elevations or depths, again relative to a reference such as mean sea level, calculated ellipsoid, or other. Here in Khartoum State the International Terrestrial Reference Frame epoch 2000.0 (ITRF2000.0) adopting WGS 84 ellipsoid was utilized, together with the national vertical datum.

The base map is available and organized according to accepted specifications and mapping standards, covering the entire Khartoum State territory showing land use, residential areas, agricultural areas, main roads and the river Nile. In general, the base map meeting the user requirements, and readily available and accessible for government departments, individuals and private sector organizations. The updating of spatial data usually done based on the survey teams works, and hoping to be based on State wise transactional activities in the near future.

The current main challenges for Khartoum State in terms of spatial data infrastructure development will include non-organized data acquisition, data quality, standardization, policies, data sharing and integration. The Survey Directorate **data input** subsystem allows the staff users to capture, collect, and transform spatial and thematic data into digital form. The **data storage** and retrieval subsystem organize the data, spatial and attribute, in a form which permits it to be quickly retrieved by the staff user for analysis, and permits rapid and accurate updates to be made to the database. This component usually involves use of a database management system for maintaining attribute data. The **data manipulation and analysis** subsystem allow the user [9], to define and execute spatial and attribute procedures to generate derived information. This subsystem is commonly thought of as the heart of the Survey Directorate GIS, and at the moment distinguishes it from other database information systems and computer-aided drafting (CAD) systems.

Here the authors are well aware that Leading State organizations are actively taking the initiative to evolve from a data and process driven enterprise framework to a user driven framework. The user driven framework supports internal and external user involvement with a focus on improving and enhancing business processes and bi-directional sharing of geographic information.

5. Survey Directorate GIS System

The Survey Directorate was an early adopter of GIS technology in Sudan, and has a very mature operation. In 1990s, the Directorate began to migrate its hard copy maps and CAD-based products to GIS. In GIS applications, a base map is defined as a map or multiple map layers containing visible surface features and boundaries (e.g., topography, roads) that furnish an essential background upon which thematic and other georeferenced data or layers are overlaid. Attributes, features, naming convention, are important implications of Khartoum State Basemap.

The GIS Infrastructure at the Survey Directorate is based on Esri platform for GIS data editing and analysis. The GIS supports workflows adopted by the Directorate, starting from plot allocation, building permits, property development, and land use planning to the localities daily work activities. It is also used to maintain underlying Basemap data. The Directorate also planned to provide information to internal users, along with GIS-enabled systems for future Land Management System (LMS) [9], [10}.

The mission of the Directorate is to effectively and efficiently Serve Khartoum State departments, government and private entities as well as the community, through application of advanced technologies, systems and advanced techniques in surveying, mapping and GIS, such as the establishment of the Khartoum GNSS Reference Stations (GRS) as surveying system. These systems will enhance the Khartoum spatial data capabilities and to support land boundary determination and property delineation and setting out of Cadastral surveys, together with infrastructure development and resource evaluation surveys of utilities and construction (Fig. 3).

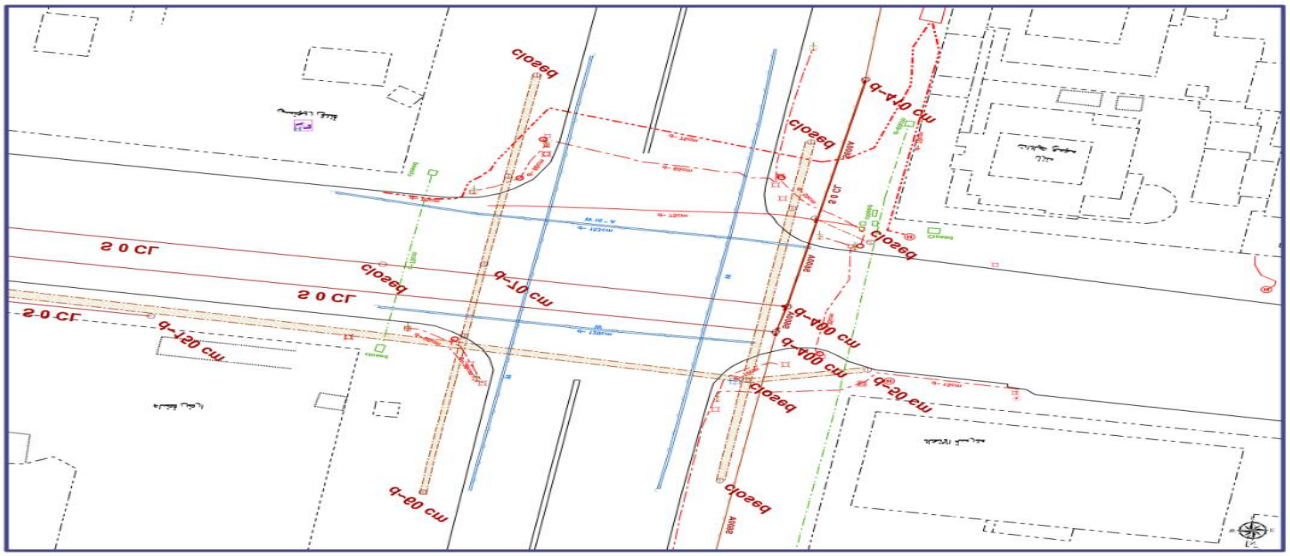

Figure 3: Shows GIS Utility Layer

The Directorate geospatial data system is planned to be integrated in many workflows, to serve all Khartoum Departments, in a seamless direct editing and provides higher data quality and faster turnaround time. Potential planned workflows for this level of integration include automation of the CAD to GIS transformation processes, and generation of the plots and many types of spatial data directly by the staff users in an integrated system, and processing of customer data requests.

The Khartoum State Survey Directorate has recently developed its strategic plan for spatial data and survey services, even though as a geomatics entity has been long established. This Strategic Plan can be considered as a living document that assesses both current needs and future trends for Ministry of Planning of Khartoum State to identify priorities for several years. The development of such plan is directly aligned with the Khartoum State strategic plan, and as a consequence let the Directorate to raise its geospatial maturity level, to attain and maintain land use (Fig.4) and geospatial solutions.

It is the high time for the Survey Directorate to play its important role in GIS and geospatial implementation in Khartoum State, with added value to participate in the national wide leadership in Geospatial applications, and to define and use an organizational structure that will allow it to administer the goals and policies in its plans [1],[4], [6]. This structure has to be developed to allow Khartoum State to fulfill its mission and to operate with a clear vision of its role as a leader State in terms of Geospatial solutions and e-government implementation. The Directorate strategic program is well aligned with overall entity priorities. Awareness is high across the entity with regular capacity buildings and training sessions for its employees for providing spatial related services. Policies need to be developed for spatial data, spatial data sharing and exchange of data within Khartoum State entities and with other entities as well. Image data is most often used to represent graphic or pictorial data. Most often, image data is used to store remotely sensed imagery, e.g. satellite scenes or orthophotos, or ancillary graphics such as photographs, scanned plan documents, etc. Image data is typically used in GIS systems as background display data; or as a graphic attribute. Remote sensing software makes use of image data for image classification and processing. Typically, this data usually, be converted into a raster format (and perhaps vector) to be used analytically with the GIS. Image data is typically stored in a variety of industry standard proprietary formats. These often reflect the most popular image processing systems at public and private sector levels.

6. Spatial Data Standards and Specifications

In Sudan as in many regions of the globe, spatial data can be divided into two categories, the base maps and thematic or mapping for user applications. User or application data standards will depend on the requirement of the user and the objectives of the application. The base map standard is feature based, this means that each map feature may have its own defined standard that may be different from other map features [2], [8]. Each feature is also associated with a particular category. Each category may contain a list of features for that category and information describing their standards and attributes used to define the standard. In case of Khartoum State, the adoption of base map standards and specification are useful for data exchange of digital base maps and for updating of information. For Khartoum State has to utilize three different techniques in order to share and exchange data with the community.

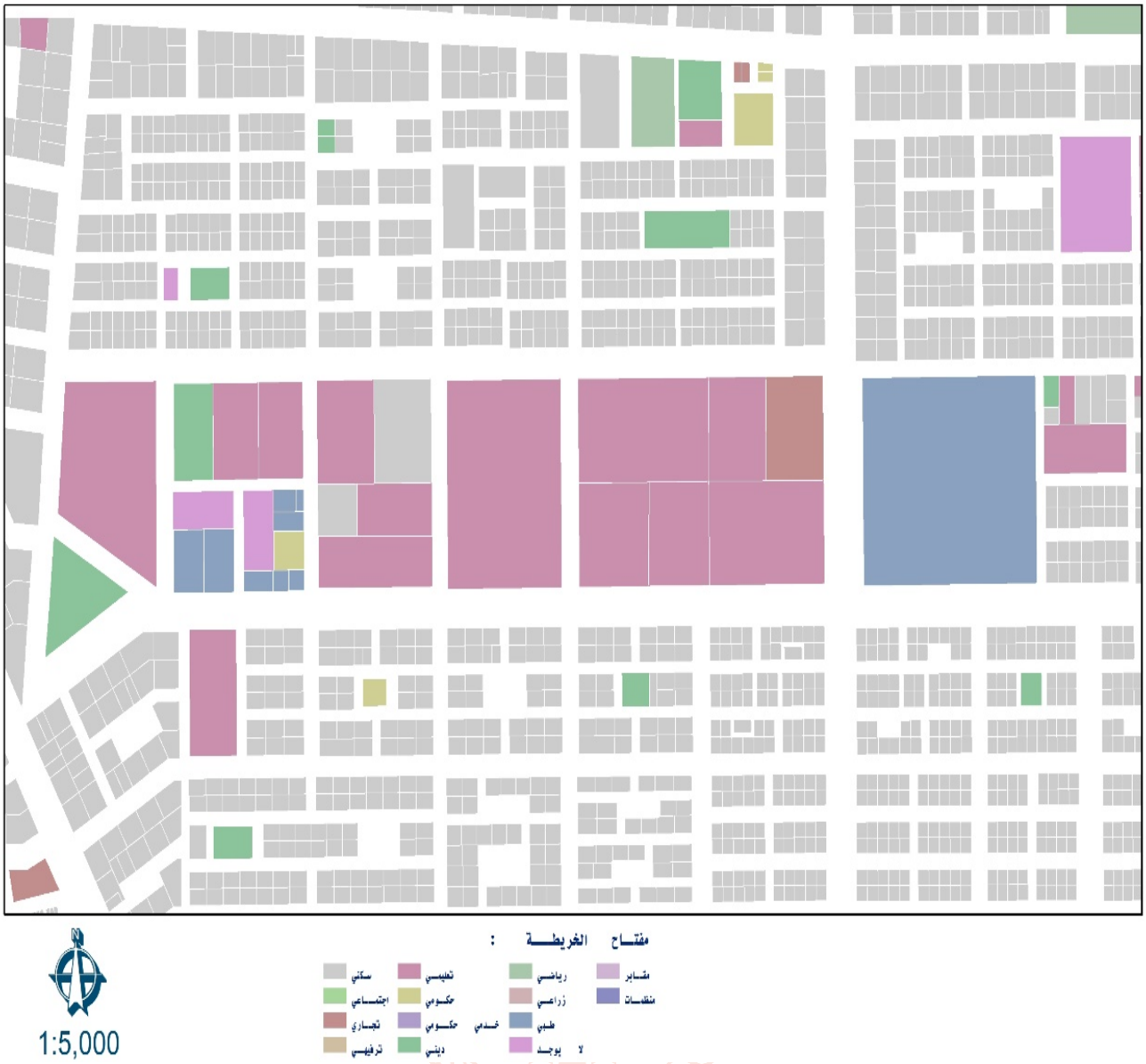

Figure 4: shows Land Use Layer

The first technique is the one being used to submit data to the Survey Directorate, and identify the transactional data that need to be provided to the Directorate, and the regular initiated SD survey updates.

For successful implementation of SDI and Khartoum State enterprise solutions, the following priority business drivers are to be considered:

1. Business Transformation of Government Services – achieve fundamental advances in processes and service to citizens
2. Improved Stakeholder Service Delivery –develop more effective processes and services to satisfy stakeholder needs
3. Spatially Enabled Enterprise Computing – architect and implement geospatial technology, throughout the system, for use by all
4. Point of Entry Business Transaction Data Capture – provide ready access to transactional data throughout the enterprise by automating the data management workflow to capture data input and updates at the customer transaction point.

The Geospatial system of the Directorate of Survey has to be divided into three units the *Development, Technical and Quality Control (QC) units* and the *Data Exchange unit.* These Units are to be responsible for the development, implementation, and maintenance of GIS services across the Directorate and aiming to provide services across the State and the provision of GIS services to external clients. In achieving this goal the Directorate has to perform a number of tasks including:

- The maintenance of a comprehensive geo-spatial database of Basemap layers, land plots, utilities and service corridors, roads, and other datasets.

- The facilitation of online and offline access (for viewing and querying) of these current GIS layers to different category of users throughout Khartoum State.
- The delivering of geo-spatial data updates to other external stakeholders either on transactional basis or through on-line FTP links or off-line on portable storage media.
- Growing utilization of GIS to other business units at Khartoum State and providing necessary support and capacity building services.

Another key task of the Directorate is to have an initiative for the integration of the GIS with other systems in Khartoum State. The Directorate has also to work on the integration of GIS with the Sudan Survey Authority as well as the following Khartoum State departments, Urban Planning, Utility Departments. Information Centre and Infrastructure and Road Department.

7. Conclusion

Khartoum State has to develop all the policies required for the implementation of spatial data infrastructure and geospatial systems of today, these may include the adoption of an accurate reference frames and spatial data infrastructure standards and specifications and standard levels of service agreements. These policies and regulations are crucial for spatial data sharing, integration and mitigations, and for the implementation of enterprise GIS and geospatial solutions.

It's a high time for Khartoum State to implement its strategy that aims to produce efficiencies and higher customer satisfaction based on geospatial solutions and to open a new era in the provision of government services to the general public. To guarantee the successful implementation of the geospatial system in the State, the Survey Directorate has to be considered as the focal point for spatial data acquisition, access and delivery and to play its important role in GIS and geospatial implementation, and to participate in the national wide leadership in Geospatial applications.

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