Implementing 3d Spatial Data Infrastructure For Oman - Issues And Challenges

Khalid Ahmed AL KALBANI and **Alias ABDUL RAHMAN, Malaysia - Talal AL-WADHI** and **Fuad Al SHANNAQ, Oman**

Key words: 2D and 3D Geospatial datasets, 2D SDI, 3D SDI

ABSTRACT

This paper reviews the state of current 2D and 3D Spatial Data Infrastructure (SDI) in Oman. Based on this, several issues will be discussed and relate it to 3D geospatial datasets and other services within the government and the private sectors as well as other users in the country. The review shows that there are several issues and challenges to implement full 2D and 3D SDI. Currently, Oman has made noticeable progress in 2D SDI but not yet in 3D domain. To date, there are no serious efforts and initiatives by the authority to materialize the 3D SDI. This paper will end by describing a comprehensible framework for implementing the 3D SDI, as several issues and challenges will be discussed. We expect, these issues and challenges of 3D SDI in Oman can prompt better services for several potential users.

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1. INTRODUCTION

Geographical Information Systems (GIS) is a geospatial technology tool for capturing, optimizing analyzing, management and storing geospatial data. It has various tools for analyzing, and representing the geospatial data in real world in 2D (two-dimensional) space. Currently, the 3D (three-dimensional) geospatial tool and their related applications are considered as a trend in (GIS) for representing the reality in interactive 3D virtual environment. 3D is simply defined as "*a representation of a three-dimensional, real-world object in a map or a scene, with elevation values (z-values) which is stored within the feature's geometry*" (ESRI, 2017). Therefore, the 3D technology has been widely deployed in all geo-associated fields, such as photogrammetric surveying, cartography, civil engineering, planning and others. The capability of 3D technology now has attracted many specialists and researchers in different disciplines.

Most countries around the world have succeeded in applying 2D and 2.5D (two-and a half-dimensional) Spatial Data Infrastructure (SDI) for planning and infrastructure management (Ho et al., 2013; Alwardi, 2015). Other countries such as the United States of America (USA), Canada, some Europe countries, Asia and Australia are working toward 3D geospatial data infrastructure (SDI).

Nowadays, buildings in mega cities and urban areas are complicated in structure such as multi-floor buildings and underground infrastructures, require to use 3D geo-datasets. Thus, it is clear that the 2D and 2.5D geo-datasets are not able to accommodate complex 3D elements and structures. Additionally, employing the 2D GIS may not be a useful tool to analyze complex problems and so there is an urgent need to shift to 3D GIS (Roić, 2012; Kitsakis et al., 2016). This means that efforts should be exerted to further study the possible functions of 3D SDI and its usefulness.

This paper is divided into four sections. The second section discusses the current status of 2D SDI in Oman including GIS history in Oman, Oman National Spatial Data Infrastructure (ONSDI) and some arising issues on the current implementations. Then, section three investigate the current status of 3D geospatial data in Oman and the limitation of 3D geospatial data in key sectors. Initial findings of the study are highlighted in section four by proposing a framework of Oman's national 3D SDI.

2. CURRENT STATUS OF 2D SDI IN OMAN

Oman has been working with geo-datasets and information since more than 34 years ago. However, majority of the GIS databases are distributed at different authorities and GIS sectors

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around the country (Alwardi, 2015). However, most of these authorities produce their own geo-datasets based on their own requirements. In fact, the GIS authorities are using 2D geo-datasets in their core businesses for mapping purposes.

2.1 History of geospatial data in Oman

In 1984, Oman government established the National Survey Authority (NSA) under the military supervision for survey and mapping (for defense and civilian purposes). Later, NSA created a geoinformation sector to collect spatial data and classify aerial photography and storage in geo-database. NSA has formulated the Oman 2D geospatial manual (policies and standards) to be used as a reference by all users and stakeholders for data collection, maintenance, and dissemination of geospatial data to facilitate the production of harmonized geospatial data (Das *et al.*, 2017). The first utilization of geoinformation in Oman for civil purposes was in 1989, through the Development Council which used the GIS for land information system (LIS entities). Later on, in 1992, the government established the first independent GIS department at Supreme Committee for town planning and censuses using the latest geoinformation platform (NCSI, 2017a).

Since then, geospatial culture was spread to many ministries among Oman to meet their own business requirements such as spatial data production, support the development and the urbanization plans. The majority of these departments have started working separately based on their core businesses and they have established their own geodatabases with various standards and platforms (AutoCAD, MicroStation, ArcGIS). Through implementation of joint ventures between different ministries in Oman, has created a lot of challenges such as absence of unified geo-database, data error (codes, projections, indexes, metadata), lack of sharing, time consuming and budget wastage.

However, to address the challenges and issues that are related to geo-dataset, the government has established the Oman National spatial strategy (ONSS) and Oman National Spatial Data Infrastructure (ONSDI) strategy in 2014. This was under the Supervision of Supreme Council for planning (SCP), the Steering Committee (SC), Directorate General of National Spatial Data Infrastructure and the National Centre for Statistics Information (NCSI) to coordinate, facilitate and support sharing and utilization of geospatial information across multiple government organizations in Sultanate of Oman (NCSI, 2017a).

Currently, there are two important geospatial agencies in Oman. They are the NCSI and NSA which emphasizes on the importance of the ONSDI as a tool for the government to implement geospatial in various sectors.

2.2 ONSDI strategy

The Steering Committee (SC) , the National Centre for Statistics Information (NCSI) and Directorate General of National Spatial Data Infrastructure are working together to establish the union ONSDI which will be the platform to develop the National Geospatial Database (NGDB) (NCSI, 2017a). In addition, the NGDB is being built based on the international

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standards (OGC/ISO) adopted for the Omani requirement. However, the ONSDI became the responsible for maintaining an efficient centralized platform for geospatial data. Moreover, ONSDI cooperates with Information Technology Authority (ITA) and NSA to enhance the GIS investment and avoids duplication of cost and centralized licenses.

The NGDB initiative has been completed 4 years from the date of existence. During that period, some aspects of its strengths have emerged as well as weaknesses as mentioned below:

a)   **Strengths**
  • Centralized geospatial data in one portal.
  • More flexible as geospatial data provider than other GIS agencies (public and private) in Oman.
  • Minimize data production time (from 6 to 2 months).
  • High quality and more accurate data.

b)   **Weaknesses**
  • Disconnected geospatial data provider with stakeholders requirements.
  • Lack of cooperation and coordination between public and private sectors and absence of unified standards.

3. CURRENT STATUS OF 3D GEOSPATIAL DATA IN OMAN

Oman has made noticeable progress in integrating the 2D and 2.5D geo-dataset into most of its governance infrastructure (NCSI, 2017a, 2017b). In contrast, the 3D geospatial implementation is limited and most of 3D data comes from photogrammetric and LiDAR. Hence, most 3D GIS works have only been carried out in the academic researches as well as the consultative studies which are a compulsory condition in any government project contract. Moreover, up to now, there is no serious implementation for 3D geo-dataset in Oman sectors both in public and private.

3.1 Limitation in 3D geospatial data Implementation in key Sectors of Oman

As reported by NCSI, (2017a, 2017b) most of the Omani government sectors keep the flow of geospatial work in their GIS departments in 2D geospatial data, because they believed that the 2D geospatial data is good enough for their core business and fulfill their needs on regular basis. On the other hand, there is no legislation pushing the GIS authorities to utilize 3D geospatial data.

What is crucial is that though Oman National Spatial Data Infrastructure (ONSDI) and other geospatial sectors have stated their visions, objectives and standards about GIS, the actual 3D implementation seems to be uncertain. It can be said that the knowledge of the potential

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benefits of the 3D geospatial data is insufficient in the GIS domain through the implementation of it is still in the early stages.

3.2 Need for 3D geospatial data in Oman

The 3D SDI becomes one of the solutions for planning and managing many smart cities, thus, the 3D data is greatly required for urban, utilities, security, public safety and municipal entities(Li *et al.*, 2013; Mao, 2014; Salim, 2017). In contrast, there are still some countries, of which Oman is not an exception, that rely entirely on processing their geospatial data in 2D. However, 3D SDI has a wide range of benefits. Implementation of 3D geospatial data can reduce costs and save time, increase accuracy and improve efficiency. It can also improve workflows, increase productivity, manage resources, enhance the quality of services, support decision making and offer further functionality through the z-dimension.

3.3 3D geo-spatial implementation and 3D SDI challenges

In fact, most 3D SDI projects around the world even in the developed countries face a lot of challenges that affect the SDI upgrading process and sometimes it stops at various stages. Therefore, some of these projects (SDI) may need a constructive framework with expensive and multi-period budget. Moreover, they require a flexible platform to storage the data in various 3D formats. In this point, Alsultan and Rahman (2015) and Alwardi (2015) mentioned that there are many issues facing the 2D and 2.5D SDI in their country(Saudi Arabia and Oman) which are financial wastage, lack of geospatial awareness, economic development challenge, lack of infrastructure and clarity with regards to geospatial strategy. They also mentioned lack of trained human resources, data availability, cost of data acquisition, data completeness, budget constraints, lack of awareness in top management, data quality, data format compatibility, high hardware and software cost, rapid innovations in technology, unclear project scope and volume of data. In fact, the most challenges and issues facing the implementation of 3D SDI are the same as for the 2D SDI. However, there are other obstacles can be encountered in relation to the 3D geo-dataset such as 3D complexity format, 3D legation and policy, 3D registration for objects, 3D data management, modeling and presenting information.

4. FRAMEWORK FOR IMPLEMENTING THE 3D SDI IN OMAN

3D SDI differs from one country to another in terms of different issues including the economy, 3D awareness, technology, framework and others (Kitsakis et al., 2016). In fact, the full 3D SDI transformation needs a systematic framework for upgrading and integrating the 2D to 3D geospatial data. Moreover, it should be based on a clear understanding of the challenges and potential values of 3D SDI (Blomqvist, 2010; Xu *et al.*, 2010; Kitsakis and Dimopoulou, 2016; Biljecki, 2017; Salim, 2017).

4.1 Degree of readiness for 3D geo spatial data infrastructure in Oman

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The study will be based on a questionnaire which will be sent to all the service organizations within the government, private sector and other users in the country, Oman. The purpose of the e-questionnaires is to determine the level of 3D geo-dataset implementation in Oman as well as find out the challenges that facing upgrading from 2D to 3D SDI to find out the challenges and data management issues. Moreover, one of the expected advantages of the study is that it will illustrate 3D prototype (Figure 1) for the Arabian infrastructure environment.
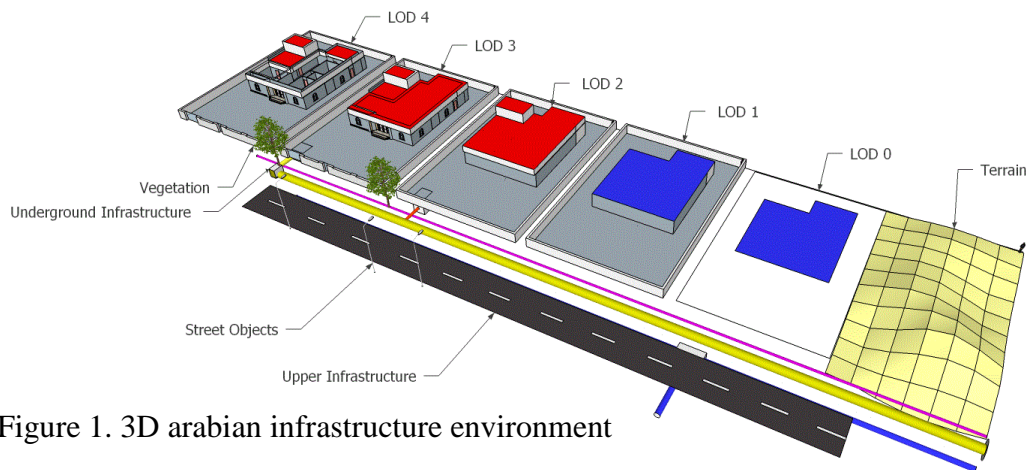
Figure 1. 3D arabian infrastructure environment

4.2 Key outline

In order to implement and use the 3D geo-dataset and 3D SDI in Oman, the key outlines that can be addressed for the future implementation are:

- Upgrading the ONSDI structures from 2D to 3D.
- Monitor and coordinate the 3D implementation and management of the 3D roadmap, and develop an action plan across the government geospatial sectors.
- Associate with the national and international institution in terms of 3D implementation and research.

5. CONCLUSION

This paper attempts to review the current status of 2D and 3D Spatial Data Infrastructure (SDI) in Oman. However, the geospatial framework provides the key outline to achieve the master plan goals and assess the progress. In fact, some of the geospatial communities build their strategic in 2D geospatial for long periods. Then later, they face various challenges for upgrading it to 3D and 4D. In fact, strategic plans and missions should be flexible in order to accommodate new technology.

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The initial study shows that further steps are need for 3D SDI such as organize 3D geospatial workshop in Oman (to share the 3D geospatial knowledge and to identify the most important challenges in developing 3D SDI). In future studies, we will enhance and investigate further in order to address the requirement for the 3D SDI.

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BIOGRAPHICAL NOTES

Khalid Ahmed Alkalbani is a researcher at the Department of Geoinformation, Faculty of Geoinformation and Real Estate, Universiti Teknologi Malaysia (UTM), Skudai, Johor, Malaysia. He received a degree (2005) and MSc (2010) in Geography from Sultan Qaboos University (SQU), Oman. He is currently working on his PhD research concerning 2D and 3D Spatial Data Infrastructure (SDI).

Alias Abdul Rahman is A professor at the Department of Geoinformation, Faculty of Geoinformation and Real Estate, Universiti Teknologi Malaysia (UTM), Skudai, Johor, Malaysia. He received a degree in Surveying and Mapping Sciences from North East London Polytechnic, England, UK in 1987, Postgrad Diploma in GIS from ITC, Netherlands, and MSc in GIS also from ITC, Netherlands. In 2000 he received his PhD degree from University of Glasgow, Scotland, U.K. He currently leads the 3D GIS research group in the faculty.

Talal Yousuf Al-Awadhi is an Assistant Professor at the Department of Geography, Faculty of Arts and social Science, Sultan Qaboos University (SQU), Muscat, Oman. He received a degree in geography from Sultan Qaboos University (SQU) in 1993, MSc in GIS from Kingston University, UK in 1997. In 2003 he received his PhD degree from Newcastle Upon Tyne University, UK. He currently the Head of Geography Department.

Fuad AlShannaq is CEO of JAL Technology company, Muscat, Oman. He received a degree in Mapping and Surveying from Ecole National des Sciences Geographiques-NSG-IGN, Paris, France in 1983, MSc in Photogrammetry from Universiteit Twente-ITC, Enschede, Netherlands in 1988.

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CONTACTS:

Khalid Ahmed Alkalbani | Alias Abdul Rahman

UniversitiTeknologi Malaysia

3D GIS Research Lab

Faculty of Geoinformation and Real Estate

81310 UTM Skudai, Johor, Malaysia

E-mail: kulaib2020@gmail.com | alias@utm.my

Talal Al-awadhi

Sultan Qaboos University

Department of Geography

College of Arts and Social Sciences

SQU, Muscat, Oman

E-mail:alawadhi@squ.edu.om

FuadAlshannaq

Jal Technology

Muscat, Oman

E-mail:info@geojal.com.om

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