

FACTORS IMPEDING THE DEVELOPMENT OF  
OMAN SPATIAL DATA INFRASTRUCTURE

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**I lovingly dedicate this thesis to my family who supported me at each step of the way to achieve this level.**

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## ABSTRACT

Spatial Data Infrastructure (SDI) is an innovative concept introduced more than twenty years ago to allow the sharing and reuse of geospatial data. The National Spatial Data Infrastructure (NSDI), an SDI expanded to the national level, is now widely considered as an essential basic infrastructure for a country in this information era. To date countries all over the world, irrespective of their size, economic strength, political stability and population size, have developed, developing or considering developing their own SDI. A number of developed countries had successfully developed an impressive operational SDI while others are still progressively developing theirs. Yet for other countries the SDI development still remains an innovative concept. Understandably, besides the political and economic factors, many interrelated technical and non-technical factors can affect the development of SDI, the complexity of which can increase with the increase in the level of jurisdictions involved in spatial data sharing. Oman was one of the countries that had taken up the early initiative but unfortunately all that was known of the initiative was some feasibility studies conducted by non-national institution. Therefore this research has attempted to investigate the factors impeding the SDI development of Oman as an effort to revive the initiative to develop an operational Oman SDI, seen as an integral infrastructure to Oman's future development and an important component in disaster and environmental management. Through this study, it was found that SDI is about communications between SDI participants to share spatial data. Through the thorough review of the data gathered from interviews and questionnaires, this research methodology was supported by systematic inspection and analysis of the essential data. The main stumbling block to Oman's effort in building the SDI is the non-technical factors, including the human aspects entailing the lack of knowledge and awareness of spatial data and use of GIS, lack of knowledge on SDI concept and SDI benefits, and also the lack of cooperation, collaboration and coordination among the participants. It can be concluded that the lack of knowledge and awareness make communication between SDI participants difficult, thus almost impossible for cooperation, collaboration and coordination. This had left Oman with no option but to leave the initiative as an innovative concept, are now identified to be given the highest priority to enable Oman to pave the way forward.

## ABSTRAK

Infrastruktur data spasial (SDI) adalah konsep inovatif yang diperkenalkan lebih dua puluh tahun dahulu untuk membolehkan perkongsian dan penggunaan semula data spasial. Infrastruktur data spasial Negara (NSDI), iaitu SDI yang diperkembangkan ke peringkat nasional kini dianggap secara meluas sebagai suatu infrastruktur asas yang penting bagi sesebuah negara dalam era maklumat ini. Kini negara-negara serata dunia, tanpa mengira keluasan, kekuatan ekonomi, kestabilan politik dan saiz penduduknya, telah, sedang dan akan membangunkan SDI masing-masing. Beberapa negara maju telah berjaya membangunkan SDI mengagumkan yang kini beroperasi sementara negara-negara lain masih terus membangunkan SDI mereka. Namun bagi negara-negara lain pula, pembangunan SDI mereka masih lagi tinggal sebagai suatu konsep inovatif. Mudah untuk difahami bahawa, selain dari faktor-faktor politik dan ekonomi, banyak faktor-faktor teknikal dan bukan teknikal yang boleh mempengaruhi pembangunan sesuatu SDI. Kerumitan bertambah dengan meningkatnya tahap bidang kuasa yang terlibat dalam perkongsian data spasial. Oman adalah salah satu dari negara yang telah memulakan inisiatif awal tetapi malang sekali apa yang diketahui mengenai inisiatif ini hanya beberapa kajian kemungkinan yang telah dilaksanakan oleh institusi asing. Oleh demikian, kajian ini menyiasat faktor-faktor yang menghalang pembangunan SDI Oman sebagai usaha untuk menghidupkan semula inisiatif bagi membangunkan SDI Oman yang beroperasi dan dilihat sebagai infrastruktur penting untuk pembangunan Oman pada masa hadapan serta sebagai komponen penting dalam pengurusan persekitaran dan bencana alam. Melalui kajian ini, didapati SDI adalah berkenaan komunikasi antara peserta-peserta SDI untuk berkongsi data spasial. Melalui ulasan menyeluruh data yang diperolehi dari temuramah dan soalselidik, metodologi kajian ini di sokong dengan penelitian dan analisis yang sistematik terhadap data penting hanya mendapati penghalang utama dalam usaha Oman untuk membangunkan SDI adalah faktor-faktor bukan teknikal, lebih tepat lagi, aspek-aspek berkaitan manusia seperti kekurangan pengetahuan dan kesedaran mengenai data spasial dan penggunaan GIS, kekurangan pengetahuan tentang SDI konsep dan faedah SDI, dan juga kekurangan kerjasama, kolaborasi dan kodinasi antara peserta-peserta. Dapat disimpulkan bahawa kekurangan pengetahuan dan kesedaran menjadikan komunikasi antara peserta-peserta SDI susah, hinggan hampir tiada kemungkinan untuk berkerjasama, berkolaborasi dan berkodinasi. Perkara ini menyebabkan Oman tiada pilihan tetapi terpaksa meninggalkan inisiatif tersebut sebagai konsep inovatif sahaja. Kini faktor-faktor ini dikenalpasti sebagai keutamaan terpenting yang membolehkan Oman mencorakkan halatuju ke hadapan.

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## LIST OF ABBREVIATION

|        |   |   |
|--------|---|---|
| AD-SDI | - | Abu Dhabi Spatial Data Infrastructure                 |
| ADSIC  | - | Abu Dhabi Systems and Information Centre              |
| AGI    | - | Association for Geographic Information                |
| ANZLIC | - | Australia New Zealand Land Information Council        |
| APSDI  | - | Asia-Pacific Spatial Data Infrastructure              |
| APSMA  | - | Australia Public Sector Mapping Agency                |
| ASDI   | - | Australia SDI   |
| BSDI   | - | Bahrain Spatial Data Infrastructure                   |
| CCOG   | - | Canadian Council on Geomatics                         |
| CGDI   | - | Canadian Geospatial Data Infrastructure               |
| CGIS   | - | Centre for GIS  |
| CMI&C  | - | Construction Material Industry & contracting          |
| CNIG   | - | National Centre for Geographic Information            |
| CSDGM  | - | Content Standards for Digital Geospatial Metadata     |
| DBMS   | - | Database Management System                            |
| DGI    | - | Digital Geographic Information                        |
| DGIWG  | - | Digital Geographic Information Working Group          |
| DGMAN  | - | Directorate General of Meteorology and Air Navigation |
| DEM    | - | Digital Elevation Model                               |
| DIGEST | - | Digital Geographic Information Exchange standard      |
| DM     | - | Dhofar Municipality                                   |
| DNF    | - | Digital National Framework                            |
| DTED   | - | Digital Terrain Elevation Data                        |
| DTM    | - | Digital Terrain Model                                 |
| EDB    | - | Economic Development Board                            |
| EGII   | - | European Geographic Information Infrastructure        |

|         |   |   |
|---------|---|---|
| eGU     | - | e-Government Unit                                       |
| EU      | - | European Union  |
| EUROGI  | - | European Umbrella Organisation for Geographic           |
| FACC    | - | Feature and Attribute Coding Catalogue                  |
| FGDC    | - | Federal Geographic Data Committee                       |
| FIPS    | - | Federal Information Processing Standard                 |
| FRC     | - | Future Requirement Committee                            |
| FUGRO   | - | FUGRO Middle East and Partners company                  |
| GCC     | - | Gulf Cooperation Countries                              |
| GDI     | - | Geographical Data Infrastructure                        |
| GEMINI  | - | Geo-spatial Metadata Interoperability Initiative        |
| GII     | - | Geographical Information Infrastructure                 |
| GIS     | - | Geographic Information System                           |
| GML     | - | Geography Markup Language                               |
| GNP     | - | Gross Nation Product                                    |
| GPS     | - | Geographic Positional System                            |
| GSDI    | - | Global Spatial Data Infrastructure                      |
| HM      | - | His Majesty   |
| IACG    | - | Inter-Agency Committee on Geomatics                     |
| ICSM    | - | Intergovernmental Committee of Surveying and Mapping    |
| ICT     | - | Information and Communication Technologies              |
| INSPIRE | - | Infrastructure for Spatial Information in Europe        |
| ISO     | - | International Organization for Standardization          |
| ITA     | - | Information Technology Authority                        |
| MaCGDI  | - | Malaysia Canter for Geospatial Infrastructure           |
| MECA    | - | Ministry of Environment and Climate Affairs             |
| MGS     | - | Muscat Geo System Company                               |
| MM      | - | Muscat Municipality                                     |
| MOAG    | - | Ministry of Agricultural                                |
| MOH     | - | Ministry of Housing                                     |
| MOHR    | - | Ministry of Heritage                                    |
| MOI     | - | Ministry of Inertial                                    |
| MONE    | - | Ministry of National Economy                            |
| MORM&WR | - | Ministry of Regional Municipalities and water Resources |

|          |   |   |
|----------|---|---|
| MOTC     | - | Ministry of transport and communication                               |
| MWS      | - | Military Welfare Service  |
| MyGDI    | - | Malaysian Geospatial Data Infrastructure                              |
| MZEC     | - | Mazown Electric Company   |
| NaLIS    | - | National Infrastructure for Land Information System                   |
| NCSP     | - | National Centre for Spatial Planing                                   |
| NGDB     | - | National Geographic Data Base   |
| NGDF     | - | National Geospatial Data Framework                                    |
| NGISA    | - | National Geographic Information System Authority                      |
| NGISSC   | - | National GIS Steering Committee                                       |
| NHO      | - | National Hydrographic Office  |
| NIT      | - | Navigation Information Technology                                     |
| NTDB     | - | National Topographic Database   |
| NSA      | - | National Survey Authority   |
| NSDI     | - | National Spatial Data Infrastructure                                  |
| NSGI     | - | Portugal National System for Geographic Information                   |
| Omantel  | - | Oman telecommunication company  |
| ONSDI    | - | Oman National Spatial Database Infrastructure                         |
| ORDBMS   | - | Object-Relational Database Management System                          |
| PCGIAP   | - | Permanent Committee on GIS Infrastructure for Asia and the Pacific    |
| PCGIAP   | - | Infrastructure of Geographic Information Systems Asia and the Pacific |
| PDO      | - | Petroleum Development for Oman  |
| RDBMS    | - | Relational Database Management system                                 |
| RSDI     | - | Regional National Spatial Data Infrastructure                         |
| SCTP     | - | Supreme Committee of Town Planning                                    |
| SDI      | - | Spatial Data Infrastructure   |
| SI       | - | Spatial Information   |
| SIPC     | - | Sohar Industry Port company   |
| SQL      | - | Structured Query Language   |
| SQU- COA | - | College of Arts – Sultan Qaboose University                           |
| SQU-RSC  | - | Remote Sensing Center– Sultan Qaboose University                      |
| SVG      | - | Scalable Vector Graphics  |



|      |   |   |
|------|---|---|
| SWOT | - | Strength Weakness Opportunities Thrust Analysis |
| TDB  | - | Topographic Database                            |
| UAE  | - | United Arab Emirates                            |
| UK   | - | United Kingdom                                  |
| UN   | - | United Nation                                   |
| URA  | - | User Requirements Analyses                      |
| URIs | - | Uniform Resource Identifiers                    |
| USA  | - | United States of America                        |
| UTM  | - | Universal Transverse Mercator                   |
| WSDH | - | Water Supply Dhofar                             |

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## CHAPTER 1

### INTRODUCTION

#### 1.1 Background

Spatial Data Infrastructure (SDI) is an innovative concept introduced more than twenty years ago to allow the sharing and reuse of geo-spatial data. Developed countries such as Australia, United States of America (USA), Canada and many European countries have enjoyed many benefits from their successful operational SDIs. The National Spatial Data Infrastructure (NSDI) which refers to the SDI implemented at national level is not merely a database but includes the technology, policies, standards, and human resources necessary to acquire, process, store, distribute, and improve utilisation of geospatial data (USA, 1994). It has become an important part of the infrastructure for a country. Spatial data infrastructure is indispensable for providing geospatial information for government and civilian decision making. It is essential for optimising land use, stimulating economic activity, managing natural disasters and hazards and for developing environmental policy. It has often been quoted that as much as eighty percent of all local government decisions are spatial in nature (FGDC, 1996; O'Flaherty *et al.*, 2006). As such, as many as more than 120 countries (Crompvoet, 2006) in the world have attempted to develop their own national SDI. However, many countries faced some kind of problems at different stages of the SDI development. It was observed that countries with strong and stable economy with high demand and use of spatial data mostly managed to eliminate the various problems pertaining to the SDI development.

Transitional economies such as Brazil have also succeeded in developing their SDI (Davis and Fonseca, 2006). More recently Uganda and Jordan have begun developing their SDI. The Gulf Cooperation Countries (GCC) of Qatar, United Arab Emirates (UAE), Sultanate of Oman, Bahrain, Saudi Arabia and Kuwait had begun developing their SDI systems. Qatar was one of the earliest countries to pioneer SDI development. Besides Qatar, Bahrain and Abu Dhabi in the UAE have also succeeded.

SDIs have been developed for different purposes. Conventional SDI systems were developed mostly for economic and environmental purposes. Following the recognition of the benefits from such SDI systems, a number of countries such as Australia, Canada and Japan are now building marine SDI as an extension to their successful national SDI. There are at present a number of specific purpose SDIs being developed or conceptualised such as the Arctic SDI and the Antarctic SDI. These were created to support scientific data management for scientific research in the Arctic and the Antarctic respectively. Similarly, other specifically developed SDIs include a Cultural Heritage SDI, Humanitarian SDI, Avalanche SDI, Laser Scanning SDI and the recently created Spatial Data Infrastructure for Development (SDI4MDGs). The SDI4MDGs is specifically developed for monitoring and achieving the Millennium Development goals, which relates to the goals established following the Millennium Summit of the United Nations in 2000 which aimed amongst other to eradicate poverty and to promote sustainable development (section, 2.4.6).

Developing an SDI system requires a lot of cooperation and effort between many parties. It is complex and dynamic and requires the commitment of example datasets, expertise, funds, technology and time. Thus, it is not unusual for many countries to face different kinds of problems in developing their spatial data infrastructure so much so that some countries have succeeded in implementing operational SDI systems, many others are still working to complete and implement their SDI and yet others have put development of their SDI on hold for a variety of

reasons. There are also countries in which SDI development has been postponed to allow for changes to reflect their particular needs.

The factors affecting the development of SDIs range from the problem of lack of digital and up-to-date spatial data (as in the case of African countries), lack of funding (as in the case of many transitional and developing countries), lack of internet and telecommunications facilities and electricity as in Nigeria and many other African countries to lack of political support such as in the case of many countries where poverty, food security, health-care (AIDs) and other social problems are their main priority.

## **1.2 Problem Statement**

The development of Spatial Data Infrastructures has taken place in more than 120 countries worldwide within the past two decades and Oman being one of the earliest countries to adopt the initiative, started the initiative way back in 1995.. The experience of many countries in developing their spatial data infrastructure has been shared at many conferences and in numerous published literatures. Although the Global Spatial Data Infrastructure (GSDI) association took the initiative to publish the SDI Cookbook (GSDI, 2009) to provide guidelines for the use of countries contemplating the development of their own SDI, it is just not sufficient for countries to merely follow the guidelines of the SDI Cookbook because different countries have different forms of governance, economic systems, societal values and culture, making any one country, and therefore their problems in SDI development, unique from the other countries. Thus, while the success factors of the exemplary operational SDIs are to be analysed and emulated, the factors impeding or contributing to the failure of the SDI development of any country (of which Oman is no exception) are to be thoroughly and adequately identified and analysed to enable the continued progress of the dynamic and complex SDI development till the achievement of an operational SDI.

### **1.3 Research Questions**

This research was carried out by systematically observing the following research questions :

- (i) What is a spatial data infrastructure and what does it consist of?
- (ii) Which countries have successfully developed their spatial data infrastructure and why?
- (iii) What are the factors that affect the development of a spatial data infrastructure?
- (iv) What is the current situation of spatial data infrastructure in the Sultanate of Oman?
- (v) What are the characteristics and types of spatial data used by the Geographic information (GI) communities in Oman?
- (vi) What are the factors affecting or impeding the development of an Omani Spatial Data Infrastructure initiative?

### **1.4 Research Aim**

The aim of this research is to identify the key barriers affecting the development of Oman Spatial Data Infrastructure so that appropriate solutions could be recommended to rectify the current problems in the development of the Oman SDI.

### **1.5 Research Objectives**

The objectives of this research include the following:

- (i) to study the nature and the development of a spatial data infrastructure.
- (ii) to identify the key factors that affect the development of spatial data infrastructure.
- (iii) to identify the factors impeding or inhibiting the development of Oman spatial data infrastructure.

- (iv) to recommend steps to be taken to enhance development of Oman spatial data infrastructure initiative.

## **1.6 Research Motivation**

Oman is a developing country seeking to instigate Information Technologies (IT). The reason for this study is to contribute to directing effective implementation of SDI as part of the larger government initiative in promoting IT. By implementing SDI, Oman will be streamlining organisational decision making which will contribute to implementing IT and making Oman a more modern country.

## **1.7 Significance of the Research**

It has been nearly twenty years since the National Survey Authority of Oman first initiated the idea in 1995 to adopt the development of a National Geographic Data Infrastructure (NGDI). While many countries in the world have successfully or partially successful in developing their national spatial data infrastructure within this time period, Oman does not make much progress and it is yet to see the development of the national SDI to materialise. Therefore, this study is important as it seeks to identify the factors which may contribute to Oman's failure and is significant to provide recommendation(s) to rectify the situation and to pave the way forward to a successful implementation of the NSDI.

## **1.8 Thesis Outline**

The thesis is organised in five chapters as outlined below:

- (i) **Chapter 1.** The first chapter provides an introduction to the subject matter of the research and defines the research problem. It then identifies the aim of the research and the research questions which were addressed to solve the problem.

- (ii) **Chapter 2.** The chapter outlines the scope of the spatial data infrastructure (SDI) and lists the various definitions of the SDI to indicate its complexity and dynamics. It also provides an overview of the development of SDI systems in other countries to show the various forms they can take and their wide scale acceptance by many countries in the world. Details on special purpose SDI systems are also included in this chapter.
  
- (iii) **Chapter 3.** This chapter outlines the methods used to identify and describe the current situation in Oman and the user requirements.
  
- (iv) **Chapter 4.** The chapter presents the result of the research relating to the most important factors identified to affect the development of SDI. These factors are compared to the findings relating to the development of the Oman SDI. It highlights the status of spatial data activities and provides a vision of the most important factors that impede the implementation of the Oman SDI.
  
- (v) **Chapter 5.** The final chapter discusses relevant issues of the research in the context of improving the progress in the development of the Omani SDI and concludes with suggestions for future research.



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