

IMPLEMENTATION FACTORS FOR SUCCESSFUL SPATIAL DATA INFRASTRUCTURES IN A SMALL, CENTRALISED NATION STATE

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1. Introduction

The main concept behind any consideration of implementing a Spatial Data Infrastructure (SDI) appears to focus on the creation of a network connecting the databases of geospatial data users and providers, allowing them to share and exchange data under approved standards and data exchange policies at national level (Rajabifard et al., 2001). Further, McLaughlin and Nichols (1994) suggest that "unless the spatial databases exist and unless the policies and standards are in place to facilitate the access and use of spatial data on a national scale, the opportunities will be lost" (p. 63). But SDI is more than an efficient integrated/networked geographic information database; its importance comes from the fact that it can play a major role in supporting governmental (and also non-governmental) strategies and projects. Thus, in addition to the important pre-requisite components of SDI - a commonly presented triumvirate of data, technology and policy - it is vital that any SDI implementation addresses the applications of SDI and its user communities across the whole field of human activity.

SDI can support a range of organisations in their day-to-day management, decision making, and planning, in addition to influencing positively the services provided by both the public and the private sectors (McLaughlin and Nichols, 1994). The awareness of the importance of implementing SDI at the national level has been heightened, therefore, in the past two decades amongst the public and private sectors, and also amongst citizens. Such awareness has reached every national government, and a large number of individuals interested in geospatial data handling. The study described in this paper addresses the possible implementation of a national SDI (NSDI) within the Kingdom of Bahrain, a small nation state in the Gulf region, considers the role of geospatial data providers, and determines the readiness of the governmental structures to embrace such a system.

The purposes of the study described here are to:

- study and assess generic success factors for NSDI implementation in the governmental and non- governmental organisations that possess or use geospatial data;

- identify the local conditions in Bahrain enabling or mitigating against the implementation of a NSDI;
- assess each relevant organisation's existing level and requirements of resources, data, technology, and infrastructure influencing the implementation of the NSDI;
- identify the requirements for policies and standards in any proposed Bahrain Spatial Data Infrastructure (BSDI);
- determine the initiatives and strategies that are needed to improve the local conditions if NSDI is to be implemented in the Kingdom of Bahrain.

2. Success factors for NSDI implementation

A significant number of studies around the world have been undertaken to examine the potential for NSDI implementation, the actual execution of such an initiative, and the resultant applications of a successful system. Such studies have grown in importance as the implementations have become more broad-ranging in thematic scope, wider-covering in geographical area, and more expensive in financial terms. The results of such studies have revealed a range of possible issues to be considered by the Bahraini authorities considering NSDI implementation. Each SDI initiative can be examined to assess the important features specific to that organisational implementation, the main components common to other SDI implementations, the success factors which have led to adoption of SDI, and those obstructions recognised as hindering implementation. Examples of these are given in *Table 1*.

A total of 29 features / success factors / obstructions have been drawn primarily from the case studies reviewed, but also from general SDI definitions, and components presented in the literature. Not only do the individual components influence the creation of a NSDI, but also each other. A compilation and combination of the issues has led to 11 key factors selected for the purpose of assessing the local conditions in relation to SDI implementation at national level in the Kingdom of Bahrain. These 11 factors have been chosen due to the frequency with which each is mentioned in different case studies; its particular relevance to local conditions in Bahrain; the relative importance of the case study itself in terms of its achievements, richness, and lessons provided; and the perceived contribution of each factor to answering the question 'is Bahrain ready for a NSDI implementation?'

The 11 factors have been further categorised into three types: **Resources**, which consist of organisational characteristics, human resources, financial resources, and training; **Policies**, which particularly address cost recovery, data ownership, and awareness; and **Data and Infrastructure**, which consist of network infrastructure, data exchange, data updates, data availability and quality.

3. Setting the scene for Bahrain's NSDI

As the core component of a NSDI is geospatial data, it is essential to determine the range and nature of geospatial data supply, demand and management within the nation state before NSDI can proceed. In Bahrain, the organisations listed in *Table 2* were

identified as the complete current range of national and local geospatial providers and users, and were therefore included in a questionnaire and interview survey. A total of 55 questionnaires were distributed, of which 50 were returned. Representatives of each organisation, from under-secretaries of state through directors to technical staff, were given the opportunity to respond to a series of questions about NSDI implementation and operation. The questionnaire included both technical and political questions; the expectation was that directors (48% of the respondents) would have expertise to answer both types of question. The responsibilities, educational and skill background, years of experience, and decision-making abilities were carefully ascertained from the questionnaire, with the majority of respondents in positions of authority and influence.

The attitude of those respondents with key decision-making powers (40 in total) to the principles of data sharing was assessed, along with their usage of geospatial data. The vast majority, across governmental, commercial and educational sectors, were convinced that NSDI initiatives were essential to pursue, notwithstanding the additional requirement for co-operative work and data sharing. There was a positive link between the desire to exchange data, and the number of tasks in the organisation requiring geospatial data. The need for data from the Survey and Land Registration Bureau (SLRB) was particularly dominant, because this is the source of cadastral and topographic maps, although some of these are in paper form (notably at smaller scales). A further issue is the variability in format and intelligence of the data: although the majority of SLRB data is digital, only 10% has any vector intelligence, whilst the Batelco data is almost all 'GIS-ready' (although supplied in Geomedia format – from software not used by any of the other organisations listed).

Further interesting results from the questionnaire survey concerned the workforce and their daily tasks. There was significant variation between those organisations which were regular users of geographic information (they tended to have computer literate staff, they held their own geospatial datasets, with a higher proportion of digital geospatial data, they update their datasets more regularly, they are larger organisations) and those which did not use geographic information regularly. The importance of training varied significantly across the organisations, as did the level of financial commitment to GISystems. Organisations did co-operate to assist each other – 70% were engaged in data exchange, for example, although again this masked variability, as government agencies were much more likely to exchange data than private firms or educational institutions. Updating was often 'outsourced' also. Some important aspects, such as the development of metadata, were neglected more often than they were considered, whilst other aspects, such as security, were treated very seriously.

The questionnaire responses were analysed both quantitatively and qualitatively, and interpretations of the results were collated to determine the current state of the 11 factors. These were further supplemented by semi-structured interview sessions which targeted important decision-makers and managers.

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| (1) General Directorate of IT (Central Informatics Organisation) [Cabinet Government] | (26) Central Planning Unit (Ministry of Works and Housing) [Government Ministry] |
| (2) General Directorate of Statistics and CPR (Central Informatics Organisation) [Cabinet Government] | (27) Topographic Survey Directorate (Survey and Land Registration Bureau) [Ministry of Cabinet Affairs] |
| (3) GIS Directorate (Central Informatics Organisation) [Cabinet Government] | (28) Department of Strategic, Political and Public Opinion Survey (Bahrain Center of Studies and Research) [private research company] |
| (4) Directorate of Development and Research (Ministry of Municipalities and Agricultural Affairs) [Government Ministry] | (29) Department of Publication and Data warehouse (Bahrain Center of Studies and Research) [private research company] |
| (5) Directorate of Planning (Ministry of Interior) [Government Ministry] | (30) Information Technology Department (Ministry of Defence) [Government Ministry] |
| (6) Directorate of Planning and Information (Southern Governorate) [Regional Government] | (31) Department of Operations and Training (Bahrain National Guard) [Government Ministry] |
| (7) Directorate of Sewerage and Drainage (Ministry of Works and Housing) [Government Ministry] | (32) Bahrain Internet Exchange (Ministry of Transportation) [Government Ministry] |
| (8) Directorate of Roads Design and Planning (Ministry of Works and Housing) [Government Ministry] | (33) Center for Transportation and Road Studies (University of Bahrain) [educational center] |
| (9) - (13) Directorates of Services and Development Program (Capital, Central, Muharraq, Northern and Southern Governorates) [Regional Government] | (34) College of Social Sciences (University of Bahrain) [educational center] |
| (14) Cadastral Directorate (Survey and Land Registration Bureau) [Ministry of Cabinet Affairs] | (35) Desert and Arid Land Studies (Arabian Gulf University) [educational center] |
| (15) - (19) Directorates of Technical Services (Capital, Central, Muharraq, Northern and Southern Municipalities) [Local Government] | (36) Department of Access Network Resources (Bahrain Telecommunications Company) [commercial] |
| (20) Housing Projects Directorate (Ministry of Works and Housing) [Government Ministry] | (37) Department of Access Network Planning (Bahrain Telecommunications Company) [commercial] |
| (21) Information Systems Directorate (Electricity and Water Authority) [Government Ministry] | (38) Department of Petroleum Engineering (Bahrain Petroleum Company) [semi-government] |
| (22) Information Systems Directorate (Ministry of Municipalities and Agricultural Affairs) [Government Ministry] | (39) Operations Department (Bahrain Aviation and Fuelling Company) [commercial] |
| (23) Information Technology Directorate (Ministry of Works and Housing) [Government Ministry] | (40) Al Enma'a House for Real Estate [commercial] |
| (24) Physical Planning Directorate (Ministry of Municipalities and Agricultural Affairs) [Government Ministry] | (41) Andulus Engineering [commercial] |
| (25) Technical Affairs Directorate (Survey and Land Registration Bureau) [Ministry of Cabinet Affairs] | (42) Microcentre [commercial] |

Table 2 Geospatial data handling organisations within Bahrain

Factor Groups	Key Factors	Decision Criteria	Data Source	
			questionnaire questions addressed ...	interview questions addressed ...
Resources (R)	Organisational characteristics (RO)	<ul style="list-style-type: none"> • Support of the decision makers for data sharing • Organisation's geospatial data experience • Geospatial data usage • The needs to exchange data with other organisations 	<ul style="list-style-type: none"> • The support of the decision makers for data sharing • Organisation's nature of business • The departmental tasks performed using geospatial data • The needs to exchange data with other organisations. 	<ul style="list-style-type: none"> • Organisation's geospatial data experience • Support of the decision makers for data sharing • Existing data sharing with other organisations • Organisation's Aims, mission, vision
	Human resources (RH)	<ul style="list-style-type: none"> • Adequate staff associated with the geospatial data and GIS. • Adequate expert staff in the geospatial data field. • Staff trained in GIS software. 	<ul style="list-style-type: none"> • The workforce regarded as computer literate • The number of staff members associated with GIS or geospatial data • The years of GIS experience of organisations. • The geospatial data areas of expertise • The number of professionals trained in GIS software 	<ul style="list-style-type: none"> • GIS and geospatial data recruitment needs • GIS and geospatial data staff qualifications, skills, experience • Status of employment of GIS and geospatial data staff
	Financial resources (RF)	<ul style="list-style-type: none"> • Geospatial data activities funding • Financial support for data sharing • The existing financial resources 	<ul style="list-style-type: none"> • The total budget allocated for geospatial data and GIS • The financial support for geospatial data sharing • The financial resources 	<ul style="list-style-type: none"> • Geospatial data and GIS activities budget • Available financial resources
	Training (RT)	<ul style="list-style-type: none"> • Priorities for GIS training • Existing training programmes 	<ul style="list-style-type: none"> • The priority for GIS training 	<ul style="list-style-type: none"> • Existing training programmes • GIS training budget
Policy (P)	Cost recovery (PC)	<ul style="list-style-type: none"> • Cost of the geospatial data creation, maintenance, and updates • Impact of the geospatial data sharing on the cost of data maintenance 		<ul style="list-style-type: none"> • Cost of the geospatial data creation and updates • Impact of the geospatial data sharing on cost of data maintenance
	Data ownership (PD)	<ul style="list-style-type: none"> • The existing data ownership policy 		<ul style="list-style-type: none"> • Ownership of geospatial data • Existing of data ownership agreements

		<ul style="list-style-type: none"> Existing of data ownership agreements 		
	Awareness (PA)	<ul style="list-style-type: none"> The existing level of NSDI awareness Existing and future NSDI awareness programmes 		<ul style="list-style-type: none"> NSDI awareness Existing and future NSDI awareness programmes
Data and Infrastructure (D)	Data exchange (DE)	<ul style="list-style-type: none"> The geospatial data exchange with the other organisations The method of geospatial data exchange with other organisations 	<ul style="list-style-type: none"> The exchange of data with other organisations The geospatial data exchange with the governmental organisations, the private sector, and the educational institutions. The method of geospatial data exchange with other organisations 	
	Data updates (DU)	<ul style="list-style-type: none"> The frequency of geospatial data updates The place of geospatial data updates 	<ul style="list-style-type: none"> The frequency of update of geospatial data The place of update of geospatial data 	
	Data Availability and quality (DA)	<ul style="list-style-type: none"> Geospatial Data format Intelligence of geospatial data Geospatial data quality checks Metadata availability Data availability 	<ul style="list-style-type: none"> The geospatial data in digital format The intelligence of geospatial data The quality check of geospatial data The metadata of the geospatial data Possessing of geospatial data The organisation's relationship with geospatial data 	
	Network infrastructure (DN)	<ul style="list-style-type: none"> Organisation's network type Security setup and measures Number of PCs engaged in GIS work 	<ul style="list-style-type: none"> The organisation's network type The security measures of the organisation The number of PCs engaged in GIS work 	

Table 3 Questionnaire and interview survey: addressing the 11 factors

Main Factors	Readiness requirements	Final Findings
It has supportive organisational characteristics, human resources, and financial resources	The Kingdom of Bahrain has supportive organisational characteristics to implement SDI at national level if it has support from the decision makers for geospatial data sharing, uses geospatial data for the departmental tasks, and needs to exchange data with other organisations.	Supportive
	The Kingdom of Bahrain has supportive human resources to implement SDI at national level if it has adequate staff associated with the geospatial data and GIS, adequate expert staff in the geospatial data field, and staff trained in GIS software	Not supportive
	The Kingdom of Bahrain has supportive financial resources to implement SDI at national level if it has funding for geospatial data activities and the related projects, and has financial support for geospatial data sharing.	Supportive
It has an appropriate level of data updates, data availability and quality, and network infrastructure	The Kingdom of Bahrain has an appropriate level of data updates to implement SDI at national level if the geospatial data are updated frequently and satisfy the end user needs.	Appropriate
	The Kingdom of Bahrain has an appropriate level of data availability and quality to implement SDI at national level if the geospatial data are available in intelligent format, of suitable quality, and associated with metadata.	Not Appropriate
	The Kingdom of Bahrain has an appropriate level of network infrastructure to implement SDI at national level if it has a data network at national level, a security setup and an adequate number of PCs engaged in geospatial data and GIS work.	Appropriate
It has any level of training, awareness, and data exchange	The Kingdom of Bahrain has an appropriate level of training to implement SDI at national level if the organisations set priority for GIS and geospatial data training and has supportive existing training programmes.	Satisfactory
	The Kingdom of Bahrain has an appropriate level of awareness to implement SDI at national level if the decision makers and the staff in the organisations are aware of the NSDI concept and its benefits.	Not Appropriate
	The Kingdom of Bahrain has an appropriate level of data exchange to implement SDI at national level if there is an exchange of geospatial data among the organisations.	Appropriate

Table 4 Results of the Bahrain 'readiness model'

A 'readiness model' based on the results of assessing the relative importance of the 11 key factors was created to determine if and when Bahrain was ready to proceed with a NSDI initiative. The model relies on positive responses to the following circumstances:

1. Bahrain has supportive organisational characteristics, human resources, and financial resources.
 2. The geospatial data managers can offer an appropriate level of data updates, data availability and quality, and network infrastructure.
 3. There exists within Bahrain any level of training, awareness, and data exchange.
- These targets were further defined indicating exactly how such circumstances become positive, as shown in *Table 4*. The results of the questionnaire and interview survey, along with personal interpretation of the geospatial data handling community in Bahrain has revealed that there are positive responses which can be made to some of the circumstances, but negative responses to others.

Based on the readiness model, although Bahrain has supportive factors such as the organisational characteristics, financial resources, data updates, data networks, and existing data exchange, there are other factors that are not supporting NSDI implementation, such as the human resources, data quality and format, awareness, and training. Based on the study findings, the readiness model shows it is clear that the Kingdom of Bahrain is not ready to implement NSDI; but that it is not far from being ready and this can be achieved by strengthening the unsupportive factors, mainly the data format and quality, and the existing human resources.

In order to undertake and implement NSDI in the Kingdom of Bahrain, the government of Bahrain has to capitalize on the supportive factors and make the effort to improve those weak ones to bring them to the appropriate level. The following conclusions are presented:

- The existing hard copy data need to be converted to digital data, and the digital data need to be converted to intelligent data to meet the NSDI global standards.
- There is much concern regarding the data quality and metadata. Creating metadata and applying quality control procedures are essential for a successful NSDI implementation in Bahrain.
- The existing Government Data Network infrastructure can support NSDI implementation, considering the high speed of the network in addition to the available security level.
- A strategic awareness plan is essential, as the majority of the organisations in the geospatial data field are not aware of the NSDI concept and its benefits. An increase in awareness will encourage top management to support the NSDI implementation.
- In addition to NSDI components such as the standards and policy, the success of the NSDI implementation requires a champion to lead it.
- There is a need for a data exchange policy at national level covering important NSDI-related issues such as cost recovery, data ownership, and liability, taking into account the opinions of both the geospatial data providers and users from different industries including the governmental organisations, the private sector, educational institutions, and the citizen.

- Qualified human resources with appropriate skills and experience are essential for the success of any NSDI implementation. The existing human resources in Bahrain are not supportive, and there is a need for a strategic plan at national level to qualify the human resources in the concerned organisations in terms of their NSDI knowledge, skills, and training to meet the global NSDI implementation requirements and standards.
- The study points out that the existing organisational characteristics are supportive for NSDI implementation, mainly the existing support from the decision makers for data sharing and the existing exchange among the concerned organisations.

A series of further recommendations has been made based on the outcomes of the questionnaire and interview survey: it is expected that the government of the Kingdom of Bahrain will take these into consideration when new policy is introduced to assist in the management of geospatial data across the country.

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