CRITICAL SUCCESS FACTORS MODEL FOR SPATIAL DATA INFRASTRUCTURE IMPLEMENTATION IN ABU DHABI EMIRATE

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ABSTRACT

In 2007, Abu Dhabi Emirate launched its Spatial Data Infrastructure Program (AD-SDI). Crown Prince of Abu Dhabi declared a vision for the Emirate to establish one of the best SDI in the world. The main drawback was to answer the question of how to measure AD-SDI effectiveness in achieving Abu Dhabi's vision on the SDI. A conceptual framework is developed using combination of qualitative and quantitative methods and being applied in four stages. First stage deals with review of theory and framework development based on the extensive literature review. Second stage explores selected case studies of the world's best SDI practices in United States, Australia and Malaysia. In the following stage, outcomes from preceding stages are utilized to develop SDI survey questionnaires for Abu Dhabi geospatial community. The questionnaires have been distributed to stakeholders and users of geospatial data in government and private sectors. Finally, findings from the survey questionnaires have been used to create a suitable preliminary CSF model for the AD-SDI and to measure impact on their implementation in Abu Dhabi. The developed preliminary CSF model for the AD-SDI consists of six (6) main categories with their respective 42 success factors being identified. All 42 factors are assigned with weightage accordingly by using statistical approach to measure their degree of priority. However, after systematic integration and evaluation process, a new revised version of primary CSF model for the AD-SDI are generated with 6 main categories but the total number of success factors is reduced to 33. The adopted main categories for the primary CSF model have been developed based on the survey findings in issues mainly related to organizational matters, level of communication, data standards and socio-economy. Validation process has been carried out to evaluate effectiveness of the selected primary model in implementing AD-SDI. The new primary model is accepted by the state authority to be adopted in implementing a comprehensive and modern SDI in Abu Dhabi. The success of AD-SDI will be followed by adopting the model for the implementation of future nation-wide SDI in the United Arab Emirates.

ABSTRAK

Program *Spatial Data Infrastructure* (SDI) di Abu Dhabi Emirate (AD-SDI) telah dilancarkan pada tahun 2007. Putera Mahkota Abu Dhabi telah mengutarakan visi untuk Abu Dhabi membina salah satu SDI yang terbaik di dunia. Kekurangan yang nyata pada masa itu adalah untuk menjawab persoalan tentang sejauh manakah keberkesanan perlaksanaan program AD-SDI dalam merealisasikan visi tersebut. Satu rangka-kerja konsep telah dihasilkan menggunakan kombinasi kaedah-kaedah kualitatif dan kuantitatif serta telah dilaksanakan dalam empat peringkat. Peringkat pertama menjurus kepada sorotan teori dan pembangunan rangka-kerja berdasarkan kepada kajian literatur. Peringkat kedua melaksanakan sejumlah kajian kes terpilih berkaitan dengan amalan terbaik SDI di United States, Australia dan Malaysia. Dalam peringkat yang selanjutnya, penemuan hasil kajian di dua peringkat sebelumnya telah digunakan untuk merekabentuk set soal-selidik yang disebarkan dikalangan pengeluar dan pengguna data-data geospatial di Abu Dhabi. Kajian soal-selidik tersebut telah dijalankan bukan sahaja melibatkan agensi Kerajaan malahan juga dikalangan sektor swasta. Akhirnya hasil dari kajian soal-selidik yang dijalankan telah digunakan untuk menghasilkan model awal *Critical Success Factor* (CSF) dan bagi mengukur keberkesanan perlaksanaan program AD-SDI di Abu Dhabi. Model CSF yang dihasilkan itu mempunyai enam (6) kategori utama dan sebanyak 42 faktor yang berkaitan telah dikenalpasti. Kesemua 42 faktor tersebut telah diberikan wajaran mengikut kaedah statistik bagi menentukan ukuran darjah keutamaannya. Walau bagaimanapun selepas proses integrasi dan penilaian dibuat, model CSF yang baru telah dihasilkan semula yang mempunyai enam (6) kategori utama tetapi hanya 33 faktor yang berkaitan sahaja dipilih. Kategori utama model CSF tersebut dibina berasaskan kepada hasil kajian soal-selidik yang telah dijalankan terutama yang berkaitan dengan isu-isu organisasi, peringkat komunikasi, piawaian data dan keadaan sosio-ekonomi. Proses validasi dilakukan untuk menilai keberkesanan model CSF tersebut dalam perlaksanaan program AD-SDI. Model CSF yang baru ini diterima oleh pihak berkuasa untuk digunapakai dalam melaksanakan pembentukan SDI yang komprehensif dan moden di Abu Dhabi. Kejayaan AD-SDI nanti akan dijadikan model bagi penubuhan SDI di seluruh United Arab Emirate.

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AD-SDI	-	Abu Dhabi Spatial Data Infrastructure – program
ADWEA	-	Abu Dhabi Water and Electricity Authority
ADSIC	-	Abu Dhabi Systems and Information Centre
ADNOC	-	Abu Dhabi National Oil Company
ASDI	-	Australian Spatial Data Infrastructure
ANZLIC	-	Australia New Zealand Land Information Council
ADWEA	-	Abu Dhabi Water and Electricity Authority
SDMC	-	Abu Dhabi Spatial Data Management Centre
CANOGGIS	-	Canadian Oil and GAS GIS
CCOG	-	Canadian Council of Geomatics
OSDM	-	Commonwealth Office of Spatial Data Management
CRCSI	-	Cooperative Research Centre for Spatial Information
CORINE	-	Coordination of Information on the Environment
CSF	-	Critical Success Factors
CAS	-	Complex Adaptive Systems
CGDI	-	Canadian Geospatial Data Infrastructure
CIO	-	Chief Information Officer
CGIS	-	Centre for Geographic Information System
GeoConnections	-	A national initiative to provide Canadians with geospatial, or geographic, information over the internet
EAD	-	Environmental Agency Abu Dhabi
FGDC	-	Federal Geographic Data Committee
GI	-	Geographic Information
INSPER	-	EU portal for Geographic Information
ISO	-	International Standardization Organisation
MD	-	Metadata
NSDI	-	National Spatial Data Infrastructure

OGC	-	Open Geospatial Consortium
QA	-	Quality Assurance
QC	-	Quality Control
SDI	-	Spatial Data Infrastructure
GIS	-	Geographic Information System
GSDI	-	Global Spatial Data Infrastructure
UAE	-	United Arab Emirates
WWW	-	World Wide Web
IT	-	Information Technology
E-government	-	Electronic Government
GDI	-	Geospatial Data Infrastructure
EEA	-	European Environmental Agency
EU	-	European Union
JSDI	-	Japanese National Spatial Data Infrastructure
GPS	-	Global Positioning System
FGD	-	Fundamental Geo–spatial Data
OMB	-	Office of Management and Budget
NSGIC	-	National states Geographic Information Council
GDP	-	Gross Domestic Product
WALIS	-	West Australia Land Information System
IACG	-	Inter- Agency Committee for Geomatics
KPIs	-	Key Performance Inductors
NaLIS	-	National Infrastructure for Land Information System
LRAs	-	Land Related Agencies
MCGDI	-	Malaysian Center for Geospatial Data Infrastructure
MSD	-	UAE Military Survey Department
EAD	-	Environmental Agency Abu Dhabi
DMA	-	Department of Municipalities and Agriculture
DPE	-	Department of Planning and Economy
NIMA	-	National Imagery and Mapping Agency
PPP	-	Public-Private Partnerships
PSI	-	Policy and Legislation on access to public sector information
SSDI	-	Statewide Spatial Data Infrastructures

ICT	-	Information and Communication Technology

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CHAPTER 1

INTRODUCTION

1.1 Background

Appropriate information and the resources for maximum utilization may not always be readily available as information is an expensive resource, particularly in countries that are still undergoing the process of development. Many programs and projects at the national, regional, and international levels are working towards improving access to available spatial data, promoting its re-use, and ensuring that additional investment in spatial information collection and management results in a pool of spatial information that is continuously growing, readily available and useable. It is easily noticeable that there is a rapid and vast change in the way better-resourced communities address critical issues of social, environmental and economic importance in regions characterized by an availability of geographic information, in combination with the power of Geographic Information Systems (GIS), decision-support tools, databases, and the World Wide Web (www) and their associated interoperability.

In our present day, the process of decision-making at all levels of government and private industries are affected by the increasing role of Geographic Information Systems (GIS) that facilitate spatial analysis. In turn, GIS analysis depends on many factors such as the availability, quality, and compatibility of digital geographic data. Development of these data is normally the highest cost-factor in the use of technology to address today's problems. Billions of dollars are invested annually in

producing geospatial data, but many of these data collection activities are redundant as data already exist. Sometimes the reason could be that these data are hard to find, frequently undocumented, or in incompatible formats (FGDC, 2005).

However, even in the new era of networking computers, the social norms of the past continue to forbid users from finding and thus using critical geographic information. This could lead to either the abandoning of proposed projects or to unnecessary and usually expensive recaptures of existing geographic information. The discovery, acquiring, exploitation and sharing of geographic information is vital to the decision process which would easily be possible for local communities, nations and regional decision-makers only through common conventions and technical agreements (GSDI, 2004) such as national and international data infrastructures.

Furthermore rapid development and advanced technology have created a need for geographic spatial databases to help in aiding growth and development all over the world. Tens of billions of dollars in the industrial world have been spent in the creation of systems. Systems were developed and designed in order to serve specific needs and communities such as urban planning, land records and businesses, etc. The Mapping Science Committee of the National Academy of Science reported spending to be $ 4.4 billion (Groot and Mclaughlin, 2000). There are many countries trying to develop their own spatial data infrastructure (SDI) to remove duplication and redundancy of their geospatial data.

Fuziah Abu Hanifah *et al*., (2007) stated that in the critical reviewing of the Malaysian SDI the many countries are developing SDIs to improve access and sharing of spatial data. The current SDI provides mainly the ability to access and retrieve spatial data. The development of these SDI models have not met user needs as expected. Hence, the concept of an SDI needs to progress so that it allows more than just the ability to access geospatial information. It needs to be enhanced so that it is possible to share data, business goals, strategies, processes, operations and value added products and services in order to support a spatially enabled government. This applies for many countries who are trying to implement the SDI concept on their local and national levels.

In context, many poor countries needs the SDI to develop and monitor their growth therefore it is often said that Africa is poorly mapped; that is, there is a paucity of geospatial information. Without proper geospatial information, it is not possible to use GIS for the purpose of analyzing development needs and planning projects or monitoring the impact of development on projects. This can serve as a clear example of the nature and the status of the geospatial data in one of the five continents. The study illustrates the reasons why there are poor data for Africa. Clarke (2008) also defines two reasons behind the case, viz., the low standard of living in Africa and the lack of governmental support. Clearly, this example stresses the importance of knowing the nature of a given place before trying to fit or implement SDI. The geospatial African project had wasted time and effort before realizing that there were problems of communication, data availability and data access. Furthermore, one of the biggest drawbacks in the African project was the educational level and the expertise. Thus, the following statement is given: where to be effective, there must be a critical mass of expertise in GIS. The local academic institutions often are unable to provide the required technological skills (Clarke, 2008).

There are different standards of living and economical situation for different countries. This drives us to a very important question: 'how can countries improve their SDIs? And then can money be saved as well as time on the implementations of their newly built SDIs. In other words, how can we study its efficiency and effectiveness in a systematic way so that SDIs can be improved? Details about the need for SDI in the United Arab Emirates are discussed in Chapter 2.

Many problems which are unsolvable could affect the model of newly framed geospatial arguments. Many designers tend to implement solutions for problems they are sure can take ages to solve. For example, country x doesn't have good network between their local and private stockholders. Implementations of the SDI could be delayed until a good network is built either in the next month or in the next twenty years. However, one must consider that such property could lead to saving time and cost of building a framework. Therefore, one of the mistakes that could lead to inefficient national geospatial framework is to import a readymade framework that doesn't account for the properties and the local system in a given country.

Although the coverage and format of most data, as being observed, have been mainly focused on the needs of the original collecting agency, the scope still exists for these agencies to further develop data in response to the needs of other users including those in the private sector (Hall, 2003).

1.2 Research Formulation

1.2.1 Statement of Research Problem

Nowadays, there is no doubt that spatial information plays a crucial role in the sustainable development of countries. It is one of the backbones of the e-government concept. Similarly, it is widely agreed that the most adequate framework to handle these spatial information on a national, regional or international level is the SDI concept. The term Spatial Data Infrastructure (SDI) has numerous definitions across countries, regions and disciplines. These definitions differ as considerably as do the stated objectives of the more than 120 SDI initiatives now underway across the globe, with varying degrees of success (Longhorn, 2004). This concept has been around for almost three decades and some 150 countries are at some stage of its implementations. However it seems that all of these experiences have known failure in some aspects. More information related to SDI is discussed in the literature review of Chapter 2.

The main problem is how to measure the effectiveness of AD-SDI so that it can become one of the best SDIs in the world. To reach a good understanding of where and how AD-SDI is effective, it is important to evaluate it using primary model derived out of scientific points of view. Therefore researcher created a CSFs model using scientific approaches and methods and then applied on AD-SDI.

Scholars define evaluation as follows: evaluation is about finding answers to questions such as 'are we doing the right thing' and 'are we doing things right'. There are prominent questions for SDIs implementation. The development of which has been very dynamic over the last decade and has involved significant learning from

other national or local initiatives (Rajabifard, 2008).

Until today there are no clear studies to gather, analyze and prioritize critical success factors for the implementation of SDIs in general. Good understanding of the critical success factors (CSFs) that affect the success and failure of SDI implementation will help in defining CSFs primary model and then applying the CSFs model to AD-SDI. Up to now not much of the work has been done in discovery, analysis and classification of the CSFs that affect the SDIs implementation. There is only been one paper written by Crompvoets and Bregt (2008) which did not cover the creation of a CSFs model but instead it focused on using the CSF concept to determine the factors for certain countries.

1.2.2 Research Questions, Objectives and Scope of Study

In this study, there are several questions that need to be answered and fulfilled in order to achieve the aim and objectives of the study. The research questions are as follows:

1. Can the understanding of existing theory on success and failure, implementation and organization be applied to existing national and state SDI implementation models to improve the goal of a successful implementation?

2. How can these successful models be rigorously described and classified?

3. What are the critical success factors that influence the successful implementation of SDI and which factors have the most influence?

4. Can the varying national and state organizational characteristics, capacities and attitudes be related to successful SDI implementation or outcomes?

5. Can a generic model be developed which can guide future national/state SDI implementation?

The aim of this study is to asses in scientific approach the effectiveness of

SDI implementation using the Critical Successful Factors (CSF) model. To fulfill this aim there are several objectives outlined and they are as follows;

1. To gather and determine the critical success factors that affect the effectiveness of the SDIs implementations using case study method.

2. To classify and analyze all determined critical success factors according to their significance and effect on the effectiveness of the SDIs implementations.

3. To develop the critical success factors of the primary model using the case study.

4. To apply the CSF primary model on the AD-SDI and measure the CSFs significance and the effect on the effectiveness of the AD-SDI implementations using mixed methods of qualitative and quantitative methods.

The scope of the research is described in many fields of view such as the model being used, the way of analysis, and many more. The explanation of the scope is indicated in the following statement:

1. The large SDI area of knowledge and the diversity of the types of the SDIs in the world have affected the research in the limited excitant of the literature review considering the amount of the facts and information needed to build the CSF primary model.
2. The sensitivity of publishing all facts about the current SDIs experiences in the world have impacted the CSF primary model, however, good care are taken when the information and facts were abstracted from the literature review and the case study.
3. The diversity of SDI definitions has affected the construction of the CSF 6 categories.
4. The choice of the case study was constrained to the top 3 experiences namely USA, Austral and Malaysia. This will in shower common extracted CSFs which can be presented on the CSF primary model.

5. The fact of the descriptive information about SDIs has forced the researcher to use the case study method.
6. The nature of the primary CSF model were gathered from descriptive information using the case study and the literature review has forced researcher to integrate questionnaire to test the CSFs using AD–SDI question.
7. The use of two different methods have forced researcher to apply mixed method to measure test and measure AD – SDI effectiveness.
8. The limited time to do the literature review affected the amount of the data that entered to the primary model which is limited to 67 participants.

1. 3 Significance of the Study

As described in the above sections, measuring CSFs is not only important for AD-SDI but it is also important for all countries that implement SDIs. CSFs could help countries to tone and refine their processes and mentor their SDIs on the local, national and international levels. CSF model can help SDIs in different ways such as: prevents errors and time loss due to recurrence of errors such as duplicating works, Most SDIs have their own concerns and problems. Modeling the CSFs will allow new initiatives to personalize models which will optimize and tune the effectiveness of SDIs implementations, designing a well-defined critical success factors model could help in choosing the most effective methods and processes. Hence, resources, time and effort can be saved or better utilized.

On the level of managements CSFs models could show the senior management's key concerns of SDI implementation. The CSFs will help in developing strategic plans for the implementation of the SDIs.

The CSFs will illustrates the key areas of each stage of SDIs life cycle and the major causes of SDIs failures the end it will lead on evaluating the reliability of SDI. Furthermore CSFs will identify the threats and the hazards of SDIs lifecycle so quick thereby can take place. CSF helps to measure and to understand the productivity of people.

This study looks into how measurements can be determined to measure effectiveness and efficiency of CFSs (Rajabifard, 2008; Crompvoets and Grus, 2009; Grus, *et. al*., 2008; Eelderink, 2006; Onsrud, 1998). Other scholars have stressed the importance of having evaluation framework in place so the real progress, effectiveness and efficiency can be measured. Therefore, this study will develop a CSFs model. This model is considered as primary and can be used by different SDIs. The CSFs model is generated from different literature using the CSFs concept and approach (Noah, *et. al*., 2001; Crompvoets and Grus, 2009). The model will be applied to AD-SDI in order to find the CSFs that affect the AD-SDI implementations negatively and positively. Then it will be enhanced and quick wins can be achieved to improve the effectiveness of AD-SDI implementations.

1.4 Research Approach

In this study, CSF model was developed using the case study and the survey method which are considered as qualitative and quantitative methods respectively. Therefore using mixed methods allows the research to be carried out more robust and provide better results. The full description of this research approach will be discussed in detail in Chapter 4.

1.5 Structure of Thesis

This thesis is structured and organized in a way that will guide the reader from the basic problems and concepts up to the comprehensive understanding of CSF model for SDI implementations.

Chapter One

Chapter one deals with the introductory information about the problem and the significance of the studying CSF factors with regard to effective implementations

of SDIs. This chapter also illustrates the aim, objectives, scope, methodology and structure and organization of the thesis.

Chapter Two

This chapter reviews the literature related to spatial data infrastructure in terms of factors that contribute to the successful implementation of SDI and SDI in the context of United Arab Emirates (UAE) and Abu Dhabi.

Chapter Three

This chapter discusses about the creation of the CSF primary model based on the literature review and developing the criteria for design and data entry for the primary CSF model. The chapter begins with introduction then a review of the current evaluation approaches with their methodology. The CSF primary model creation is discussed in this chapter. Identification of the CSFs and their priorities are reflected in the primary CSF table.

Chapter Four

This chapter discusses about research methodology and design and the best method to develop and evaluate the primary CSF model using the mixed method between case study and survey.

Chapter Five

Chapter five encompasses the discussions case study. All case study were arranged structured to give similar information approach in the end of the chapter the primary model were developed.

Chapter Six

This chapter discusses about the final results from the AD-SDI survey. The survey was analyzed and full description and statistics were given.

Chapter Seven

The final AD–SDI model were created and integrated with the CSF primary model. The final AD–SDI model were plotted in a table were the impact of the case study CSFs factors are measured and tested against the survey results.

Chapter Eight

The final chapter involves conclusions of the research and the final recommendations for further study. This chapter also concludes the findings of this study.

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