



Master Thesis

submitted within the UNIGIS MSc. programme
at the Department of Geoinformatics - Z_GIS
University of Salzburg, Austria
under the provisions of UNIGIS India framework

Designing Local Spatial Data Infrastructure Framework for Municipalities

A Case Study of Northern Borders Municipality, Kingdom of Saudi Arabia

by

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A thesis submitted in partial fulfilment of the requirements of
the degree of
Master of Science (Geographical Information Science & Systems) – MSc (GISc)

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Arar, KSA March 2019

Science Pledge

By my signature below, I certify that my project report is entirely the result of my own work. I have cited all sources of information and data I have used in my project report and indicated their origin.

Arar, Saudi Arabia, 22 March 2019



Place and Date

Signature

Acknowledgements:

At the outset, I thank Allah for his kindness and blessings, And I would like to send my deep thanks and gratitude to the immaculate soul of my father who made his life for my refinement, education and personal development, A greeting of longing, thanks and pride for you, Dad.

I am grateful to my supervisor, Dr. Shahnawaz, for his guidance, flexibility and support me, I have benefited greatly from his experiences throughout my long study journey, with all the meanings of sincerity and gratitude I would like to say thank you Dr. Shahnawaz. Also, I would like to say thanks to all the instructors throughout the study period. Finally, I would like to say thanks to my family, thanks to my wife for her patience and emotional and intellectual support.

Mohamed Ali,

Abstract:

The local government and the municipal sector in particular produce and use a vast amount of spatial information, So improving the geographic information systems (GIS) practices in local government is critical in providing efficient government services, decision support and promoting sustainable development. More than ever, the local government urgently need Spatial Data Infrastructure (SDI) to share and exchange data, internal operation, eliminate duplication of data and access data from multiple sources under the standardization umbrella, Which will reflect positively on the national economy and growth of investment and business. Assessing the current status of GIS practices is the first step required to develop improvement plans and design the framework for implementation of local SDI, Any action outside this framework will be a loss of the accumulated investment in previous projects in GIS.

This research focused on the assessment of GIS practices in the municipalities as a first step to move to spatial data infrastructure (SDI) in local government (The Northern Borders Municipality-NBM in Saudi Arabia) as a case study. The approach of case studies and surveys were used, Data were collected through interviews, questionnaires, and observations. The research was based on several data analysis tools such as GIS Capability Maturity Model (GISCMM), GAP Analysis and SWOT Analysis.

The findings of the GIS Capability Maturity Model (GISCMM) assessment of NBM indicate that a moderate status with average 0.52 (In progress but with only partial resources available) for the components of GIS Enabling Capability (EC) assessment. But the assessment of the components of Execution Ability (EA), the ratings were generally low, It is one of the most important weaknesses revealed by findings of GISCMM in NBM GIS unit. Where components were rated at a low level (Level One: Ad-hoc processes and Level Two: Repeatable processes) included 16 components which represent about 74% of the total EA assessment components. According to the municipal data catalogue gap analysis, the results indicate that 22 features from 78 features (total fundamental datasets) representing 28% of the total fundamental data are missing data. In addition, there is a loss

of attribute data as well as a lot of metadata missing which are necessary for the implementation of municipal SDI, Where the percentage of missing metadata is 60% of the total fundamental datasets. According to GIS SWOT Analysis and analysis of the findings of questionnaires and interviews indicate that there is a big problem that the municipal GIS is unplanned, where the GIS practices in the NBM lack a strategic plan and a objectives business plan with a time plan. This problem is related to the problem of the absence of a specific organizational structure for the GIS unit and the lack of professional GIS staff, The municipality has also not developed a sustainable training plan to raise the professional level of the GIS team or the users training plan. In contrast, the municipality had strengths in IT infrastructure, spatial data and software availability. Also, the findings indicate that government agencies, in general, are not ready to be integrated into the local government with the municipality. The integration may be gradually agency-by-agency, despite the modest evaluations of some GIS components of NBM it is the most powerful government agency in the Northern Borders Region in terms of GIS practices in spatial data, IT infrastructure, financial and human resources, and previous experiences.

The research presented its recommendations regarding future studies and practices as follows:

- The GIS Capability Maturity Model (GISCMM) should be a component of GIS practices in municipalities and government agencies.
- The results of the GIS's practices assessment, strengths and weaknesses should be taken into account in the development of the municipal geospatial strategic plan.
- The research recommended that develop programs within a strategic plan to raise awareness of the benefits of using spatial information.
- Improving this research more and applying it to other municipalities and government agencies.
- Recommend further researches to address more individually detailed topics: Role of geospatial strategic plans in achieving development, Operational framework of local SDI and Metadata role in local/municipal SDI.

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List of Acronyms

CAD	Computer-Aided Design
CMM	Capability Maturity Model
EC	Enabling Capability
EA	Execution Ability
FGDC	Federal Geographic Data Committee
GIS	Geographic information systems
GISCOM	GIS Capability Maturity Model
GMI	USRIA's GIS Management Institute
INSPIRE	Infrastructure for Spatial Information in the European Community
IT	Information Technology
MOMRA	Ministry of Municipal and Rural Affairs
NBM	Northern Borders Municipality
NSDI	National Spatial Data Infrastructure
ROI	Return on Investment
SDI	Spatial Data Infrastructure
SWOT	Strengths-Opportunities-Weaknesses-Threats
USRIA	Urban and Regional Information Systems Association

Chapter-1: Introduction

1.1. Background

We are living in an age of tremendous information, with the pace of innovation and creativity accelerating. Local governments must quickly integrate into this age and take advantage of the vast amount of information to solve their problems. They must adopt new ideas and plans with a comprehensive vision that enables them to deliver high-quality government services. This will only happen by assessing previous experiences internally and externally, taking advantage of the pros, addressing the negatives and developing a plan for future steps and objectives.

Using of geographic information systems (GIS) is a critical factor in the efficient delivery of government services, as comprehensive and updated spatial information will increase the efficiency of urban land administration, natural resource management, transportation facilities, utility services, risk management, and statistical information to support decision making. To achieve this, GIS must be transformed from the separate projects and isolated data silos into a spatial data infrastructure (SDI) that allows for interoperability and exchange of information among all government agencies. According to the Federal Geographic Data Committee, Spatial data infrastructures (SDIs) consisting of policies, standards, and procedures aim to provide an environment that encourages co-operation in data production and sharing (FGDC 2000; Rajabifard, Williamson et al. 2000). The improvement of GIS practices in local government and the transition to SDI will maximize the use of spatial information and increase the use of GIS and also increase the users base, As Majeed (2018) points that the government with SDI enabling would identify opportunities for innovative uses of geospatial information technologies in local, state and federal levels (Majeed 2018).

1.2. Literature Review

In the underlying literature review, Several studies and previous research have examined the assessment of GIS in local governments to identify strengths, weaknesses and develop a strategic plan for improvement of GIS and local SDI.

Majeed (2018) published a scientific paper aimed to demonstrate that by developing and implementing SDI the use of GIS in government agencies at local, state and federal levels can be improved and extended, the paper examined GIS in Malaysia. McDougall et al. (2002) investigated some of the technical and institutional impediments that must be addressed within Australian local and state jurisdictions in order to realize SDI benefits. Salvemini (2004) presented his vision for designing a path for the local government to move from GIS to SDI. O'Flaherty et al. (2005) Presented a study which focused on the deployment of Geographical Information Systems (GIS) and Spatial Data Infrastructures (SDI) within local government in Thai Provinces. Vries (2006) took a closer look at why the processes of information production, dissemination and exchange are not sufficiently effective at the local level. Leong et al. (2008) identified the important factors which determine the success and failure of GIS implementation through the analysis of case studies in Asia And analyze the local situation of current GIS usage in Luang Prabang of Lao PDR. Smit et al. (2009) presented at what appears to be an alternative SDI development paradigm. The focus is on the vertical institutional relationships that exist between the Provincial government and Local Authorities within the Western Cape province of South Africa. the research aimed to evaluate whether a hierarchical top-down approach truly exists or whether SDI in the province is more a result of a bricolage of bottom-up activity. Hickel and Blankenbach (2012) discussed the solution for a cost-efficient local Spatial Data Infrastructure (local SDI) with the aim of capacity building and technical development of SDI components in municipalities in the south of Hesse, Germany. Saputra (2011) conducted a study on a model of spatial data infrastructure for the local government level and its implementation to support e-government applications based on GIS. using the

case study area of Depok City Government in Indonesia. [McDougall, et al. \(2009\)](#) published an article on exploring local government SDI within Australia to assess its capacity to contribute to higher level SDI initiatives. And a comprehensive survey of over 100 local government authorities was undertaken to assess their SDI capacity and collaborative initiatives. Using a single case study of a local government in Bekasi in Indonesia. [Ramadhan et al. \(2011\)](#) Presented a study to assesses the implementation of GIS in the e-Government system provided by ninety-one institutions in Indonesia. [Jomar \(2018\)](#) presented a study to determine the Geographic Information System (GIS) capabilities of the Local Government Units In the seventeen LGUs of the Province of La Union that utilises a GIS in the Philippines, [Alrwais et al. \(2015\)](#) Presented a maturity model for evaluating local government usage of GIS, The study applied widely tested on Southern California local governments through an online questionnaire. [Kurwakumire \(2014\)](#) presented a public sector GIS evaluation methodology, In order to determine whether GIS systems are meeting their intended objectives, In public sector organizations in Uganda. In the Kingdom of Saudi Arabia, [Kubara \(2002\)](#) presented a study which focused on evaluating the use of GIS in Saudi Arabia. A questionnaire was mailed to a total of 80 agencies to evaluate the use of hardware, operating software, application software, data, maps, and personnel. The study recommended that GIS standards and specifications are so urgently needed in order to use available GIS properly ([Kubara 2002](#)).

[Al-Ramadan \(2013\)](#) presented research which about Assessment of GIS Adoption in Saudi Arabia (Obstacles and Challenges), The research discussed the challenges related to the lack of leadership, coordination and lack of spatial data, And recommended increase awareness of GIS and secure human resources in GIS ([Al-Ramadan 2013](#)).

1.3. Motivation

More than ever, the local government urgently need SDI to exchange and sharing data, operate internally, eliminate duplication of data and access data from multiple sources under the standardization umbrella, Which will reflect positively on the national economy

and growth of investment and business. SDI crucial role was confirmed in supporting the economy and promoting business in both private and public sectors all over the world at global, regional, national and local levels (Genovese et al. 2009). A hierarchical move from the bottom up (from Local to National/Global) in investing in spatial information will lead to sustainability and thus to economic benefits, many countries believe they can benefit both economically and environmentally from better management of their spatial information by taking a perspective that starts at a local level and proceeds through state, national and regional levels to a global level (Rajabifard and Williamson 2001).

Local SDI is not so good in most countries of the world except for some developed countries, although Local SDI is the base of the pyramid for operational operations and risk management, Also is the closest hand to updating and maintaining of data, but global attention has been directed to state/national SDI, The result is that in many cases local government does not use the state SDI. Although local government is responsible for controlling or maintaining the integrity of specific land-related data in the state/national SDI (Jacoby, et al. 2002). However, the development of national SDI policy has been less than inclusive of all of the jurisdictional participants with a particularly low level of participation at the local government level (McDougall et al. 2005).

At the level of local government in Saudi Arabia within the vision of the Kingdom 2030, which aims to achieve sustainable urban development and balanced to improve the quality of life, Ministry of Municipal and Rural Affairs (MOMRA) issued a decision to form a guidance committee to study the current situation and the future need for the components of the spatial information infrastructure (SDI) of the municipal sector (Ministry of Municipal and Rural Affairs. MOMRA). The most important responsibilities of the Committee are:

- Supervise the assessment of spatial information databases, standards and policies used, and current technologies and human resources in the municipal sector.
- Study how to minimize data duplication.
- Develop a future vision for the sustainability and balance of urban development and support the development of geo- applications in the municipal sector.

- Studying and evaluating methods of managing, exchanging and publishing spatial information inside and outside the municipal sector.
- Supervising the ability of the participants in urban planning to access the spatial information infrastructure (SDI) of the municipal sector.

At the national level, Saudi Arabia issued decision No. 388 dated 27/10/2010 transforming the Interim Committee for Unifying Standards and General Principles of the requirements of establishing the National Geographic Information System (GIS) into a permanent committee called (National Committee For Geographic Information System). The most important decision objectives were the establishment of the SDI program according to the latest national and global standards and specifications, the preparation of the vision, the objective, the detailed tasks, organizational structure, the human and financial resources of the GIS program, Unifying of GIS standards and technical specifications at the level of Kingdom of Saudi Arabia ([National Committee For Geographic Information System NSDI](#)).

This research will focus on the assessment of geographic information systems (GIS) practices in the municipalities as a first step to move to spatial data infrastructure (SDI) in the local government (The Northern Border Municipality-NBM) as a case study and preliminary survey of GIS capabilities in some government agencies). Assessing the current status and determining the maturity status of GIS in local government is an essential step to develop a roadmap and framework to design and implement the SDI in local government as well as to reap other gains from the assessment findings such as the ability to develop a strategic plan to improve GIS practices based on the current status to reduce the waste of funds, And help decision-makers to prioritize and promote needed GIS projects. Once strengths and weaknesses are identified, Then directing the projects towards needs. SDI's growth and completeness come through successive steps, projects and accumulated efforts in GIS. Local public spatial data management is an engine for the development of SDI ([McDougall et al. 2009](#)).

1.4. Aim And Objectives

❖ Research Aim:

The overall aim of this research is assessing the current status of maturity of geographic information systems (GIS) in the Northern Borders Municipality to identify opportunities for transition to local spatial data infrastructure (SDI) and identify the most important challenges that may hinder the transformation and how to overcome them.

❖ Research Objectives:

The following objectives were identified to achieve the overall aim:

- Assessing the current status of geographic information systems (GIS) in the Northern Borders Municipality in terms of spatial datasets, IT infrastructure, human resources, standards, and policies.
- Verify the readiness of government agencies to implement local SDI or participate as gradually in Municipal SDI.
- Define the characteristics and benefits of municipal spatial data infrastructure (SDI).
- Evaluating the strengths and weaknesses of the current status of GIS in the Northern Borders Municipality.
- Identification of the opportunities and challenges of transition to municipal SDI.
- Providing the recommendations that help overcome challenges and support the transition to the SDI in the Northern Borders Municipality.

1.5. Research Questions

To achieve the research objectives the following research questions have to be answered in this research.

- What is the current status (maturity level) of the Geographic Information System (GIS) in the Northern Borders Municipality?
- What are the characteristics of SDI?
- What are the benefits or motives of the municipal/ local SDI?
- What are the strengths and weaknesses of GIS in the Northern Borders Municipality?
- What are the opportunities for the transition to SDI in the Northern Borders Municipality?
- What are the challenges of moving from GIS to municipal SDI?
- What are the steps or recommendations that boost opportunities for the transition to SDI in the Northern Borders Municipality?

1.6. Organization of Thesis

This research is divided into six chapters and we can report the thesis structure as follows:

Chapter One: Introduction

The first chapter presents background on the topic, including literature review and research motivation, as well as research aim and objectives and research questions.

Chapter Two: Methodology

This chapter clarifies the methodology, methods of data collecting and data analysis tools.

Chapter Three: Assessment of GIS Practices

In this chapter, the performance of the GIS Capability Maturity Model (GISMM) and the findings of the municipal assessment are presented.

Chapter Four: Spatial Data Infrastructure

This chapter covers concepts of Spatial Data Infrastructure (SDI), characteristic of Local / Municipal SDI and the motivations for SDI development in local government.

Chapter Five: The Opportunities of Transition to Local SDI

This chapter including performing of Data Catalogue GAP Analysis and GIS SWOT Analysis, It also discusses the findings and provides practice recommendations.

Chapter Six: Conclusions

This chapter delivers conclusions and recommendations for future practices and researches.

Chapter-2: Methodology

2.1. Methodology:

The method approach which will apply in this study is case studies and surveys. This methodology was chosen because the research addresses a modern issue which actually occurs in real, One from cases can be studied covering aspects of investigation and research. The methods of data collecting are interviews, questionnaires, and observations.

2.2. Data Collecting :

Data will be obtained through interviews, questionnaires, and observations according to the following context:

2.2.1. Interviews

Several interviews will be held and the general focus will be on GIS-SDI in the municipality. Other points such as financial resources, priorities of upper management in spatial data investment, awareness of benefits and uses of spatial data will be discussed by asking questions and listening to the views of participants, Issues and questions will vary by interview group and agency, the target groups for interviews will be:

- Manager of Information Technology department and Specialists and responsible for the GIS unit in the Municipality.
- Departments and branches managers in the municipality.
- Consultants and project managers related to GIS.
- Specialists and responsible for spatial data in some government agencies.

2.2.2. Questionnaires

Four questionnaires will be used and direct questions will be asked during the interviews. One questionnaire will be published on the Internet to obtain the required information. Each questionnaire will be used with a specific role for measurement and data collection. The questionnaires were carefully prepared in terms of selecting, arranging and formulating

the questions to achieve objectivity, avoiding bias and encouraging unreserved response in order to obtain the data required for the study. Three questionnaires were written in Arabic. The fourth questionnaire was the maturity model questionnaire, which was drafted in English, where there was no need to translate it into Arabic because it was addressed to specialists in GIS. The following questionnaires were used:

❖ **GISCOMM Questionnaire**

In this questionnaire, USRIA's GIS Management Institute (GMI) modified Capability Maturity Model (CMM) questions in 2013 will be used ([USRIA](#)), covering all aspects of enabling capability and execution ability of municipal GIS. The questionnaire will be filled during the interview with the IT group, specialists and officials of the GIS unit in the municipality. The questionnaire aims at measuring the maturation of the GIS practices in the municipality. The results of data analysis will reveal the strengths and weaknesses of the GIS in the municipality.

❖ **Municipal Departments/ Branches Questionnaire**

This questionnaire will be aimed at internal department and branches managers of the municipality (case study), which provides services to people and requires spatial data in the implementation of their tasks. The questionnaire will be filled during the interview with this group. The questionnaire aims to obtain data on the type of spatial data they need to carry out their tasks from the municipality GIS unit or from other agencies as well as the spatial data they already have or produce. The questions will also cover many aspects to measure the readiness of the departments for the interoperability of spatial data.

❖ **Government Agencies Questionnaire**

This questionnaire will target the specialists and those responsible for spatial data in some government agencies that provide services to people and require spatial data in the implementation of their tasks (electricity, water, transport, etc.). The questionnaire will be filled during the interview with this group.

The questionnaire aims to obtain information on the type of spatial data they need or already have or produce, as well as to verify whether these agencies have GIS units and how many staff they have, and then ask how these data are combined together in order to spatial data infrastructure integration, Also what about standardized standards, policy development, any office has more qualifications and capabilities to host SDI, how to homogenize spatial data to be interoperable between agencies. It should be noted here that the assessment of the status of GIS in government agencies will not be as comprehensive and profound as in the municipality (case study), But data will be collected to reveals the size of opportunities and challenges for SDI implementation in the municipality for sharing data with other government service agencies.

❖ **SWOT Questionnaire**

This questionnaire will target a wide range of GIS consultants, project managers, staff and departments and branches manager of the municipality, The questionnaire will be published online and sent the link to the target groups via e-mail and social media.

This questionnaire aims at surveying the strengths and weaknesses of the GIS in the Municipality, as well as the available opportunities to build on them to improve GIS practices in the municipality, also the challenges and difficulties in using GIS in the municipality which hinder the interoperability for spatial data.

2.2.3. Observations

Monitoring and measuring the work environment in the municipality, including employee awareness of the use of geographic information systems (GIS), procedures for implementing transactions based on spatial data, Physical verification of municipality GIS assets (IT infrastructure and software), and other observable and measurable events.

2.3. Data Analysis:

A set of data analysis tools will be used, which will provide qualitative and quantitative results. These tools will analyze the data obtained through interviews, questionnaires, and

observations to get the results that achieve the objectives of the study. Data analysis tools that will be used in the study are as follows:

2.3.1. GIS Capability Maturity Model (GISCMM)

The GIS Capability Maturity Model is based on an assessment of both enabling capability and execution ability. Briefly, the enabling capability can be thought of as the technology, data, resources, and related infrastructure, Enabling capability includes GIS management and professional staff. However, the ability (execution capability) of the staff to utilize the enabling technology at its disposal is subject to a separate assessment as part of the model (GMI). The analysis of the results of the GISCMM will be a strong and crucial basis for assessing the current status of GIS in the municipality (case study) and will reveal the opportunities for transformation to SDI, Also will reveal the challenges to improvement and progress in GIS practices in the municipality. Further details will be discussed in the context of chapter three.

2.3.2. Data Catalogue GAP Analysis

GAP analysis will be performed on the ideal fundamental datasets which will be carefully identified according to global data standards, previous best practices and internal needs and the datasets available in the municipality data catalogue.

the results of GAP analysis for data catalogue will reveal the missing data and identify the metadata gap. These results will be important in making recommendations related to improving spatial data and metadata. Further details will be discussed in the context of chapter five.

2.3.3. GIS SWOT Analysis

A SWOT Analysis is a strategic planning method used to evaluate the strengths, weaknesses, opportunities, and threats (challenges) as they relate to a topic. The results of the SWOT analysis will be used to make recommendations in regards to improvement of GIS in the municipality. Further details will be discussed in the context of chapter five.

Chapter-3: Assessment of GIS Practices

3.1. Introduction

GIS have started in the 1960s as a method for resources management in the Canadian government led by Roger Tomlinson who was a pioneer in GIS (Foresman 1998).

Since then, the GIS growth has increased over time, its uses have expanded, Also the users base has expanded around the world.

The Kingdom of Saudi Arabia has adopted the application of geographic information systems (GIS) in many fields at the national and local levels since 1986, Since then, the adoption of GIS has begun in many government agencies and the private sector.

At the national level, the Ministry of Municipal and Rural Affairs (MOMRA) has been the first government agency to adopt GIS since 1988, Its first project aimed at managing land records through MOMRA's GIS projects in municipalities such as Urban and Regional Planning Information System (URPIS) and Cadastral Information System (CIS).

The Ministry of Transport through a project GIS for Bridges Maintenance which started in 1996. and then the Ministry of Water and Electricity through Water and Sewer Directorates of the Ministry which started its projects in Riyadh core area 2003. then the Ministry of Education through GIS Project which started 2003, And then the ministries of interior and General Authority of Tourism & Antiquities projects GIS at the national level (Al-Ramadan 2013).

At the local level, the Arriyadh Development Authority (ADA) has been the first government agency to adopt GIS since 1986 And was able to present the first digital basemap to the public at the local level in 2002 (Digital Base Map of Riyadh, <http://www.arriyadhmap.com/ArriyadhMaps/pro/>). The Royal Commission in Jubail started GIS activities in 1994. Then the GIS projects were launched at the municipal level in 2003 in the municipalities of Riyadh, Dammam, and Makkah. There are also other experiences of GIS adoption at the local level, where The King Faisal Specialist Hospital launched its project (GIS Project to track the spatial pattern of spread of cancer). And the Hasa

Irrigation and Drainage Authority (HIDA) was launched the first phase of building the base map of the agricultural oasis with the help of UN FAO in 2004 (FAO Water Reports 34, 2008).

The private sector has also made good contributions to the use of GIS in Saudi Arabia. The Saudi Electricity Company started company-wide GIS project, The project covered most areas of the Kingdom and the company in the continuous progress in the provision of services based on spatial data. ARAMCO, one of the world's largest oil companies, is implementing the ARAMCO e-Map Project, which began in 2001. Also, the Saudi Telecommunication Company carried out the GIS project to geo-reference mobile towers (Al-Ramadan 2013).

3.1.1. Definition of Geographic Information System (GIS)

The definitions of geographic information systems (GIS) differs somewhat from person to person and from institution to institution depending on the prior understanding or mental visualization for each of them to the GIS, also vary the definitions according to the professional background and fields of specialization in GIS. Definitions also differ over time for several reasons, the most important evolution of the techniques used, the evolution of analysis tools and the extensive application and usage to include new activities and solutions. This is the difficulty in defining the geographic information systems accurately and stricter because it has a dynamic nature according to the evolution of technology and software used and expansion of application domains and user base, But it retains the main components of the system which is people, Data, hardware, software and applications or procedures. Accordingly there us no absolutely agreed upon definition of a GIS (deMers 1997). The following two definitions that are comprehensive and accurate:

a GIS is a system of hardware, software, and procedures to facilitate the management, manipulation, analysis, modeling, representation, and display of georeferenced data to solve complex problems regarding planning and management of resources (NCGIA 1990).

ESRI define GIS as ((A geographic information system (GIS) is a computer-based tool for mapping and analyzing things that exist and events that happen on earth. GIS technology integrates common database operations such as query and statistical analysis with the unique visualization and geographic analysis benefits offered by maps. This is a realistic and unique definition because he mentioned (analysis of events that happen on earth) and not just analyze things. Therefore it was comprehensive and accurate because the forest fires, floods, earthquakes, volcanoes, epidemics, etc., are events that happen on earth related to time and place together not a place only.

3.1.2. GIS Structure And Elements

As we mentioned in the GIS definition, although the definitions vary according to the source and according to time, they retain the main components of the system which is people, Data, hardware, software, applications or procedures (Figure 3.1). A GIS is comprised of five key components:

- **Hardware**

Includes physical components that support data input, storage, processing, output, and presentation. such as computers, network elements, plotters, scanners, etc. It also includes field survey and data collection equipment.

- **Software**

Includes non-physical components of a data collection, processing, and analysis environment, mostly comprising of programs such as operating systems, database software, spatial data software, and geo applications, etc.

- **Data**

GIS deal with different types of data from spatial data and attribute data (descriptive data), including geographical locations, aerial photo, satellite images, statistical data, etc., which are collected and entered through the equipment. And analyzed, displayed and integrated into the decision-making system through software.

- **People**

Represents the GIS system operators, analysts, managers, and GIS users; who are in charge of identifying GIS uses, data needs, analysis needs and feeding data into the system

- **Processes**

GIS Processes Includes the steps and procedures used to manage the system, data entry, analysis, display maps, produce reports and all other related activities.

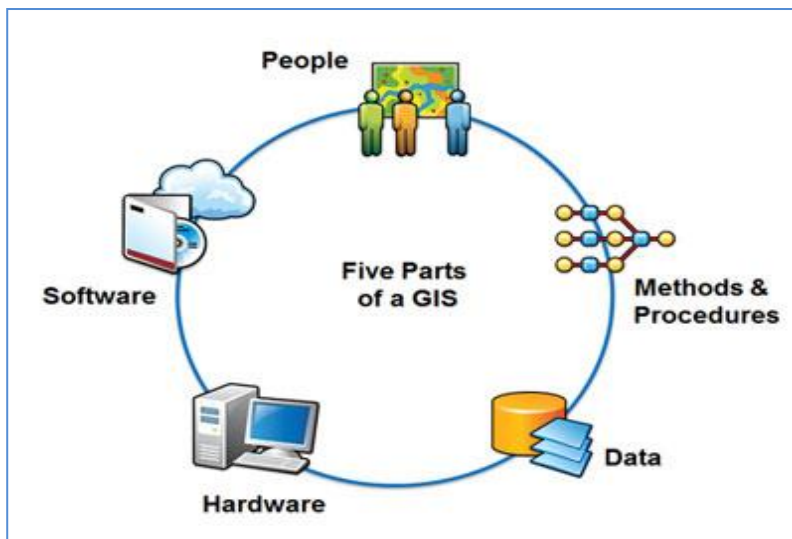


Figure 3.1: Components of geographic information system (GIS). (Source: by ESRI)

3.1.3. GIS Application in Local Government.

Integrated GIS give the local governments a solid foundation on municipal asset management and daily operations management. they can build their own maps which improve performance in many areas such as:

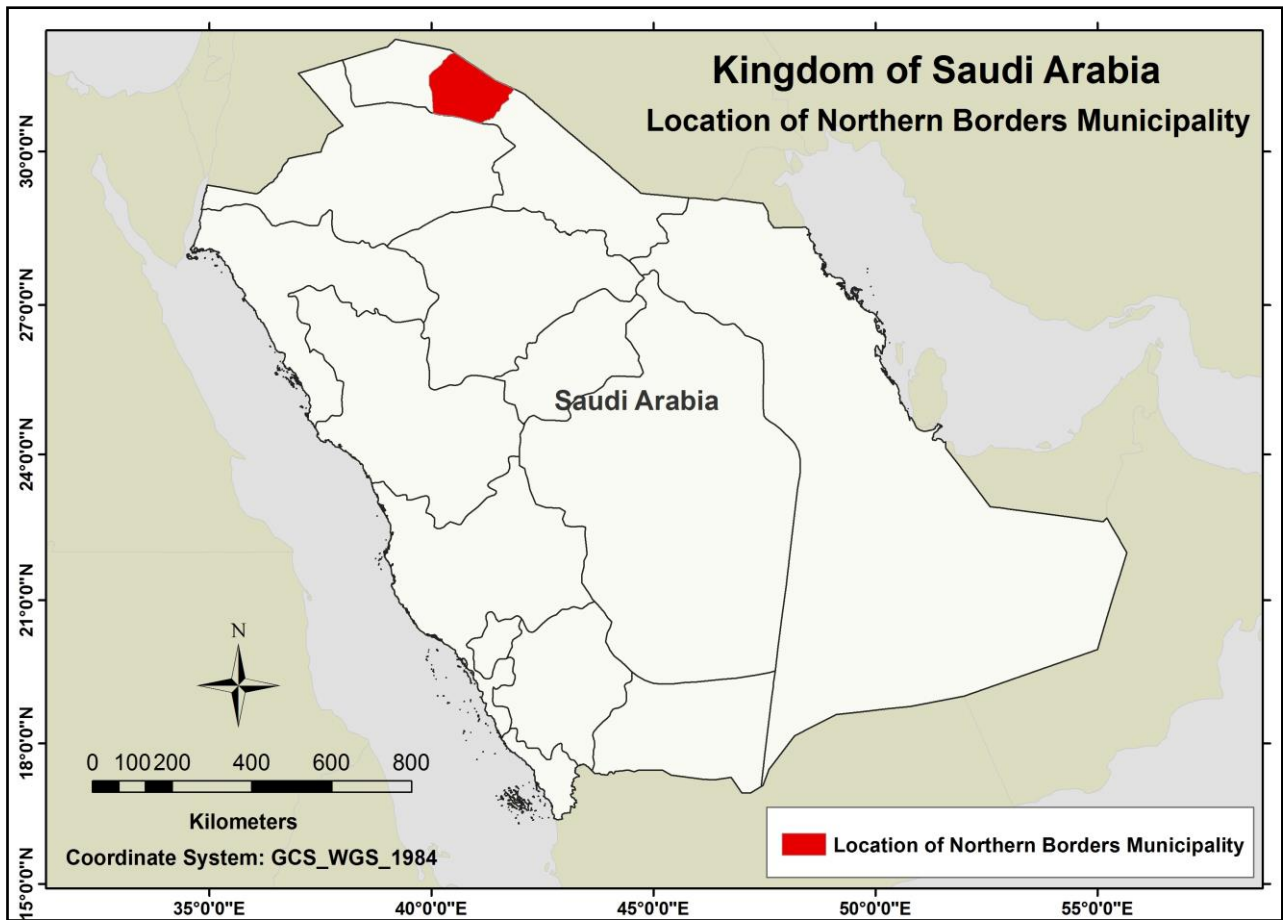
- Land-use planning
- Permit tracking
- Parcel/tax mapping
- public safety
- Road and utility maintenance
- Traffic route planning
- Event (crime, fires, flood, accidents)
- Reporting
- Emergency management
- Cartography
- Infrastructure (assessment and maintenance)
- Demographic data management
- Geological mapping and landslide hazards
- Engineering design
- Public works
- Environment
- Elections
- Green asset management
- Climate change scenarios
- Strategic planning, future development

3.1.4. The Motivation For GIS Assessment

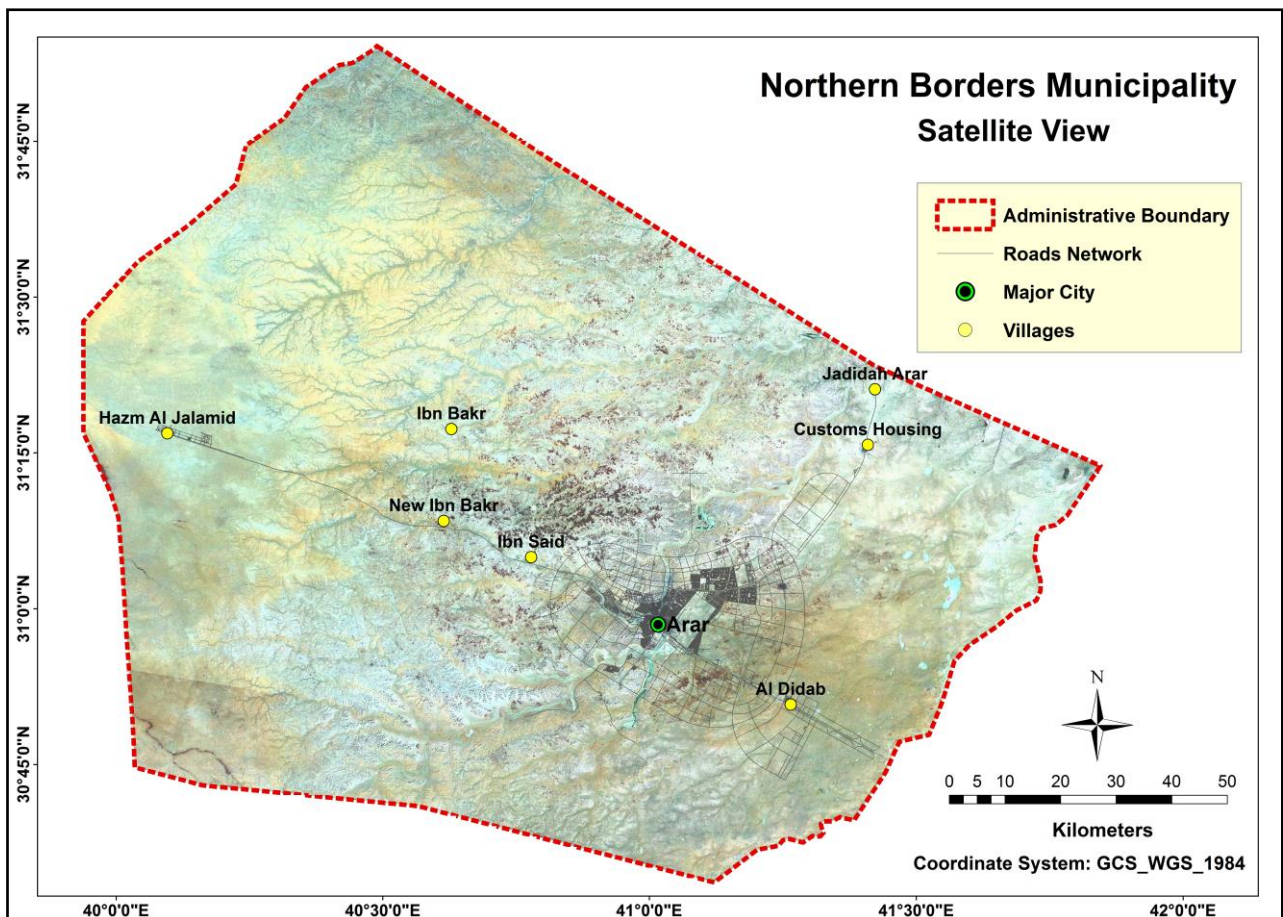
Assessing the current status of GIS is the first step required in developing improvement plans and any action outside this framework will be a loss of the accumulated investment of previous projects in GIS. Without properly understanding current GIS usage practices, improvement is difficult as the 'as is' state is not known. Thus, aiming for a specific GIS value without satisfying certain levels of organizational usage of GIS seems unfeasible ([Alrwais et al. 2015](#)). GIS assessment processes provide definitions and characteristics of the various stages traveled on the way to organizations GIS operation. It assists in benchmarking of the current status of GIS in the organization and provides a road map to the next level. Maintaining the previous investment in spatial information, developing a future investment plan to move to an advanced stage, maximizing the benefits of GIS, achieving sustainability and keeping the pace of advances in spatial data technologies are the main drivers of the GIS assessment process.

3.2. The Northern Borders Municipality As A Case Study.

The northern borders area is located in the far north of Saudi Arabia, with a length of more than 950 km along the Iraqi and Jordanian borders. Its administrative center is the city of Arar - the headquarters of the Emirate of the region - located in the area of the region 1100 km from the capital Riyadh, On the Iraqi border. The discovery of phosphate ore and the development of the King Abdullah Project for the development of the city of Waad al-Shamal in Turaif Governorate for the mining industries have made the region a distinct investment climate that sets it on the threshold of a major renaissance. the Northern Borders Region includes 10 municipalities, Arar city is The administrative capital and the headquarters of the emirate, The Northern Borders Municipality Serve the city of Arar and have some powers and influence over other municipalities. The total area of Arar city is about 16947sq km, which represents 15.3% of the total area of the Northern Borders Region and provides the services to approximately 191,000 residents ([Northern Borders Municipality](#)).



Map 3.1: Location of Northern Borders Municipality in Saudi Arabia



Map 3.2: Satellite View of Northern Borders Municipality

The municipality was established in 1971 and its most activities and responsibilities are:

- Planning and organizing the city, including prioritizing urban development, determining growth trends, controlling land use, and taking advantage of all possibilities and resources for the development of the region.
- Preparation of studies and implementation of infrastructure projects and other recreational projects and services aimed at facilitating the life of citizens.
- Concern about the environment in general and the health of citizens in particular, including the cleaning operations, markets control, regulate the movement of transport, the implementation of gardens and the landscaping of streets and public squares.

The municipality has about 327 employees working in 45 major departments and sections of the most important departments:

- Agency of Reconstruction and Projects
- Department of Urban Planning
- Department of Municipal Investment Development
- Department of Information Technology (IT)
- Department of Land and Property
- Department of municipal permits
- Agency of Services
- Department of Human Resource
- Department of Financial Affairs

These main departments include several sub-sections such as survey, agriculture, environment, GIS unit, etc. According to the organizational structure of the municipality, the GIS unit belongs to the IT department, Figure 3.2 shows the organizational structure of the Municipal IT department ([Northern Borders Municipality](#)).

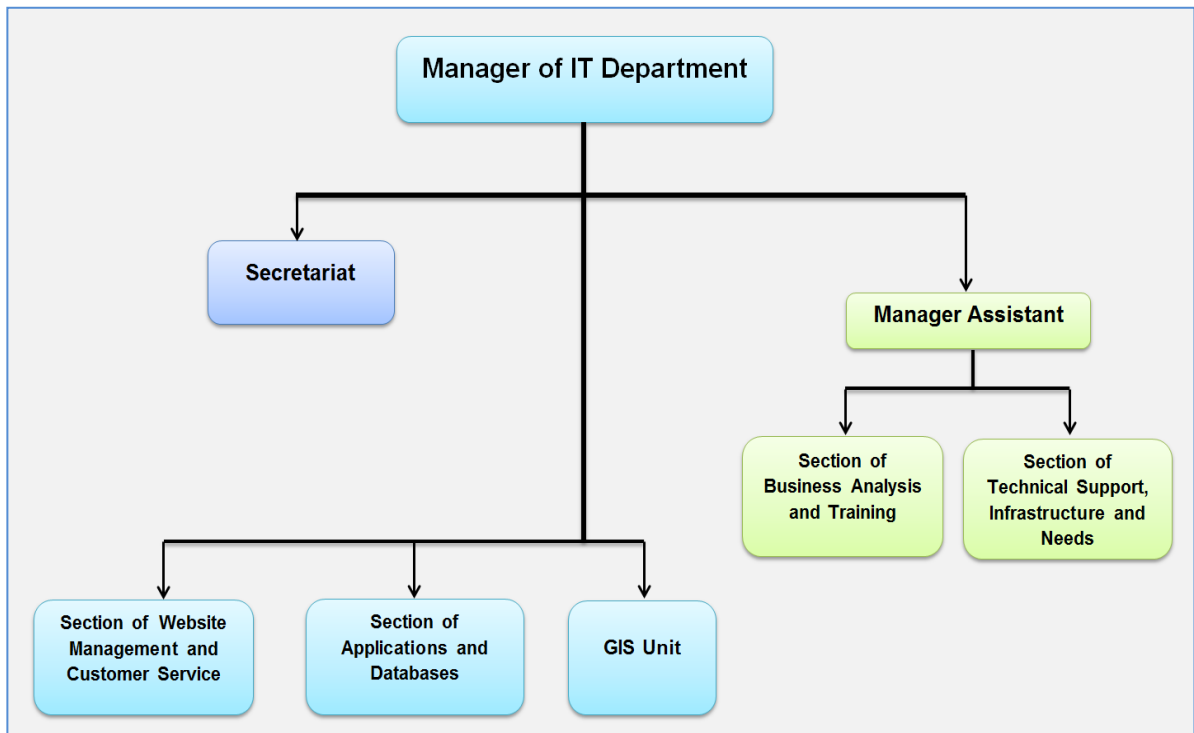


Figure 3.2: The organizational structure of the Municipal IT department.

IT Department was established in 2005, its main responsibilities were to provide technical support for IT infrastructure (hardware, networks, and software), development of municipal operations according to the latest technologies and software, as well as training of employees in the use of modern software.

The GIS unit in the municipality's IT department was established automatically (without organizational structure or strategic plan) with the beginning of the first project in GIS in 2006, A project of establishing a GIS center in the municipality. The aim was to digitize maps and establishment of e-Atlas of Arar city. Then two other projects for operation, maintenance and updating spatial data and supplying equipment and software.

3.3. GIS Assessment in The Northern Borders Municipality (NBM).

3.3.1 GIS Capability Maturity Model (GISCOMM).

A capability maturity model assesses an organization's ability to accomplish defined tasks. The CMM concept originated with the Software Engineering Institute (SEI), which published *Managing the Software Process* in 1989 to assess software contractors' ability to successfully complete large software development projects. The CMM concept has since been applied to system engineering, project management, risk management, and information technology services. A CMM assesses an organization's maturity level based on how it executes individual processes (Babinski 2011).

The GIS Capability Maturity Model is a key component of the URISA's GIS Management Institute (GMI). Its primary purpose is to provide a theoretical model of a capable and mature enterprise GIS operation within a designated organization (URISA).

This model is designed by URISA's GMI to provide a framework for addressing important questions about GIS practices in organizations. What are the characteristics of a capable enterprise GIS? What are the characteristics of a well-managed enterprise GIS?

3.3.1.1. Benefits of GIS Capability Maturity Model (GISCOMM)

It is likely that the return on investment (ROI) will increase as the level of maturity of GIS in the enterprise increases, a GIS CMM can provide an indication of the ability of local agencies to realize the potential benefits from their GIS investments (URISA), Figure 3.3 shows the local government GIS Capability Maturity Model. A GIS CMM allows local GIS operations to gauge their capability and maturity levels against a variety of measures, including:

- A theoretical end state of GIS data, hardware, and software infrastructure
- A theoretical end state of GIS organizational development
- The maturity level of other peer GIS organizations, either individually or collectively
- The maturity level of the subject organization over time

- The maturity level of the organization against an agreed target

According to Babinski (2011), Once the CMM Assessment has been completed, the Municipality will have several benefits:

- Help program managers develop and communicate program accomplishments to upper management.
- Determine where improvements and investments are needed.
- Provide input to program planning.
- Support future budget requests with regard to the investments of GIS in the municipality.
- Reorganization of operations and services as needed.
- Improve communication and collaboration within your GIS team and other departments (Babinski 2011).

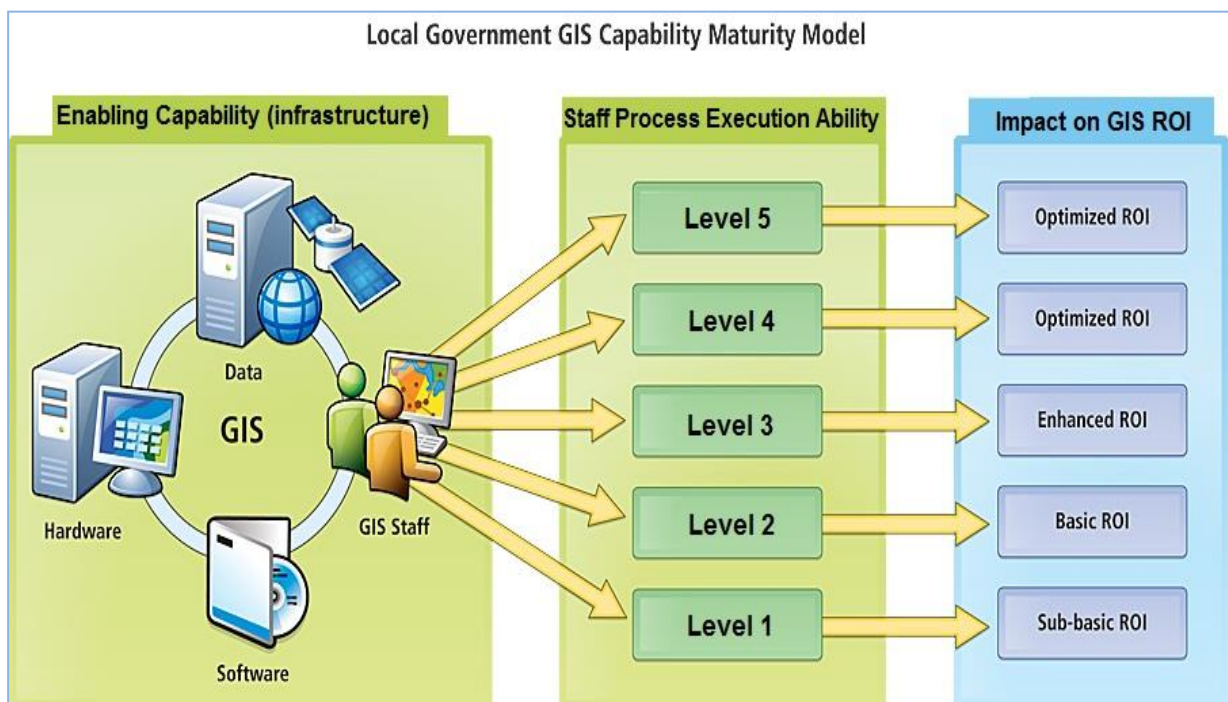


Figure 3.3: The Local Government GIS Capability Maturity Model (Babinski 2011).

3.3.1.2. GISCM Components And Assessment Categories

The GIS Capability Maturity Model (GISCM) assumes that mature agencies have more well developed enabling technology and resources and that their processes and practices maximize the effectiveness of their GIS infrastructure. Enabling capability includes technology components, data, professional GIS staff, an appropriate organizational structure, and other resources and infrastructure. Execution ability is the ability of the staff to maximize the use of the available capability, relative to a normative ideal.

As shown in Figure 3.4, The typical capability maturity model is based on an assessment of the subject organization's maturity level based on the characteristics of the organization's approach to individual defined processes. These processes are usually defined by five levels are Ad hoc (chaotic) processes, Repeatable processes, Defined process, Managed process, and Optimized processes, Table 3.1 shows the five maturity levels are reported according to (GMI).

Table 3.1: The Maturity levels in GIS Capability Maturity Model.

Level	Categories	Description
Level One	Ad hoc (chaotic) process	Typically in reaction to a need to get something done.
Level Two	Repeatable process	Typically based on recalling and repeating how the process was done the last time.
Level Three	Defined process	The process is written down (documented) and serves to guide consistent performance within the organization.
Level Four	Managed process	The documented process is measured when performed and the measurements are compiled for analysis. Changing system conditions are managed by adapting the defined process to meet the conditions.
Level Five	Optimized process	The defined and managed process is improved on an on-going basis by institutionalized process improvement planning and implementation. Optimization may be tied to quantified performance goals.

Because the GIS Maturity Assessment seems focused on the typical coordination function of many state's GIS, it seems unsuitable for municipal, county, and other agency types of GIS. So the GMI chose to adopt a modified form of GIS Maturity Assessment rating system for the Enabling Capability portion of the GIS Capability Maturity Model using seven categories, state GIS organizations assess their development in 56 specific detailed characteristics based on their current implementation of each characteristic. Table 3.2 illustrates the categories used for the Enabling Capability portion of the GIS Capability Maturity Model.

Table 3.2: Assessment categories according to the modified maturity model by GIM.

Score/ Pt	Status
1.00	Fully implemented
0.80	In progress with full resources available to achieve the capability
0.60	In progress but with only partial resources available to achieve the capability
0.40	Planned and with resources available to achieve the capability
0.20	Planned but with no resources available to achieve the capability
0.00	This desired but is not planned
Not Applicable*	Not Applicable

* This is a non-numeric response that requires an explanation of why this component should not be considered in assessing the operation.

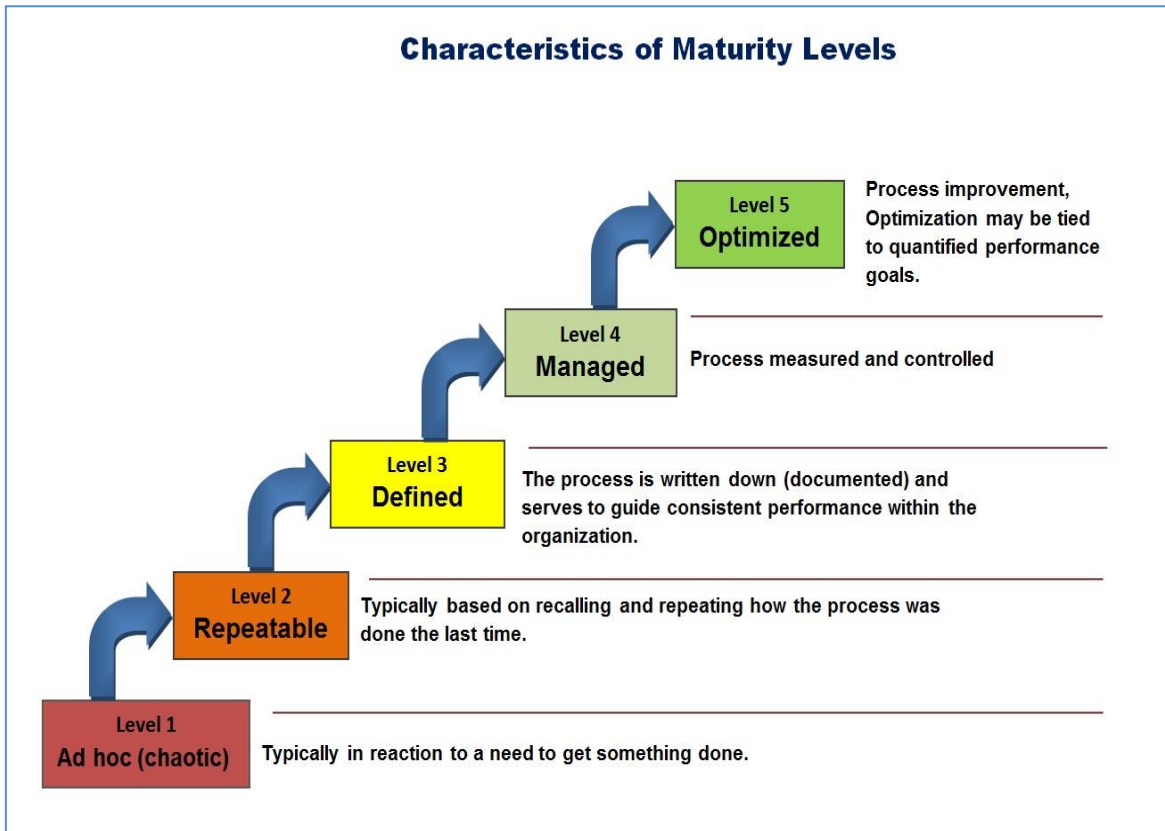


Figure 3.4: Characteristics of Maturity Model

3.3.2. Performing of GIS Capability Maturity Model (GISMM).

3.3.2.1. Questionnaires And Interviews Analysis.

An interview was held with the group of IT manager, specialists and responsible for the GIS unit in the municipality, It included three participants:

- IT Manager
- IT infrastructure manager
- GIS specialist

The main objective of the interview was to fill out the GIS Capability Maturity Model questionnaire, and we addressed many detailed questions regarding the development of municipal GIS and the current challenges. The questionnaire of the GIS maturity model took about 90 minutes. I explained to the interview group the importance of the questionnaire and its results. And this questionnaire is a self-evaluation needs objectivity and accuracy in order to have facts that will be a basis on which to build an effective improvement plan.

In the beginning, I explained the importance of GIS practices assessment in the department and the need to make them a regular annual procedure. The expected results of the GIS assessment will be the basis for the GIS improvement plan. We discussed the important role of spatial information and spatial services for improved the operations performance of the municipality and enhance the quality of services provided by the municipality to citizens and the private sector. The municipality needs comprehensive and reliable spatial data that can be easily exchanged. The discussion then revolves around the need for data standardization and the creation of a spatial data dictionary and that the Ministry of Municipal and Rural Affairs (MOMRA) it should be our reference in this issue.

All departments and municipal branches must use unified spatial information through geo-applications to prevent data conflicts. This issue needs further work in raising awareness for employees and users who produce or manipulate spatial data.

We discussed the IT infrastructure and the manager of IT infrastructure informed me that the infrastructure is generally good and ready to the interoperability of spatial data (SDI) at the level of internal departments and branches, But at the governmental agencies level, more servers and devices will be required. and I have observed as visually the components of IT infrastructure such as devices, printers, intranets, and servers, Also I have verified the spatial software used.

3.3.2.2. Performing of GISCOMM.

In the GISCOMM questionnaire, the questions are categorized by enabling capability and execution ability. For each question, the respondent (GIS Officer) is asked to self-assess their organization, provide comments, and describe documents and other evidence to support the initial self-assessment ([See GISCOMM questionnaire in Appendix A](#)).

Each section of this model focuses on individual components of the GISCOMM assessment. Each section describes the focus of the individual assessment, presents a graphic representation of NBM GIS assessment. The sections also include key analysis. These sections include:

❖ GIS Enabling Capability Assessment

The GIS CMM describes Enabling Capability as the technology, data, resources, and related infrastructure that can be bought, developed, or otherwise acquired to support typical enterprise GIS operations. Enabling capability includes GIS management and professional staff. This section of the survey includes 23 components. For each component of the Enabling Capability Assessment portion of the model, the organization can assess itself in one of the following categories:

EC1: Framework GIS Data

EC2: Framework GIS Data Maintenance

EC3: Business GIS Data

EC4: Business GIS Data Maintenance

EC5: GIS Data Coordination

EC6: Metadata

EC7: Spatial Data Warehouse

EC8: Architectural Design

EC9: Technical Infrastructure

EC10: Replacement Plan

EC11: GIS Software Maintenance

EC12: Data back-up and security

EC13: GIS Application Portfolio

EC14: GIS Application Portfolio Management

EC15: GIS Application Portfolio O&M

EC16: Professional GIS Management

EC17: Professional GIS Operations Staff

EC18: GIS Staff Training and Professional

Development

EC19: GIS Governance Structure

EC20: GIS is Linked to Agency Strategic Goals

EC21: GIS Budget

EC22: GIS Funding

EC23: GIS Financial Plan

❖ GIS Data Resources Assessment

The first four components refer to GIS data and GIS data maintenance (EC1 - EC4). In this section, the scores for EC1 through EC4 are derived from the average scores indicated for each category for each type of data. Details of this section are displayed in the section (GIS Data Resources Assessment). and a related questionnaire has been prepared for them (See [questionnaire extension for the framework and business data in Appendix B](#)).

EC1 and EC2 refer to FGDC-defined framework data available for NBM GIS unit. EC3 and EC4 refer to priority non-framework "business data" needed to meet NBM GIS application needs. Business data was identified after a visit to the municipality and an overview of the ongoing operations of GIS. Framework data and business data was identified as follows:

EC1. GIS Framework Data:

EC1a: Geodetic Control Data
EC1b: Cadastral Data
EC1c: Orthoimagery Data
EC1d: Elevation Data
EC1e: Hydrography Data
EC1f: Administrative Units Data
EC1g: Transportation Data

EC2. GIS Business Data:

EC3a: Address Data
EC3b: Census Data
EC3c: Land-use Data
EC3d: Municipal Property and Investment Data
EC3e: Sensitive-area Data (Red Zone)
EC3f: Utilities Data
EC3g: Urban Planning Data
EC3h: Land Cover Data
EC3i: Building Data
EC3j: Store Shop Data (Retail Outlet)

❖ GIS Execution Ability Assessment

This section analyzes the NBM GIS unit's self-evaluation against the Execution Ability portion of the GIS Capability Maturity Model. This section of the model focuses on the process maturity of the GIS operation. The GISCOMM describes Execution Ability as " the ability of the staff to maximize the use of the available capability, relative to a normative ideal". This section of the survey includes 22 components. For each component of the Execution Ability portion of the model, the organization can assess itself in one of the following categories:

EA1: New Client Services Evaluation and Development
EA2: User Support, Help Desk, and End-User Training
EA3: Service Delivery Tracking and Oversight
EA4: Service Quality Assurance
EA5: Application Development or Procurement Methodology
EA6: Project Management Methodology
EA7: Quality Assurance and Quality Control
EA8: GIS System Management
EA9: Process Event Management
EA10: Contract and Supplier Management
EA11: Regional Collaboration

EA12: Staff Development
EA13: Operation Performance Management
EA14: Individual GIS Staff Performance Management
EA15: Client Satisfaction Monitoring and Assurance
EA16: Resource Allocation Management
EA17: GIS data sharing
EA18: GIS Software License Sharing
EA19: GIS data inter-operability
EA20: Legal and policy affairs management
EA21: Balancing minimal privacy with maximum data usage
EA22: Service to the community and to the profession

3.4. Findings

In this part of the research, the findings are displayed in several sections. Each section focuses on individual components of the GISCOM assessment. Includes individual rating descriptions and presents a graphic representation of municipality Rating. These sections include:

- GIS Enabling Capability Assessment
- GIS Data Resources Assessment
- GIS Execution Ability Assessment
- Summary of Assessment

3.4.1. GIS Enabling Capability Assessment:

This section of the survey includes 23 components, Table 3.3 shows below the NBM ratings for Individual GIS enabling capability components assessment. In general, The average of the NBM ratings for the components of enabling capability assessment is an explicit moderate status where the average rating of 23 EC components is about 0.52 But the average is not always a title to the truth. The detailed rates of EC components indicate some strengths and reveal deficiencies. Figure 3.5 shows the findings summary of the NBM GIS unit Enabling Capability assessment.

Table 3.3: Individual enabling capability component assessment.

No.	Enabling Capability Component	Municipality Rating
EC1	Framework GIS Data *	0.86
EC2	Framework GIS Data Maintenance *	0.63
EC3	Business GIS Data *	0.82
EC4	Business GIS Data Maintenance *	0.58
EC5	GIS Data Coordination	0.40
EC6	Metadata	0.60
EC7	Spatial Data Warehouse	0.60
EC8	Architectural Design	0.80
EC9	Technical Infrastructure	1.00
EC10	Replacement Plan	0.20
EC11	GIS Software Maintenance	0.80
EC12	Data back-up and security	0.80
EC13	GIS Application Portfolio	0.60
EC14	GIS Application Portfolio Management	0.20
EC15	GIS Application Portfolio O&M	0.20
EC16	Professional GIS Management	0.60
EC17	Professional GIS Operations Staff	0.20
EC18	GIS Staff Training and Professional Development	0.20
EC19	GIS Governance Structure	0.40
EC20	GIS is Linked to Agency Strategic Goals	0.40
EC21	GIS Budget	0.60
EC22	GIS Funding	0.40
EC23	GIS Financial Plan	0.40

■ High ■ Moderate ■ Low

* The scores are derived from the average scores indicated for each category for each type of data.

- The highest individual NBM rating is for EC9: Technical Infrastructure, with a rating of 1.00 (Fully implemented). Where there technical infrastructure in place to maintain and operate the GIS and to meet the municipality business needs. Technical infrastructure includes hardware (servers, storage, desktops, input and output peripherals), network components, operating system, and GIS software. This component is interrelated with EC8 architectural

design which recorded a rating of 0.80 (In progress with full resources available to achieve the capability). However, I was unable to access the architectural design documents because of the constraints of centralization by MOMRA.

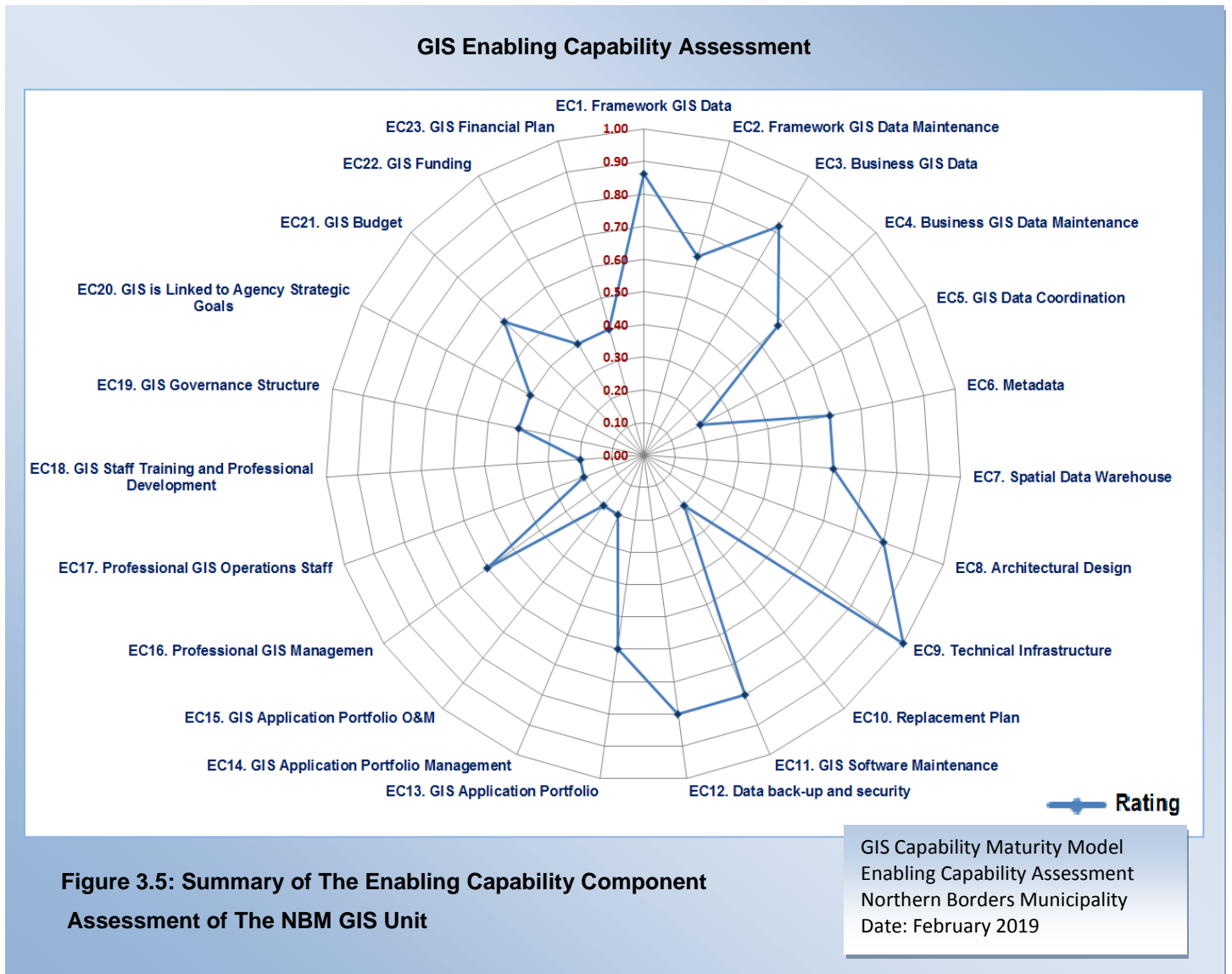
- The findings also indicate strengths of NBM GIS that including the NBM ratings for EC1: Framework GIS Data with a rating of 0.80 (In progress with full resources available to achieve the capability) and EC4: Business GIS Data with a rating of 0.78 which will discuss their individual components in the next section.
- It is also a strength of the NBM ratings for EC11: GIS Software Maintenance with a rating of 0.80 (In progress with full resources available to achieve the capability). The Municipality uses ESRI software for desktop and server (Arc GIS 10.3/Full extensions) and has been used three versions in 12 years. As for open-source' GIS software the Municipality uses the Google Earth to fill the gap of old versions of satellite images.
- The Municipality believes that the GIS software is suitable for current business needs and that it wishes to update the GIS software for the latest version, so the self-assessment is advanced but not fully implemented. The NBM ratings for EC12: Data back-up and security with a rating of 0.80 (In progress with full resources available to achieve the capability). The Municipality has a data back-up system on a separate Machine, which is periodically (weekly/monthly) replicated at different levels of transactions, data, and tables, but the Municipality wants to separate the spatial data on an independent server with the resources are available to implement it, So the self-assessment is advanced but not fully implemented.
- The NBM ratings for the components of enabling capability assessment revealed very serious deficiencies, The NBM ratings for EC14: GIS Application Portfolio Management and EC15: GIS Application Portfolio O&M with a rating of 0.20 (Planned but with no resources available to achieve the capability). Although there are three geo- applications in the municipal applications portfolio, there is still no common design and development framework in place. Also, the maintenance and modernization to ensure sustainability are

facing the problem of financial resources. The municipality's GIS officer pointed out that applications are already disabled due to lack of technical support and maintenance.

- The NBM ratings for EC10: Replacement Plan with a rating of 0.20 (Planned but with no resources available to achieve the capability). The municipality has no replacement plan due to lack of financial resources, Therefore, the assessment was low.
- The NBM rating for EC17: Professional GIS Operations Staff and EC18: GIS Staff Training and Professional Development with a rating of 0.20 (Planned but with no resources available to achieve the capability). For purposes of the GISCOM, adequate operational staffing is defined as meeting the 'roles' defined by the Geospatial Technology Competency Model. The Municipality is facing a major obstacle in providing professional GIS operations staff to meet the business. The Municipal GIS unit currently employs two specialists in an unstable through an external contractor, which is insufficient to meet business needs. Also, The instability case threatens the implementation of improvement plans on the long or medium term. The municipality's GIS officer pointed out that the low rating of this component may be a major reason for the low ratings of GIS practices in the municipality in general. At the GIS staff training and professional development, the rating was low because of its relationship with the EC17 component and the lack of financial resources.
- Weaknesses also included the component EC22: GIS Funding and EC23: GIS Financial Plan with a rating of 0.20 (Planned and with resources available to achieve the capability). During the interview, IT and GIS officials reported that the low assessment of financial resources and the budget it seems exceptional, The situation has been better in previous years and is expected to recover in the future.
- The ratings were moderate for some assessment components such as EC6: Metadata, EC7: Spatial Data Warehouse, EC13: GIS Application Portfolio, EC16: Professional GIS Management with a rating of 0.60 (In progress but with only partial resources available to achieve the capability). The GIS specialist said that the ratings of these components is not

high but also not frustrating because a little of stability in the budget and funding will increase these ratings quickly.

It should be noted here that the metadata will be assessed in detail in the data gap analysis section in chapter 5.



❖ GIS Data Resources Assessment

This section shows the NBM GIS self-evaluation against the four data-related components of the Enabling Capability portion of the GIS Capability Maturity Model that refers to GIS data and GIS data maintenance (EC1 through EC4) as shown in Table 3.4 , 3.5 The results refer to The NBM rating for EC1: Framework GIS Data with a total average rating of 0.86 (In progress with full resources available to achieve the capability) and EC2: Framework

GIS Data Maintenance with a total average rating of 0.63 (In progress but with only partial resources available to achieve the capability). The results show a gap between the ratings of availability of framework data required for business needs and the data maintenance and updating, owing to inadequate specialists and lack of financial resources in the last two years according to officials. For business data the results refer to The NBM rating for EC3:Business GIS Data with a total average rating of 0.82 (In progress with full resources available to achieve the capability) and EC4: Business GIS Data Maintenance with a total average rating of 0.58 (In progress but with only partial resources available to achieve the capability). The gap between the ratings of business data and business data maintenance seems wider.

Table 3.4: Individual framework GIS data and data maintenance. EC ratings.

No.	Framework GIS Data / Data Maintenance [EC1, EC2]	Municipality Rating
EC1a	Geodetic Control Data	1.00
EC2a	Geodetic Control Data Maintenance	0.60
EC1b	Cadastral Data	0.80
EC2b	Cadastral Data Maintenance	0.60
EC1c	Orthoimagery Data	0.80
EC2c	Orthoimagery Data Maintenance	0.20
EC1d	Elevation Data	0.80
EC2d	Elevation Data Maintenance	0.80
EC1e	Hydrography Data	0.80
EC2e	Hydrography Data Maintenance	0.80
EC1f	Administrative Units Data	1.00
EC2f	Administrative Units Data Maintenance	0.80
EC1g	Transportation Data	0.80
EC2g	Transportation Data Maintenance	0.60

For individual assessment of components EC1, EC2 (Framework GIS Data and Data Maintenance) we can report the following results:

- EC1a: Geodetic Control data with a rating of 1.00 (Fully implemented). Where the geodetic points cover the entire city and are sufficient for the present time to meet the surveying works and existing infrastructure projects. The number of geodetic points implemented by the municipality is 220 points. Geodetic data includes geographical location (X,Y Coordinates) and coordinate reference, as well as a description card for each geodetic point that includes all spatial and non-spatial data.

However, in terms of data maintenance and updating, the rating rate was reduced, EC2a: Geodetic Control Data Maintenance with a rating of 0.60 (In progress but with only partial resources available to achieve the capability). The low rating of EC2a was due to the lack of projects for the implementation of geodetic points in the last three years.

- EC1b: Cadastral Data with a rating of 0.80 (In progress with full resources available to achieve the capability). The rating was not fully implemented due to data accuracy issues, The GIS unit is working to improve data accuracy based on available human and financial resources. The Cadastral Data Maintenance (EC2b) assessment came at a lower rate with a rating of 0.60 (In progress but with only partial resources available to achieve the capability).
- EC1c: Orthoimagery Data with a rating of 0.80 (In progress with full resources available to achieve the capability). The GeoEye Image satellite with resolution (0.50 m) covers the whole city. The version 2012 is available in the municipality. The NBM plans to obtain updated satellite imagery but there are currently no dedicated resources so the rating of Orthoimagery Data Maintenance (EC2c) is low with a rating of 0.20 (Planned but with no resources available to achieve the capability).
- EC1d: Elevation Data with a rating of 0.80 (In progress with full resources available to achieve the capability). It is linked to the Orthoimagery Data component (EC1c). The rating of Elevation Data Maintenance (EC2d) with a rating of 0.80 (In progress with full resources available to achieve the capability) is higher than of the Orthoimagery Data

Maintenance (EC2c) because elevation data updating and maintenance are being carried out through the project of preparation of the strategic plan for hydrological studies which currently under execution by an external contractor.

- EC1e: Hydrography Data with a rating of 0.80 (In progress with full resources available to achieve the capability). EC2e: Hydrography Data Maintenance with a rating of 0.80 (In progress with full resources available to achieve the capability). It's a good rating for hydrography data maintenance because of The project of preparation of the strategic plan for hydrological studies which is currently under execution in the municipality by an external contractor where the project outputs represent comprehensive maintenance and updating of data.
- EC1f: Administrative Units Data with a rating of 1.00 (Fully implemented). The Municipality has completed data at the level of administrative units (City, Districts, Approved Plans Boundaries). The NBM has given priority to updating and maintaining administrative units data, so the rate has been good where the Administrative Units Data Maintenance (EC2f) with a rating of 0.80 (In progress with full resources available to achieve the capability).
- EC1g: Transportation Data with a rating of 0.80 (In progress with full resources available to achieve the capability). The municipality is trying to complete the transportation data but finds it difficult to obtain the data from the Ministry of Transport. Also, Due to a lack of resources, the rate of maintenance and updating of data is low where the Transportation Data Maintenance (EC2g) with a rating of 0.60 (In progress but with only partial resources available to achieve the capability). Figure 3.6 shows the findings summary of individual Framework GIS Data and Data Maintenance assessment of The NBM GIS unit.

Framework GIS Data / Data Maintenance Assessment

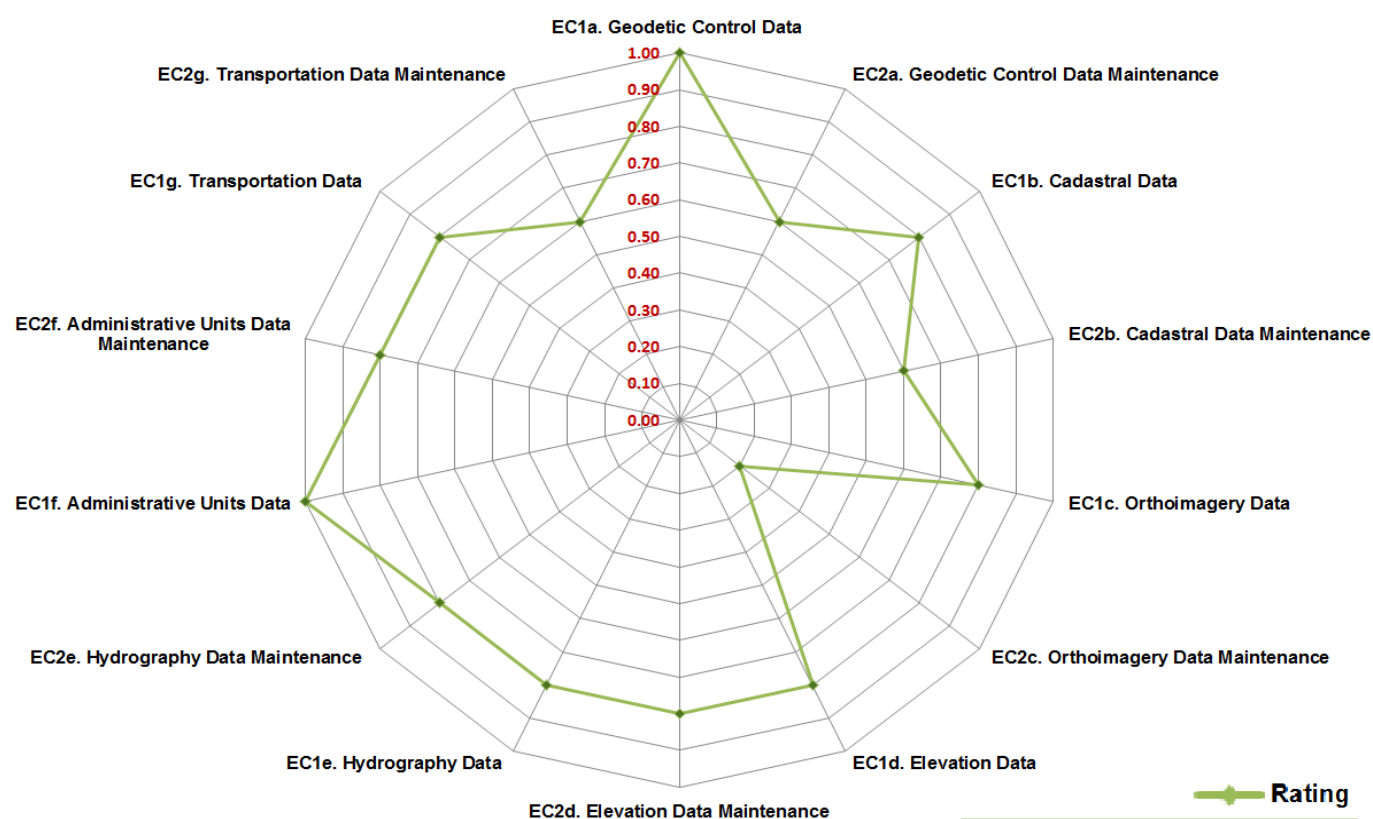


Figure 3.6: Summary of The Framework GIS Data Assessment of The NBM GIS Unit.

GIS Capability Maturity Model
 Enabling Capability Assessment
 Framework GIS Data Assessment
 Northern Borders Municipality
 Date: February 2019.

Table 3.5: Individual Business GIS data and data maintenance. EC ratings.

No.	Business GIS Data / Data Maintenance [EC3,EC4]	Municipality Rating
EC3a	Address Data	0.80
EC4a	Address Data Maintenance	0.60
EC3b	Census Data	0.40
EC4b	Census Data Maintenance	0.40
EC3c	Land-use Data	1.00
EC4c	Land-use Data Maintenance	0.60
EC3d	Municipal Property and Investment Data	0.80
EC4d	Municipal Property and Investment Data Maintenance	0.60
EC3e	Sensitive-area Data (Red Zone)	1.00
EC4e	Sensitive-area Data Maintenance	0.60

EC3f	Utilities Data	0.80
EC4f	Utilities Data Maintenance	0.60
EC3g	Urban Planning Data	1.00
EC4g	Urban Planning Data Maintenance	0.60
EC3h	Land Cover Data	0.80
EC4h	Land Cover Data Maintenance	0.60
EC3i	Building Data	0.80
EC4i	Building Data Maintenance	0.60
EC3j	Store Shop Data (Retail Outlet)	0.80
EC4j	Store Shop Data Maintenance	0.60

For individual assessment of components EC3, EC4 (Business GIS Data and Data Maintenance) we can report the following results:

- The municipality has achieved a complete implementation with a rating of 1.00 (1.00 Fully implemented) in the components of the EC3c: Land-use Data, C3e: Sensitive-area Data (Red Zone) and EC3g: Urban Planning Data. However, The data maintenance and updating rates for these components are at a low level with a rating of 0.60 (In progress but with only partial resources available to achieve the capability) due to lack of resources and job instability of the GIS staff.
- The municipality has achieved a good implementation with a rating of 0.80 (In progress with full resources available to achieve the capability) in the components of the EC3a: Address Data, EC3d: Municipal Property and Investment Data, EC3f: Utilities Data, EC3h: Land Cover Data, EC3i: Building Data and EC3j: Store Shop Data (Retail Outlet). The municipality has benefited from the progress of the address data as it has distributed maps in the public squares and vital places by the guidance maps project called "You are here now." which providing the geographical locations and access data for all nearby services such as police stations, hospitals, schools, banks, hotels, car service, and ATM.

The GIS unit in the municipality was also able to develop an internal geo-application for the management of municipal property and investment sites based on municipal property and

investment data. However, the NBM continues to suffer from the maintenance and updating of data that recorded low ratings for these components due to lack of human and financial resources with a rating of 0.60 (In progress but with only partial resources available to achieve the capability).

- The results show clear weaknesses in the components EC3b: Census Data and EC4b: Census Data Maintenance with a rating of 0.40 (Planned and with resources available to achieve the capability). GIS officials pointed out that the reason for this low rate of census data is the difficulty of obtaining the census data from the Authority for Statistics, and that there is no protocol for data exchange. This problem also appears in most non-spatial data. Figure 3.7 shows the findings summary of individual Business GIS Data and Data Maintenance assessment of The NBM GIS unit.

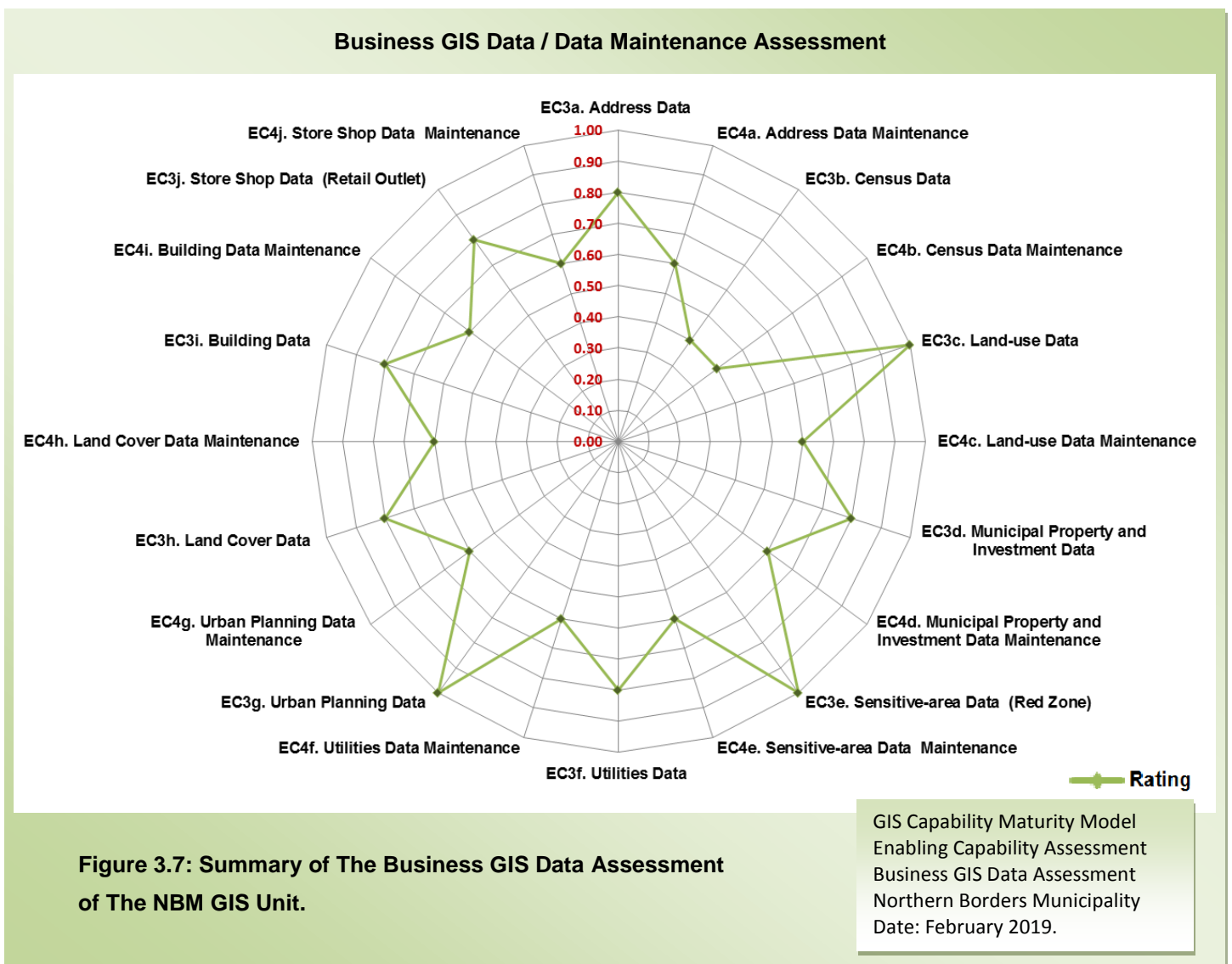


Figure 3.7: Summary of The Business GIS Data Assessment of The NBM GIS Unit.

3.4.2. GIS Execution Ability Assessment

As shown in Table 3.6 the findings of the assessment of Execution Ability Assessment components to be low with rated at Level One: Ad-hoc processes and Level Two: Repeatable processes, which represent 74% of the total EA assessment components compared to a few categories classified at a high level, which represent 26% of the total EA assessment components. There are many deficiencies and The strengths of this section of the assessment are diminished. Figure 3.8 shows the results summary of the NBM GIS unit Execution Ability self-assessment.

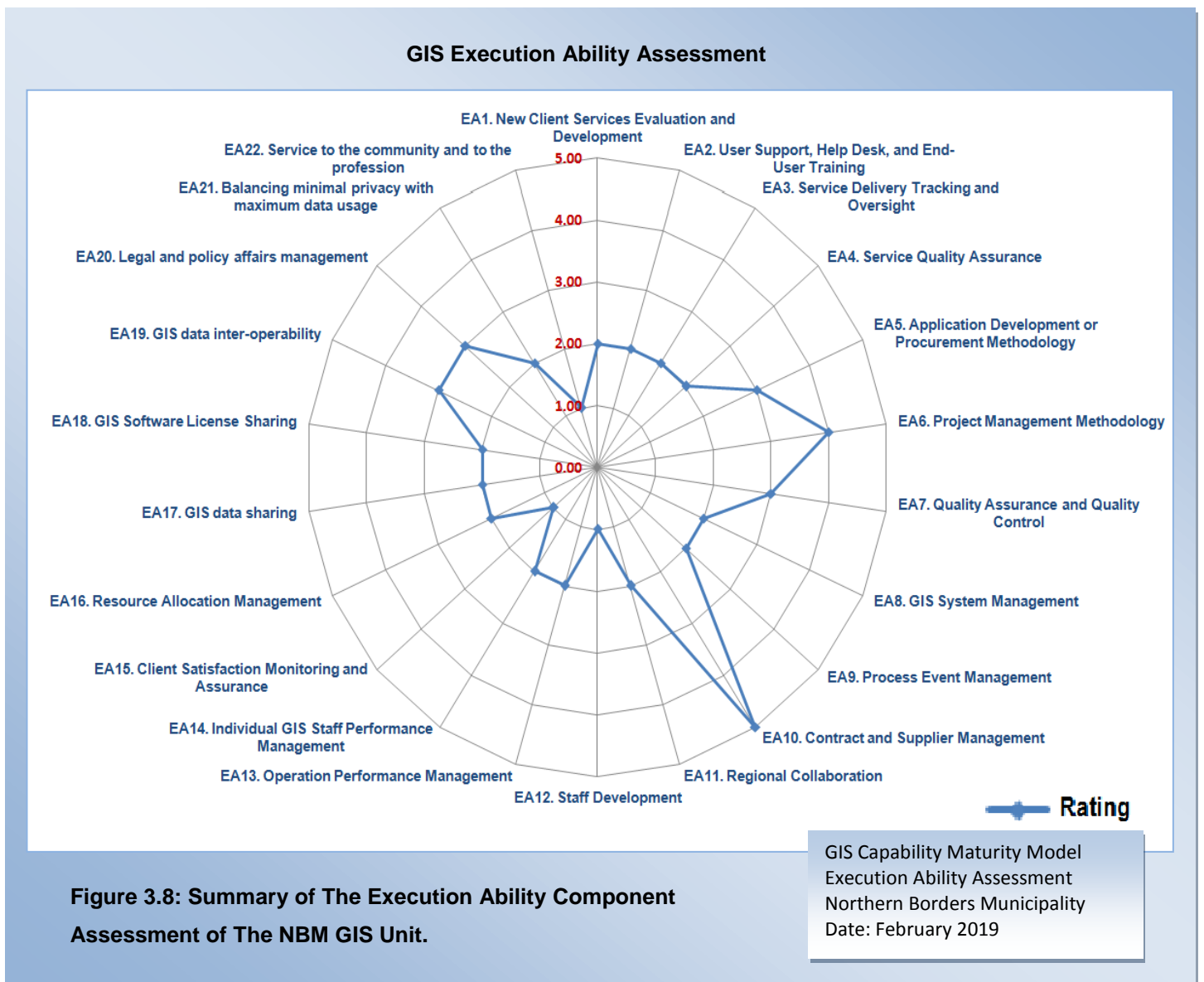
Table 3.6: Individual execution ability components assessment.

No.	Execution Ability Components	Municipality Rating
EA1	New Client Services Evaluation and Development	2.00
EA2	User Support, Help Desk, and End-User Training	2.00
EA3	Service Delivery Tracking and Oversight	2.00
EA4	Service Quality Assurance	2.00
EA5	Application Development or Procurement Methodology	3.00
EA6	Project Management Methodology	4.00
EA7	Quality Assurance and Quality Control	3.00
EA8	GIS System Management	2.00
EA9	Process Event Management	2.00
EA10	Contract and Supplier Management	5.00
EA11	Regional Collaboration	2.00
EA12	Staff Development	1.00
EA13	Operation Performance Management	2.00
EA14	Individual GIS Staff Performance Management	2.00
EA15	Client Satisfaction Monitoring and Assurance	1.00
EA16	Resource Allocation Management	2.00
EA17	GIS data sharing	2.00
EA18	GIS Software License Sharing	2.00
EA19	GIS data inter-operability	3.00
EA20	Legal and policy affairs management	3.00

EA21	Balancing minimal privacy with maximum data usage	2.00
EA22	Service to the community and to the profession	1.00

- Each of these three categories EA12: Staff Development, EA15: Client Satisfaction Monitoring and Assurance and EA22: Service to the community and to the profession (14% of the total EA assessment components) was rated at Level One: Ad-hoc processes.
- Each of these thirteen categories EA1: New Client Services Evaluation and Development, EA2: User Support, Help Desk, and End-User Training, EA3: Service Delivery Tracking and Oversight, EA4: Service Quality Assurance, EA8: GIS System Management, EA9: Process Event Management, EA11: Regional Collaboration, EA13 Operation Performance Management, EA14 Individual GIS Staff Performance Management, EA16: Resource Allocation Management, EA17: GIS data sharing, EA18: GIS Software License Sharing and EA21: Balancing minimal privacy with maximum data usage (60% of the total EA assessment components) was rated at Level Two: Repeatable processes (Typically based on recalling and repeating how the process was done the last time) meaning that they are not managed using written procedures. This rate gives a general indicator of the Execution Ability portion assessment of the GIS Capability Maturity Model at a low level, Which requires more work and adequate resources to improve GIS practices and progress in these categories.
- Each of these four categories EA5: Application Development or Procurement Methodology, EA7: Quality Assurance and Quality Control, EA19: GIS data interoperability and EA20: Legal and policy affairs management (18% of the total EA assessment components) was rated at Level Three: Defined processes (The process is written down (documented) and serves to guide consistent performance within the organization) meaning that they are managed using written procedures.

- EA6: Project Management Methodology was rated at Level Four: Managed and measured processes (The documented process is measured when performed and the measurements are compiled for analysis).
- EA10: Contract and Supplier Management was rated at Level Five: Optimized processes (The defined and managed process), The reason why this component is rated at a high rate appears to be compliance with the related laws and legislation.



3.4.3. Summary of NBM GIS Unit Assessment

Generally, The results show a moderate status with average 0.52 for the components of GIS enabling capability assessment where the ratings of status category 0.20 (Planned but with no resources available) represented 22% of the total components of enabling capability assessment, The status category 0.40 (Planned and with resources available) represented 22% of the total components of enabling capability assessment, The status category 0.60 (In progress but with only partial resources available) represented 30% of the total components of enabling capability assessment, The status category 0.80 (In progress with full resources available) represented 22% of the total components of enabling capability assessment and The status category 1.00 (Fully implemented) represented 22% of the total components of enabling capability assessment, While no component was evaluated in the status category 0.00 (This desired, but is not planned) or status (Not Applicable). Figure 3.9 shows a general indicator for ratings of GIS enabling capability assessment in the NBM GIS unit according to the status categories.

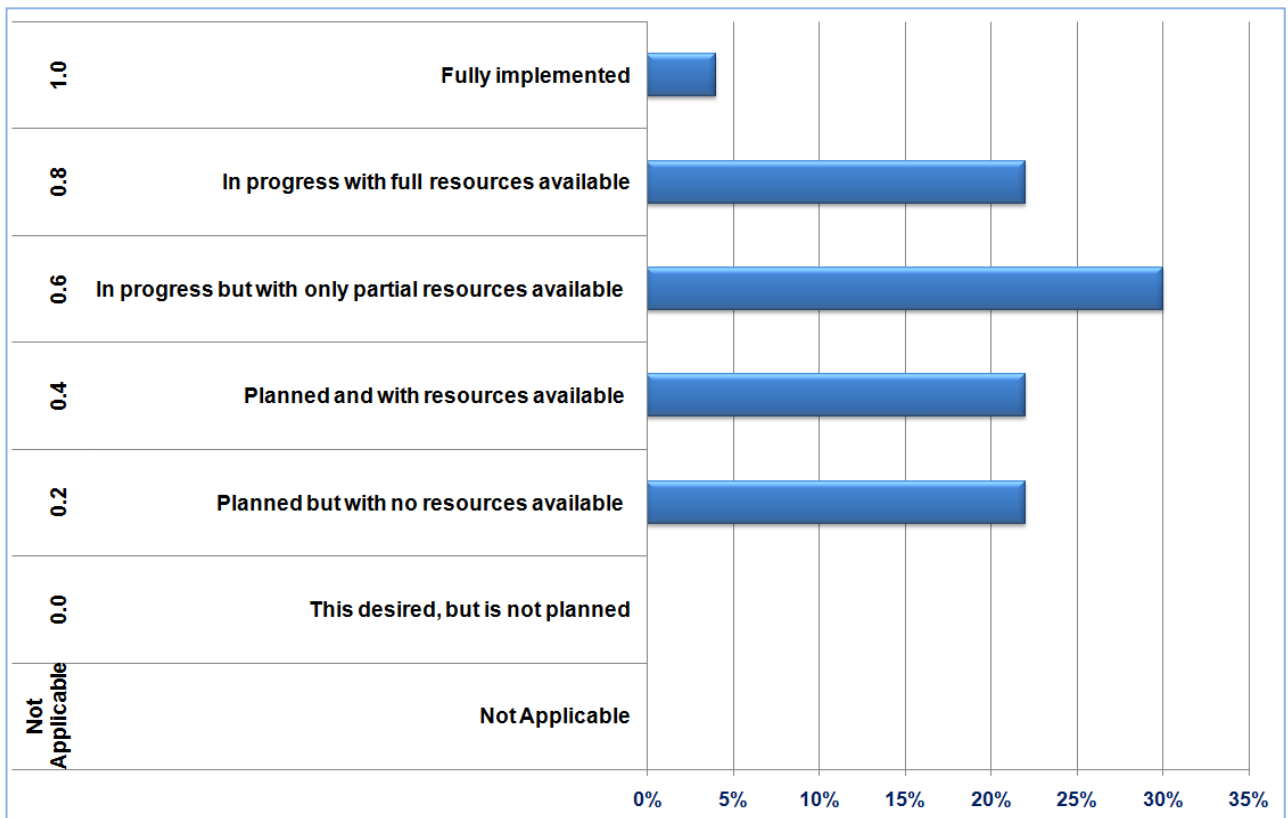


Figure 3.9: Summary of The Enabling Capability Components Assessment of The NBM GIS Unit.

In terms of GIS Data Resources Assessment in NBM GIS Unit, the results were good with high ratings where the EC1: Framework GIS Data with a total average rating of 0.86 (In progress with full resources available to achieve the capability) and EC2: Framework GIS Data Maintenance with a total average rating of 0.63 (In progress but with only partial resources available to achieve the capability). There is a gap between GIS data and GIS data maintenance, However, The GIS Data Resources in NBM GIS Unit are the most important strengths observed in the findings of GISCOM. Figure 3.10 shows the summary of GIS Data Resources Assessment in NBM GIS Unit.

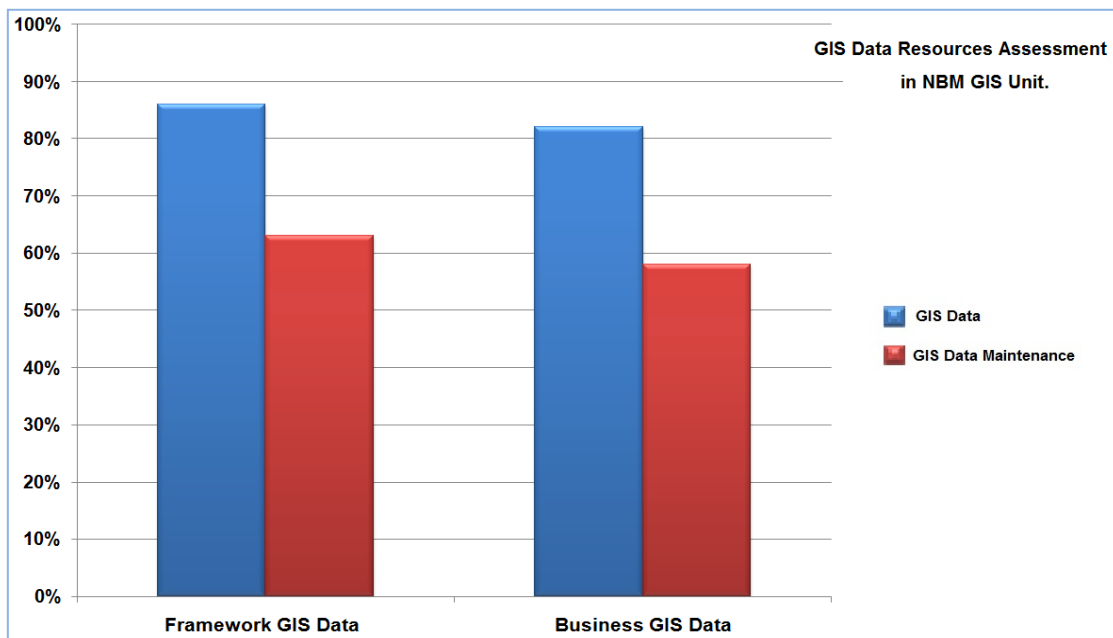


Figure 3.10: Summary of GIS Data Resources Assessment in NBM GIS Unit.

For the assessment of the components of Execution Ability, the ratings were generally low, which the most important weaknesses revealed by findings of GISCOM in NBM GIS Unit. Where components were rated at a low level (Level One: Ad-hoc processes and Level Two: Repeatable processes) included 16 components which represent about 74% of the total EA assessment components compared to the Level Three (Defined processes) which represent about 18% then Level Four (Managed and measured processes) and Level Five (Optimized processes) represent 4% of the total EA assessment components

each. Figure 3.11 shows a general indicator for ratings of GIS execution ability assessment in the NBM GIS unit according to the level categories.

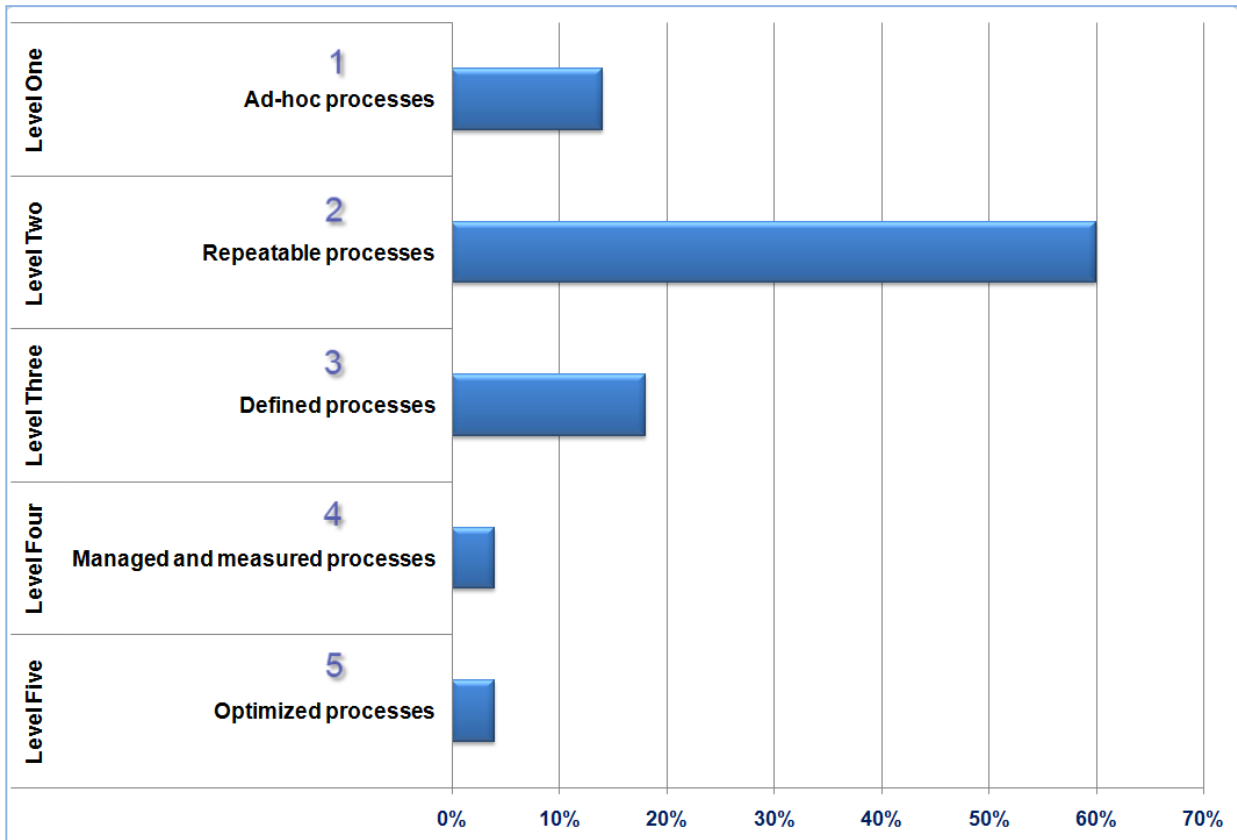


Figure 3.11: Summary of The Execution Ability Components Assessment of The NBM GIS Unit.

Chapter- 4: Spatial Data Infrastructure (SDI)

4.1. Introduction

As mentioned previously, the transition to SDI needs to assess the current state of the GIS practices environment as a first step. It also the implementation of SID requires the as a parallel step a comprehensive and deep understanding of the key concepts, key components roles, levels of SDI development and interrelationships in SDI levels interaction. In this section, we will discuss the concepts, components and organizational structure of SDI in accordance with literature review and previous studies.

4.2. Spatial Data Infrastructure (SDI) Concepts

4.2.1. SDI Definition

Spatial Data Infrastructure (SDI) is an idea of making spatial data be shared and accessed using the advanced GIS technologies, SDI refers to the integration of a number of components to create an environment which enables a wide variety of users to access precise, standardize and complete spatial information. The definition of SDI differs from institution to institution and vary according to researchers and authors, Also because of its dynamic nature the SDI definition differs over time according to the evolution of technology and software used and expansion of application domains and user base.

According to FGDC (1996), The SDI as an umbrella of policies, standards, and procedures under which organizations and technologies interact to foster more efficient use, management, and production of geospatial data (FGDC.GOV).

Nebert (2004) defines SDIs as concepts that help to denote the relevant base collection of technologies, policies and institutional arrangements that facilitate the availability of and access to spatial data. The SDI provides a basis for spatial data discovery, evaluation, and

application for users and providers within all levels of government, the commercial sector, the non-profit sector, academia and citizens in general ([Nebert 2004](#)).

According to [Rajabifard \(2007\)](#), “SDI as a dynamic, hierarchic and multi-disciplinary concept that encompasses policies, organizational remits, data, technologies, standards, delivery mechanisms, and human resource dimensions” ([Rajabifard 2007](#)).

4.2.2. Components of SDI

According to [Groot and McLaughin 2000](#) SDI consists of the following four components: Geographic data (fundamental geospatial datasets), technology (for storing, access, distribution and use of geo-information), Standards (for describing, exchanging and linking geo-information) and policy and organization. The components of SDI are highly interacted in providing spatial information for the users. The accessibility, retrieval, and delivery of any spatial information are directly based on collaboration between all components of SDI ([Groot and McLaughin 2000](#)).

According to [Rajabfard and Williamson \(2001\)](#), the core components of SDI are policy, access networks, technical standards, people and spatial data. People are stakeholders, data/service providers, users, etc. and their relationships. Data is the spatial or non-spatial which is generated, exchanged or consumed in the context of SDI. Access network referrers to communication links that connect stakeholders and data with each other and allows for communication and utilization of data/services by people or other services. SDI Policies are generally tools to monitor and control the relationships among stakeholders and the way they utilize data/services in the context of SDI. In order to facilitate the communication and exchange of spatial and non-spatial data in the context of SDI, numbers of protocols and standards are developed and being utilized. The development of these standards is, however, a dynamic process and they may change based on the dynamic needs of people, country context, and structure of information systems ([Rajabifard 2001](#)).

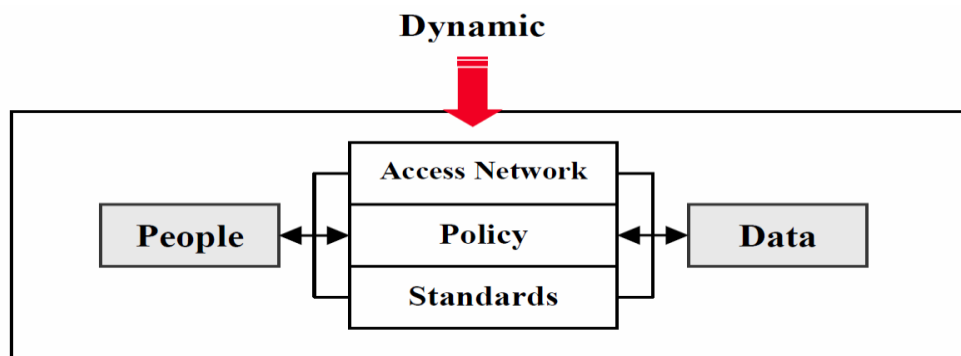


Figure 4.1: Nature and relations between SDI components (adapted from Rajabifard and Williamson, 2001)

4.2.3. SDI Hierarchy

Spatial Data Infrastructures (SDI) have different levels, These levels interact with each other through vertical and horizontal relationships. SDI takes a hierarchical structure, as the higher the level of SDI the fewer data details is reported. See Figure 4.1.

According to Rajabifard (2000) SDI hierarchy is of great importance where the SDI at the national level accommodates a central connection between the lower and higher levels to guarantee a continuous agreement on standards, policies, and sharing of data (Rajabifard et al. 2000). The hierarchical structure also refers to the importance of local /state SDI as a broad base on which to build the higher levels, where more details of data as well as issues of data maintenance and updating.

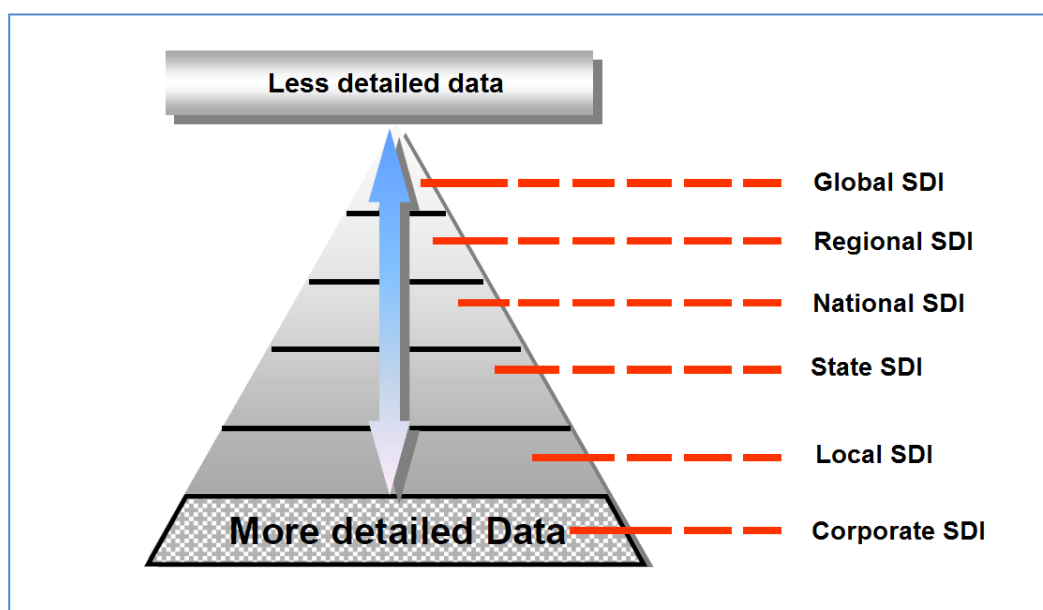


Figure 4.2: SDI Hierarchy (Adapted from Rajabifard and Williamson, 2001)

4.3. The Motivations of SDI Development in Local Government

SDIs have become very important in determining the way in which spatial data are used throughout an organization, a nation, different regions and the world (Rajabifard 2007).

SDIs is a comprehensive and ideal tool in facilitating how spatial data and spatial information systems are used and maximizing return on investment via the best way to use of spatial data available to governments, which have consumed successive budgets in their establishment and maintenance over decades. They allow the sharing of data, which enables users to save resources, time and effort when trying to acquire new datasets.

Local government is responsible for the implementation of SDI where it plays a key role in the implementation of SDI from bottom to top because the local government is a rich source of accurate and detailed spatial information which is utilized not only at the local level but increasingly at other levels of government to build the spatial data infrastructure (SDI) at a state and national level (McDougall et al. 2005). In this sense, high-level SDI initiatives should be aware of and monitor how Local Authorities deal with GI&GIS to avoid having Local SDIs in place that is not tuned (Salvemini 2004).

According to Smit (2009), the worldwide national governments are implementing SDI development policies in different stages. The underlying justifications for the creation of these SDI policies are;

- Reduction of duplication in spatial data creation and maintenance
- More efficient use of spatial data by third-party users in disparate locations
- Creating homogeneity in spatial data through prescribing standards
- Ease of access to spatial data to improve decision making with regards to specific location related phenomenon (Smit et al. 2009).

4.4. Local / Municipal SDI Model

Several patterns and models have emerged for the development of SDI, including hierarchical and process-dependent ones as follows:

- Top-down and Bottom-up Model

The top-down model is supported by legislation, regulation and Funding and executive procedures. A successful example of this model the USA's National Spatial Data Infrastructure (NSDI) and The European Union spatial data infrastructure (INSPIRE). Although these models have survived, they have not been successful in other less developed countries, The top-down approach is increasingly becoming unpopular due to high failure rates manifesting contemporary SDIs (Tumba and Ahmad 2014).

The SDIs from existing initiatives at lower levels (local/state SDI) has become more desirable in our time, where local levels are the natural evolution of GIs' practices in the organization, and we can say that the success of local SDI will necessarily lead to the success of higher levels and the opposite may not true. The user-driven bottom-up approach led to greater horizontal and vertical integration of spatial data resources on the local and regional scales (Smit et al. 2009).

- Product and Process-Based Models

According to Rajabifard (2001) Based on the strategies, aims, objectives, and status of individual SDI initiatives in different levels, two models namely product-based and process-based can be identified in contemporary SDI development, as shown in Figure 4.3.

Figure 4.3A The product-based model represents, the main aim of an SDI initiative being to link existing and upcoming databases of the respective political/administrative levels of the community. The process-based model. Figure 4.3B, This model presents the main aim of an SDI initiative as defining a framework to facilitate the management of information assets. In other words, the objectives behind the design of an SDI, by any coordinating agency, are to provide better communication channels for the community for sharing and using data assets (Rajabifard and Williamson 2001).

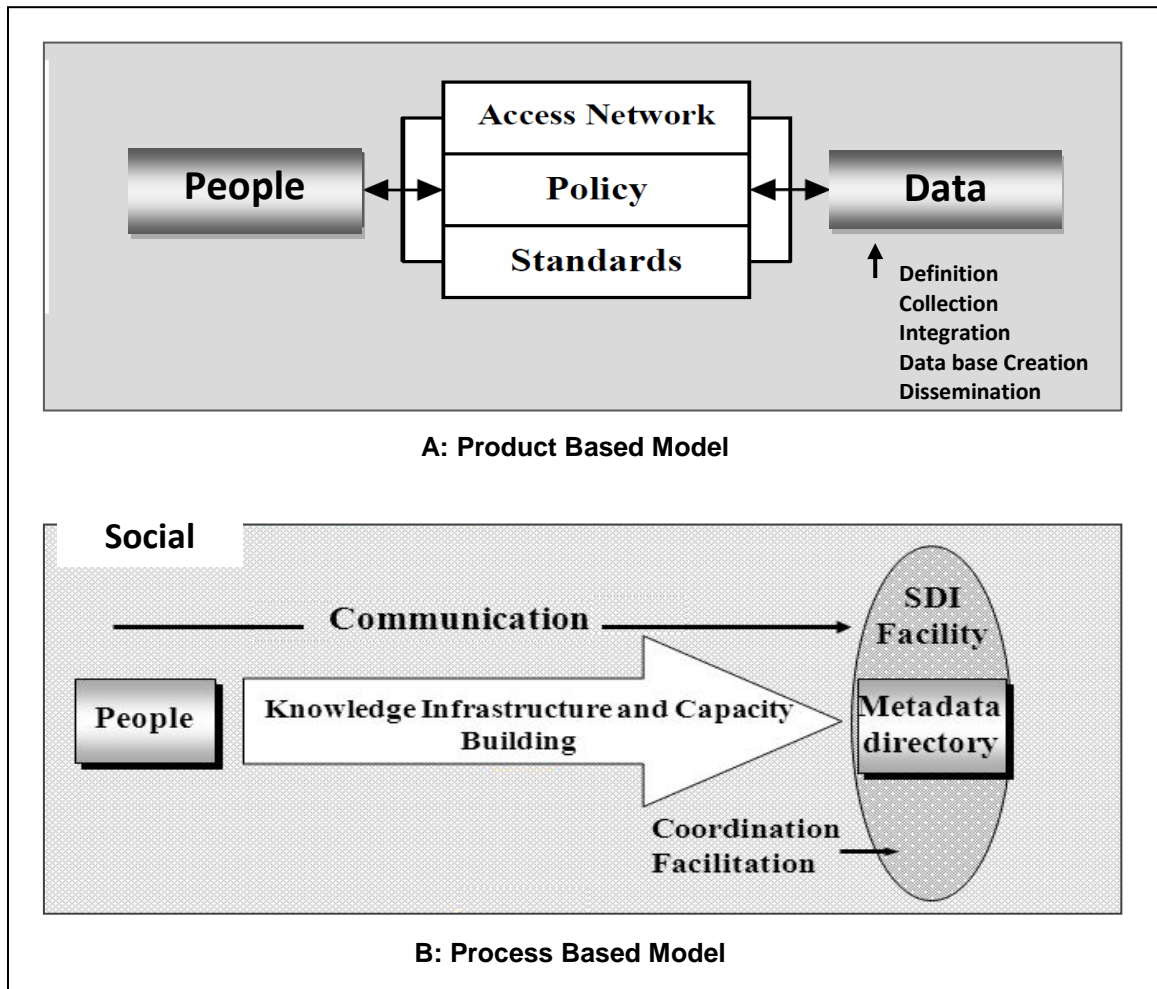


Figure 4.3: Product and Process-Based Models for SDI development (Rajabifard and Williamson 2001)

The SDI hierarchy creates an environment, in which decision-makers working at any level can draw on data from other levels, depending on the themes, scales, currency, and coverage of the data needed (Rajabifard and Williamson 2001). As Figure 4.4 shown below The Local SDI level is an operational pattern within the process-based model.

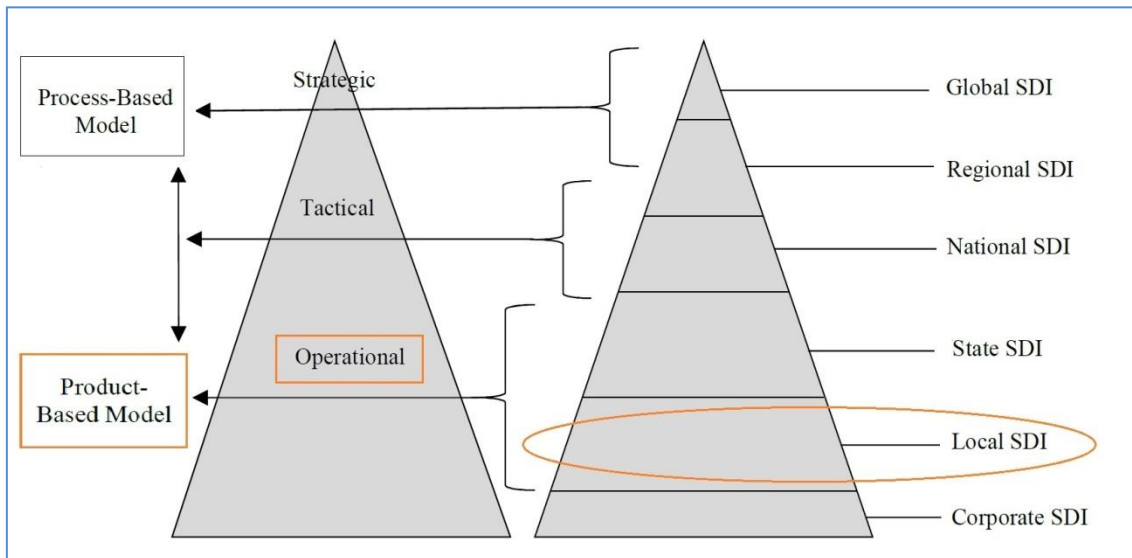


Figure 4.4: Organizational structure for SDI Hierarchy (Rajabifard, 2001)

Municipalities are one of the members of the local SDI and have an impact on higher levels with regard to the access network, Policy, and Standards. The effect here is a reciprocal relationship between SDI levels as Rajabifard (2001) pointed out in Table 4.1.

Table 4.1: Relations between different level of SDIs (Rajabifard 2001)

	Local SDI	State SDI	National SDI	Regional SDI	Global SDI
Policy	L → S L — N L — R L — G	S → L S → N S — R S — G	N → L N → S N → R N → G	R — L R — S R → N R → G	G — L G — S G → N G → R
Fundamental Datasets	L → S L → N L — R L — G	S → L S → N S — R S — G	N → L N → S N → R N → G	R — L R — S R → N R → G	G — L G — S G → N G → R
Technical Standards	L → S L — N L — R L — G	S → L S → N S — R S — G	N → L N → S N → R N — G	R — L R — S R → N R → G	G — L G — S G → N G → R
Access Network	L → S L — N L — R L — G	S → L S → N S — R S — G	N → L N → S N → R N → G	R — L R — S R → N R → G	G — L G — S G → N G → R
People	L → S L — N L — R L — G	S → L S → N S — R S — G	N — L N → S N → R N → G	R — L R — S R → N R → G	G — L G — S G → N G → R

→ Direct impact → Indirect impact — No impact
 L= Local SDI; S= State SDI; N= National SDI; R= Regional SDI; G= Global SDI

Chapter-5: The Opportunities of Transition to Local SDI

5.1. Overview

This chapter provides the performing of Data Catalogue GAP Analysis in Northern Borders Municipality against the list of fundamental datasets identified and presents the findings of the data analysis. The chapter also contains performing of GIS SWOT Analysis in The Northern Borders Municipality depending on the analysis of the interviews and questionnaires results, GIS SWOT Analysis evaluates the strengths, weaknesses, opportunities, and threats in regards to advancing a GIS's practices of the Municipality. The findings are then discussed and recommendations are made for future research and practices.

5.2. Data Catalogue GAP Analysis in The Northern Borders Municipality

5.2.1. Introduction

Gap Analysis is a strategic planning tool to help you understand where you are, where you want to be and how you're going to get there. Through the GISCOM assessment the GIS Data Resources have been assessed, included the GIS framework data and business data, the situation was not bad as average rates were recorded 0.86 (In progress with full resources available to achieve the capability) for GIS framework data and 0.82 (In progress with full resources available to achieve the capability) for GIS business data. In this section, we will conduct another assessment using the gap analysis tool of municipality spatial data catalogue compared to the fundamental datasets to be identified to identify missing data and metadata. This step will help to develop a plan to complete and improve the spatial data required for SDI implementation.

5.2.2. Fundamental Data

The Fundamental Data is a geospatial data of high interest or significant comply with standards and required by many parties to support the design and development of a country or organization.

The Permanent Committee on the Spatial Data Infrastructure for the Americas (CP IDEA) defined the fundamental data are the sets of uninterrupted and completely integrated spatial data that provide a context and reference information in a Spatial Data Infrastructure (SDI). Classifying any kind of data as a framework or fundamental data is normally subject to its availability in the major sectors where the SDI undergoes development, and to the consensus that exists between the main parties interested ([Permanent Committee on the Spatial Data Infrastructure for the Americas, CP IDEA,2013](#)).

For this section of the study The Fundamental Data will be used according to the list of fundamental datasets provided by Rautenbach (2015) in his study to identifies the fundamental spatial datasets in a local government and explorers the guidelines of international Spatial Data Infrastructure (SDI) initiatives in order to help in the planning of future strategies. Rautenbach has defined the list of data based on two lists as an initial guideline for the choice of fundamental datasets ([Rautenbach 2015](#)). The guidelines are:

- Fundamental datasets for the INSPIRE SDI as the best practices, See Table 5.1.
- Fundamental datasets According to the previous study by ([Farah and Ottichilo 2006](#)), See Table 5.2.

Table 5.1: Cornerstones datasets in the INSPIRE directive

BASIC DATA INSPIRE Annex I data	COMMONLY USED THEMATIC DATA INSPIRE Annex II data
Administrative units	Statistical units
Transport networks	Buildings
Hydrography including water catchment areas	Soil
Elevation including terrestrial elevation, bathymetry, and coastline	Geology
Cadastral parcels	Land use
Land cover	Human health and safety
Protected sites	Government service and environmental monitoring facilities
Ortho-imagery	Production and industrial facilities

Coordinate reference systems	Agricultural and aquaculture facilities
Geographical grid systems	Population distribution - demography
Geographical names	Area management/ restriction/ regulation zones & reporting units
Addresses including postal regions	Natural risk zones
	Atmospheric conditions
	Meteorological spatial features
	Sea regions
	Bio-geographical regions
	Habitats and biotopes
	Species distribution

Table 5.2: Summarized List of Fundamental datasets According to the previous study by (Farah & Ottichilo, 2006) via (Rautenbach 2015).

Level of importance	Fundamental geospatial datasets
High	Administrative boundary
	Populated places/settlements
	Topography
	Hydrography
	Addresses
	Infrastructure
	Transportation
Medium	Populated places/settlements
	Utility Networks
	Vegetation
	Geodetic controls
Low	Cadastral
	Land use
	Population data
	Agriculture/Forestry
	Poverty, Health, Security

On this basis, the list of fundamental datasets was determined according to previous studies and INSPIRE directive by Rautenbach (2015) with slight modification according to

the local nature of case study, Where coastal dataset and some classes such as fisheries and forestry were not added. Table 5.3 shows the Fundamental datasets used in spatial data catalogue gap analysis.

Table 5.3: The List of Fundamental datasets (by Rautenbach 2015)

Fundamental Datasets	
Administrative boundaries	Imagery
Addresses	Informal Trading Areas
Artificial Surfaces	Infrastructure
Building	Inland Water
Cadastral	Land Cover
Climate	Land Tenure
Conservation	Land Use
Demography	Relief
Drainage lines	River
Fire Boundaries	Roads
Fire Stations	Soil type
Flood points	Vegetation
Geodetic reference	Voting Districts
Geographical Place Names	Waste Removal Areas
Geology	

5.2.3. Performing Data Catalogue GAP Analysis

The gap analysis will be conducted by comparing the spatial data catalogue of Northern Borders Municipality (See the NBM Data Catalogue in Appendix C) against the list of fundamental datasets identified in Table 5.3. The gap analysis will conduct an investigation into the NBM data catalogue, including metadata and attribute data, to identify the gaps or missing data at the data catalogue (Data Schema), metadata and attribute data level. Table 5.4 shows a summary of the GAP Analysis.

Table 5.4: The summary of the GAP Analysis

Fundamental Dataset	Features	In the NBM Catalogue? Y/N	Data /Attribute data available? Y/N	Metadata available? Y/N
Administrative boundaries	All boundaries	Y	Y	Y
Addresses	Street Addresses	Y	Y	N
Artificial Surfaces	Applicable Artificial Surfaces	N	N	N
Building	Border Customs (Border Post)	N	N	N
	Educational Institutes	Y	Y	Y
	Health Institutes	Y	Y	Y
	Hotel	Y	Y	Y
	House	Y	N	N
	Large Building (Factory, Warehouse, etc.)	Y	Y	N
	Market	Y	Y	Y
	Islamic Education Foundation	Y	Y	N
	Municipal Council	Y	Y	Y
	Place of Worship	Y	N	N
	Police Station	Y	Y	Y
	Post Office (Postal Office)	Y	Y	Y
	Post Office Area	N	N	N
	Power Station	Y	Y	Y
	Prison (Correctional Facility)	Y	Y	N
	Ruin (Historical Building)	N	N	N
	Shopping Centre	Y	Y	Y
Store Ship Area	Y	Y	Y	
Store Shop (Retail Outlet)	Y	Y	N	
Cadastre	Cadastre	Y	Y	Y
Climate	Rainfall	Y	N	N
	Temperature	Y	N	N
	Wind	Y	N	N
	Atmospheric Pressure	Y	N	N
Coastal	All Coastal Features	Y	N	N
Conservation	Conservation (Reserve Area)	Y	Y	N
	Biodiversity Regions	N	N	N

	Ecosystem	N	N	N
	Wildlife (Fauna)	N	N	N
Demography	Population Statistics	Y	N	N
Drainage lines	Aqueduct	Y	Y	Y
	Canal	Y	Y	Y
	Furrow	N	N	N
	Pipeline	Y	Y	N
	Siphon	Y	Y	N
Fire Boundaries	Fire Boundaries Area	N	N	N
Fire Stations	Fire Station Point	Y	Y	Y
Flood points	Flood points	Y	Y	N
Geodetic reference	Control Point	Y	Y	Y
	Geoids	Y	Y	Y
Geographical Place Names	Place Names	Y	Y	Y
Geology	Hydrogeology	Y	Y	Y
	Structural Geology	Y	N	Y
Imagery	Arial Photography	N	N	N
	Satellite Images	Y	Y	Y
	Topographic Map Raster	N	N	N
Informal Trading Areas	Informal Trading Area	N	N	N
Infrastructure	Railway	Y	Y	N
	Transportation	Y	Y	Y
	Utility networks	Y	Y	N
Inland Water	Dam	Y	Y	Y
	Dry Pan	Y	Y	N
	Fish Farm	N	N	N
	Lake	N	N	N
	Large Reservoir	Y	Y	Y
	Marsh Vlei	Y	Y	N
	Mud Flats	N	N	N
	Pool	N	N	N
	Purification Plant (Water Treatment Plant)	Y	Y	Y

	Sewerage Works	Y	Y	N
	Swamp (Marsh)	Y	Y	N
	Water Tank	Y	Y	Y
	Ground Water	Y	N	N
Land Cover	Land Cover	Y	Y	Y
Land Tenure	Land Ownership	N	N	N
Land Use	Land Use	Y	Y	Y
Relief	Contour	Y	Y	Y
	Depression Contour	N	N	N
	Spot Height	Y	Y	Y
Roads	All Roads	Y	Y	Y
Soil type	Soils	Y	N	N
Vegetation	All Vegetation types	N	N	N
Voting Districts	Voting Points	N	N	N
	Voting Districts	N	N	N
Waste Removal Areas	Waste Removal Route	N	N	N

5.2.4. Findings

Table 5.4 above shows the findings of the gap analysis performance of the NBM data catalogue against the list of fundamental datasets, The table includes findings of the existing data, attribute data and available metadata. the following datasets and features are missing in the NBM data catalogue:

- | | |
|---------------------------------|---------------------------|
| 1- Artificial Surfaces | 12- Informal Trading Area |
| 2- Border Customs (Border Post) | 13- Fish Farm |
| 3- Post Office Area | 14- Lake |
| 4- Ruin (Historical Building) | 15- Mud Flats |
| 5- Biodiversity Regions | 16- Pool |
| 6- Ecosystem | 17- Land Tenure |
| 7- Wildlife (Fauna) | 18- Depression Contour |
| 8- Furrow | 19- Vegetation |
| 9- Fire Boundaries Area | 20- Voting Districts |
| 10- Arial Photography | 21- Voting Points |
| 11- Topographic Map Raster | 22- Waste Removal Areas |

The gap analysis findings indicate that 22 features from 78 features (total fundamental datasets) representing 28% of the total fundamental data are missing data. In addition, there is a loss of attribute data as well as a lot of metadata missing, which are necessary for the implementation of municipal SDI, Where the percentage of missing metadata is 60% of the total fundamental datasets, which is a serious percentage that requires improvement. Figure 5.1 shows a summary of the missing data.

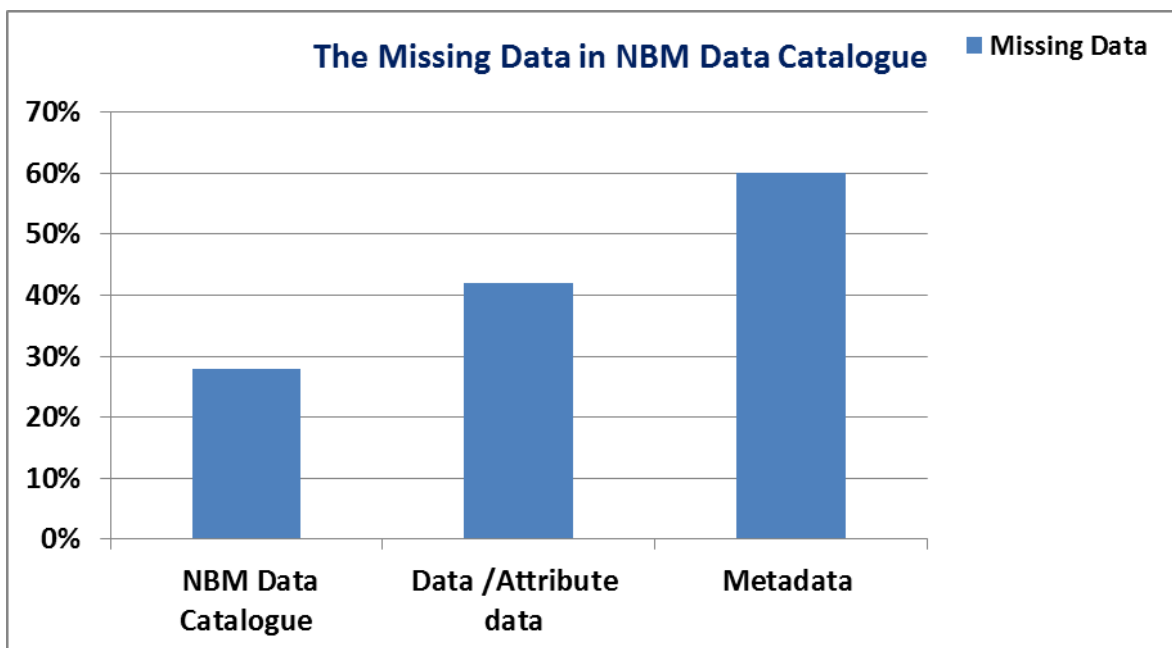


Figure 5.1: Summary of the missing data in the NBM data catalogue

Through the investigation of the NBM data catalogue and the findings of the gap analysis performance indicated above we can report the following notes:

- There is a clear problem with the lack of metadata for many data sets.
- There are a number of duplicates of some of the datasets.
- Non-spatial data (tabular and statistical) are not available although there are tables in the NBM data catalogue but no data.
- The features are available in the NBM data catalogue but in a different dataset not as described in the fundamental datasets, Therefore, the data structure (Data Schema) must be reconstructed to reorganize features as in fundamental datasets.

In general, spatial data in the Northern Borders Municipality is not bad, but there is a gap due to missing data as well as some problems such as data duplicate, lack of metadata, statistical data and updating attribute data, These problems are caused by poor data storage and maintenance. An SDI will solve this problem by creating a central storage unit for the data and implementing spatial data standards and metadata to ensure that the correct and relevant data can be found (Rautenbach 2015).

5.3. GIS SWOT Analysis in The Northern Borders Municipality

5.3.1. Introduction

A SWOT Analysis is a strategic planning method used to evaluate the strengths, weaknesses, opportunities, and threats as they relate to a topic. Based on the results of the GIS Capability Maturity Model (GISCOM) in chapter three and the gap analysis of the data catalogue in this chapter as well as the interviews and questionnaires conducted for this purpose, we will perform the SWOT Analysis to identify strengths and weaknesses as well as opportunities and threats in regards to advancing an enterprise-wide GIS and Transition to SDI in the Northern Borders Municipality as a local government entity.

5.3.2. GISCOM Results Analysis

GIS SWOT Analysis is primarily based on an analysis of the findings obtained from the GISCOM assessment, The findings included all individual components of the GISCOM assessment in the municipality In two main categories: GIS Enabling Capability Assessment and GIS Execution Ability Assessment.

The Figures 5.2, 5.3 summarizing the results of the assessment of the GISCOM, the rates were categorized into three categories High, Moderate and Low to facilitate identification of strengths and weaknesses in order to perform GIS SWOT Analysis.

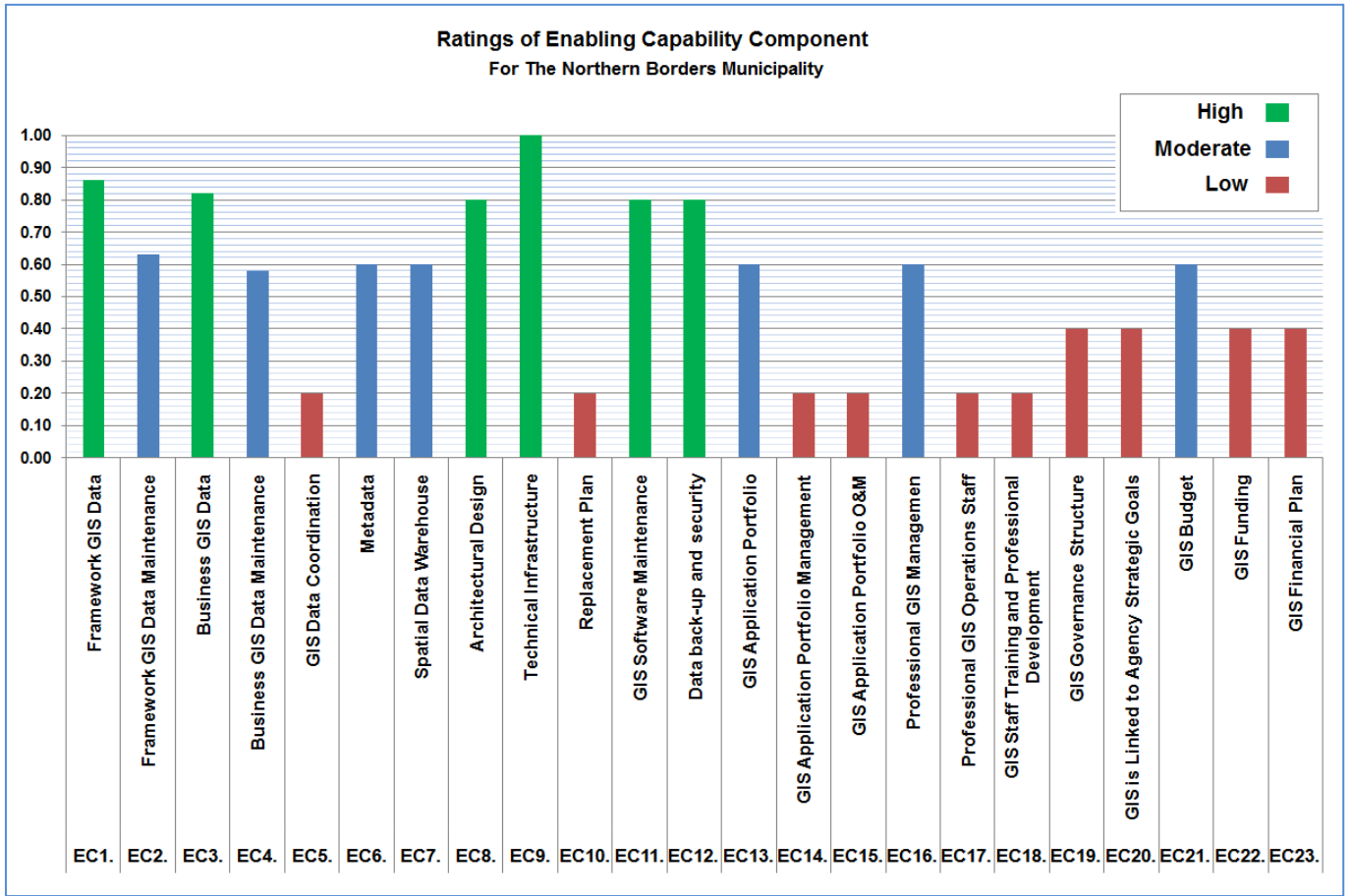


Figure 5.2: Summary Ratings of GIS Enabling Capability Components For The NBM

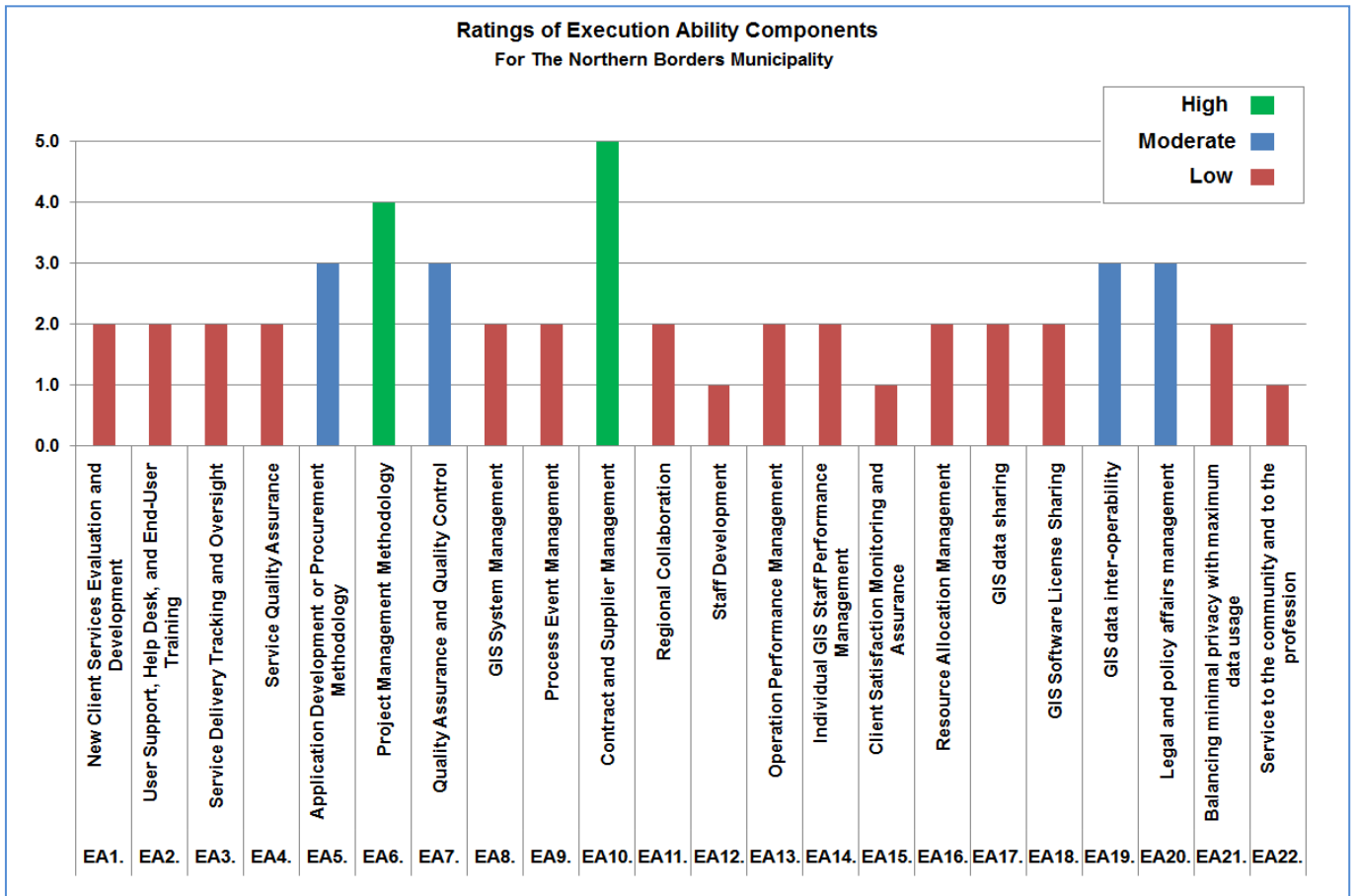


Figure 5.3: Summary Ratings of GIS Execution Ability Components For The NBM

5.3.3. Questionnaires And Interviews Analysis.

As mentioned above in the second chapter, three questionnaires will be used in addition to the main questionnaire of the maturity model (GISCOMM). The three questionnaires aimed to determine the type of spatial data already existing in the departments as well as the spatial data they required from other parties. It also aimed to determine the readiness of spatial data interoperability between The different departments and agencies. Interviews and questionnaires revealed the strengths and weaknesses of GIS practices in municipal departments and government agencies.

An interview was held with the three groups of departments and branches managers in the municipality, Consultants and project managers related to GIS and responsible for spatial data in some government agencies. Interviews were conducted in 16 visits (13 interviews for municipal departments, 3 interviews for government agencies) and the interview lasted between 30-45 minutes (See schedule of interviews in Appendix D).

Initially, I gave a definition of GIS and related concepts such as SDI, interoperability of spatial data and geo-applications. We discussed the important role of spatial information and spatial services for improving the operations performed and the quality of services provided by the agency/department to citizens and the private sector, Then we discussed the IT infrastructure status and the availability of IT infrastructure for interoperability of spatial data through geo-applications. We also spoke extensively about the challenges faced by GIS practices and the obstacles to interoperability between government agencies and departments. The most important challenges identified were the lack of GIS specialists, the lack of a fixed budget for the GIS sustainable operation, the low awareness of the importance of GIS, different data formats and The lack of standardized data standards. During the interviews, a questionnaire consisting of 27 questions was provided to measure and evaluate aspects of GIS practices in terms of human resources, spatial data, infrastructure, standards and policies, in addition to identifying the strengths and weaknesses of the GIS in the municipal Departments and government agencies (See municipal departments and government agencies questionnaires in Appendix E,F).

It should be noted here that the questionnaire of municipal departments and branches did not include the IT Department and the GIS Unit, which were evaluated in detail through the maturity model (GISCOM) questionnaire as described in chapter three.

Below we present the results of questionnaires conducted at different levels and respondents:

5.3.3.1. Municipal Departments/ Branches Questionnaire:

As mentioned above, 13 interviews were conducted at the level of departments and branches managers in the municipality, Consultants and project managers related to GIS, and the questionnaire for these groups was completed. We can report the findings as follows:

- The findings of the questionnaire indicate a low level of awareness of the importance of GIS in the municipal department's staff (Question 2). Levels (poor - moderate) scored 77% of the total responses, while the level (high) scored 23% of the total responses (Figure 5.4).

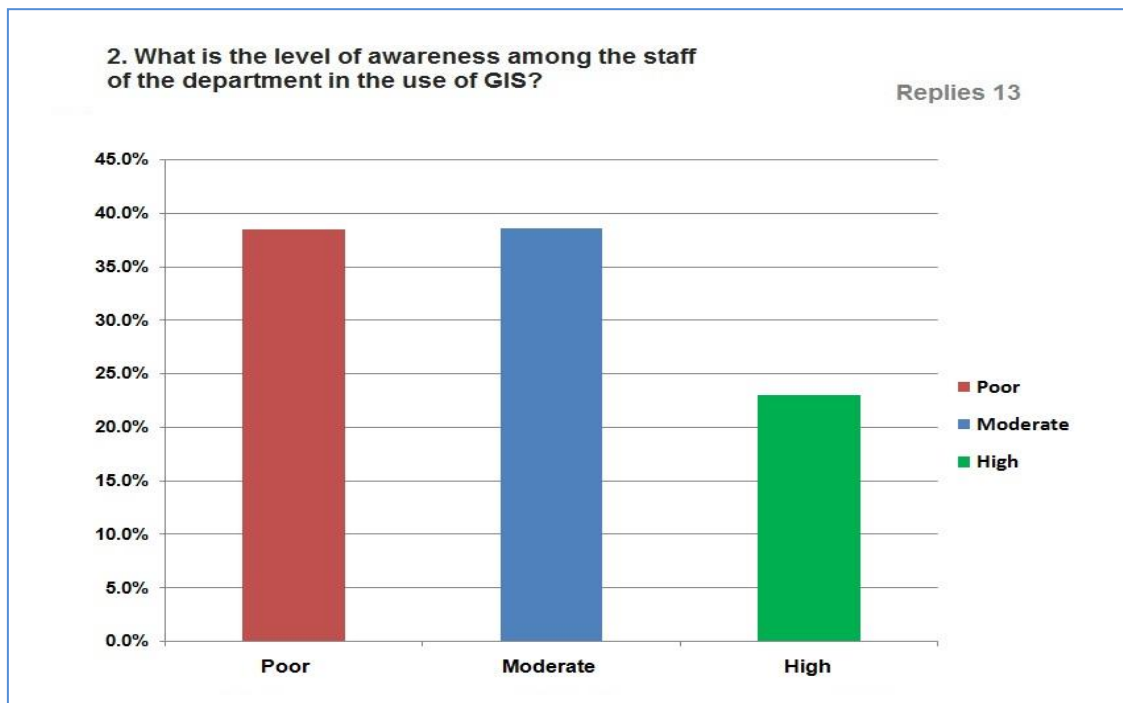


Figure 5.4: The level of awareness of GIS

- There is a state of satisfaction among the municipality's employees on the performance of the IT infrastructure (Question 4), at the level of hardware, network, software, and the

Internet, The satisfaction rate was 77%, 77%, 46%, 61.5%, respectively. In addition, 12 responses from 13 (total responses) are connected to municipal servers where scored 92% of the total responses (Figure 5.5).

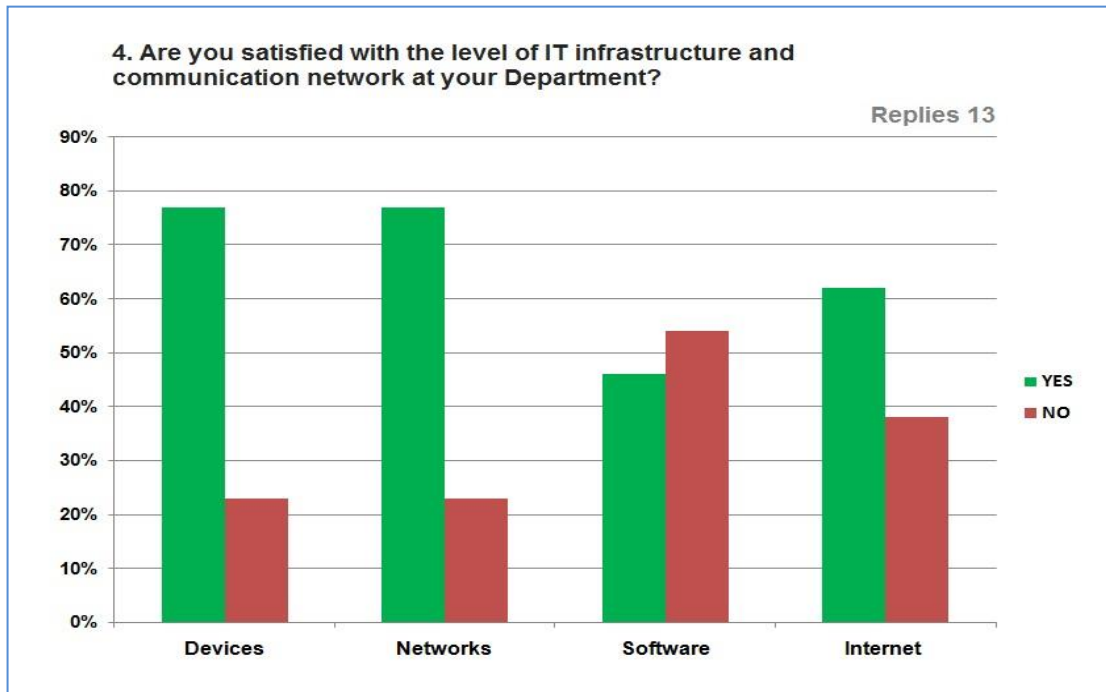


Figure 5.5: Satisfaction with the state of IT infrastructure

- The GIS software is not widely used by the municipal departments (Question 7), where (ArcGIS Desktop) scored 31% of the total responses, while Google Earth and CAD scored 92% and ArcGIS Server is not used outside GIS unit.
- For the spatial data used or those produced by municipal departments through daily transactions (Question 12), the highest response was Statistical data and reports, Locations and addresses, Land use data, Survey data which scored 85%, 54%, 46%, 46% respectively (Figure 5.6).
- The findings indicate a real problem with the metadata available in the municipal departments (Question 14), where the responses to the availability of metadata (Yes) scored 31%, (No) scored 69% of the total responses (Figure 5.7).

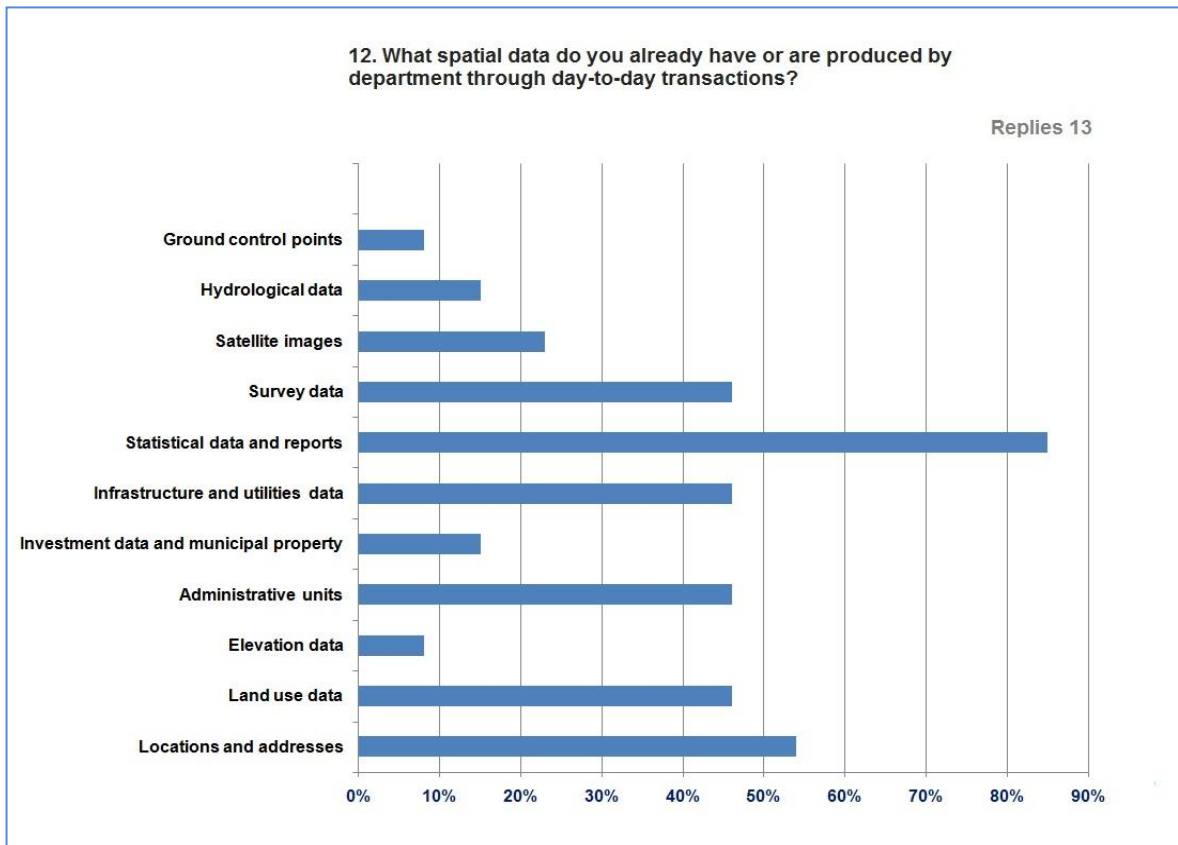


Figure 5.6: Spatial data at departments

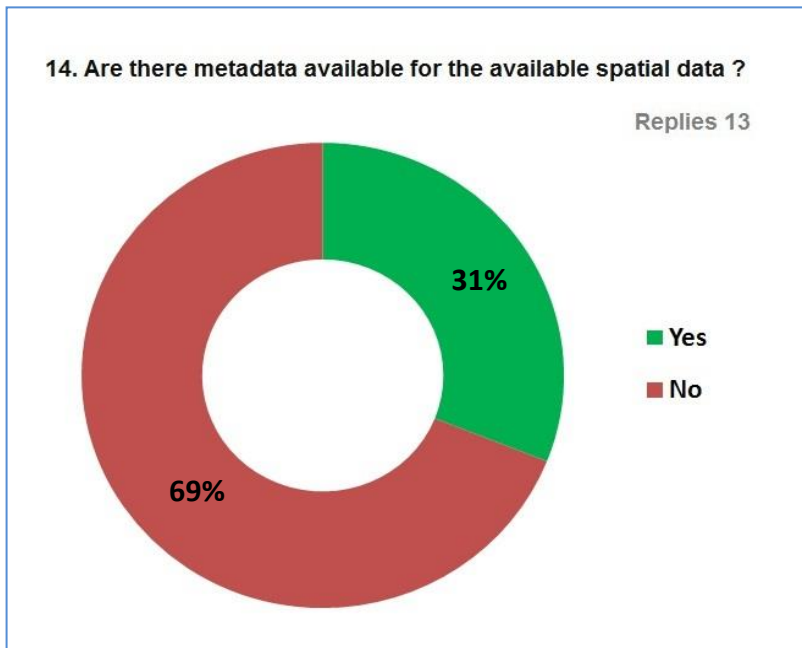


Figure 5.7: Available metadata

- For the spatial data and services which required from municipal GIS unit (Question 16), According to the responses of municipal departments and branches, The highest response was Locations and addresses, Infrastructure and utilities data and Measurements with score 100%, Land use data, Administrative units, Online Geo-

explorer, Statistical data and reports, Geo-Applications and Spatial analysis scored 92%, Then the Printed maps scored 85% of the total responses.

- For the spatial data required from other government agencies (Question 17), The highest response was Power grid data, Water network, Sewerage network, and Telecommunication network with score 92%, Then the Population statistics data, and Transport data scored 61.5%, While Meteorological data scored 54% of the total responses (Figure 5.8).

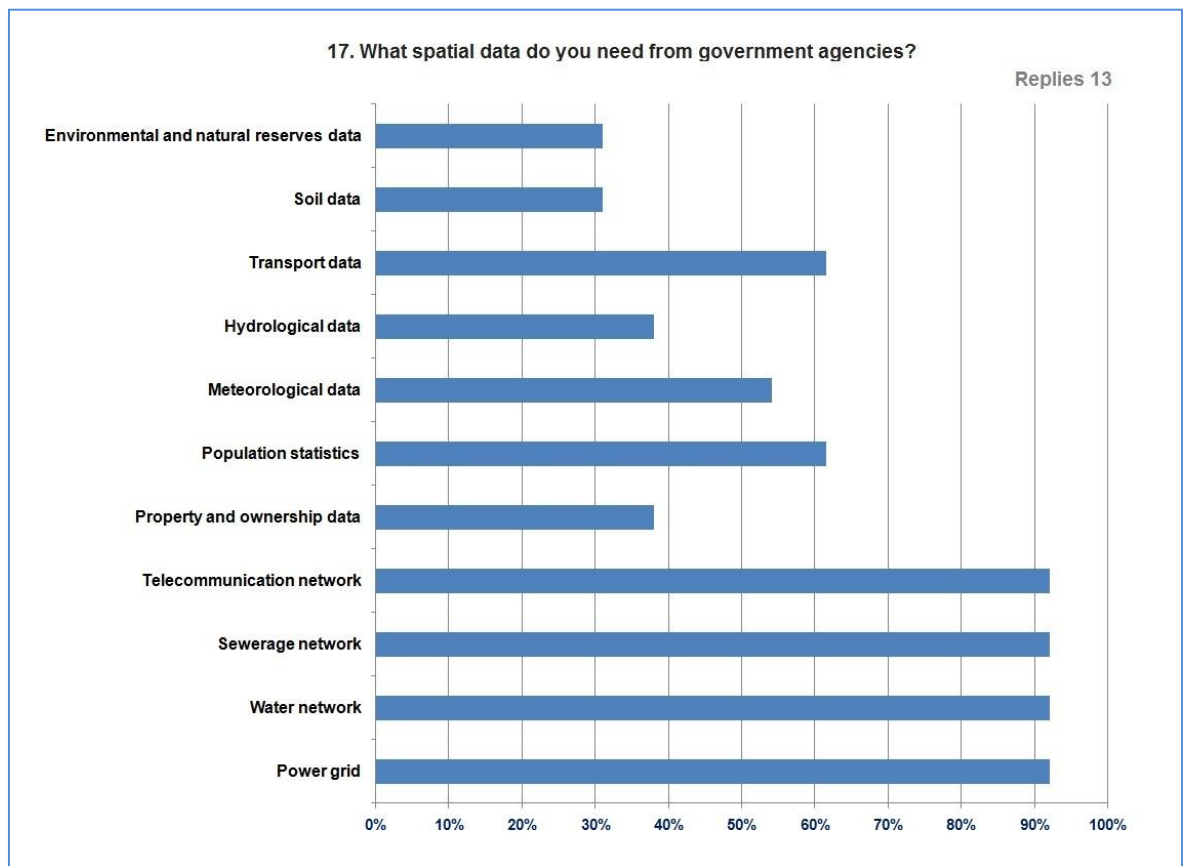


Figure 5.8: Spatial data required from government agencies

- As for how to obtain spatial data (Question 18), the findings show that the municipal departments are using the central server of spatial data in a limited domain where scored 23%, The reason has been explained in the questionnaire that the central server of spatial data not working permanently and stable. The highest response was Digital (Storage device) and Hard copy (maps and reports) with score 100%, Then by E-mail scored 38% of the total responses (Figure 5.9).

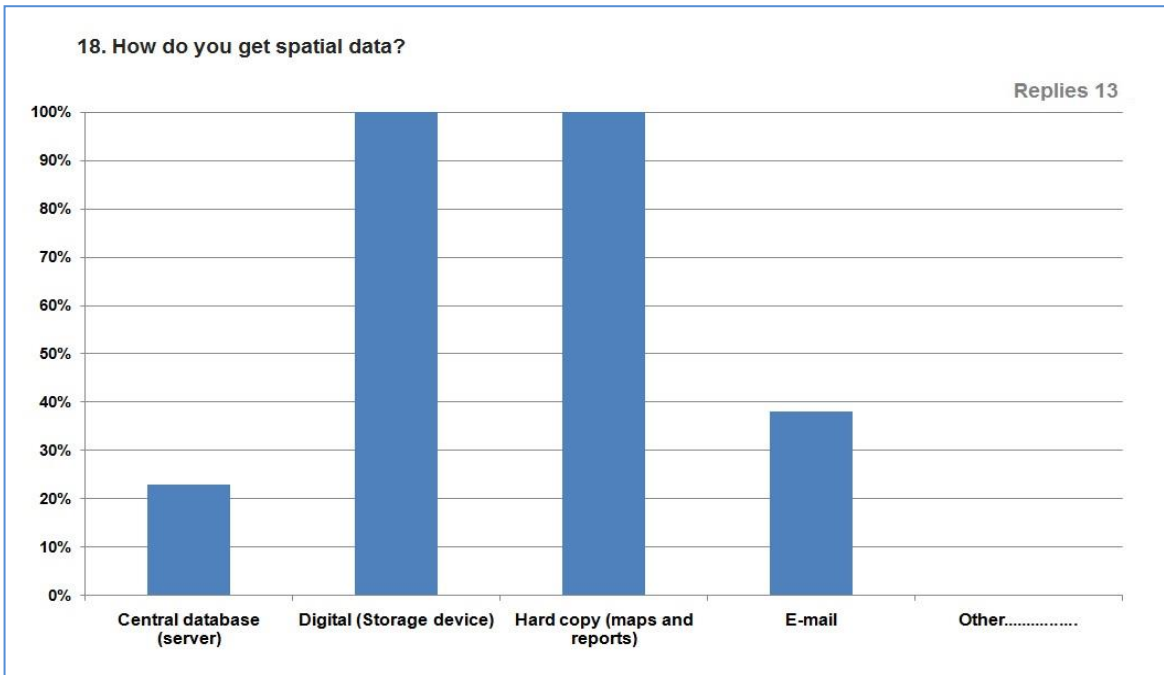


Figure 5.9: How to get spatial data

- (Question 19) The results indicated that the difficulties related with the spatial data facing the municipal departments and branches are: No integrated Data, No metadata, Data not updated and Difficulty in data access with scores 100%, 92%, 65%, 61.5% respectively (Figure 5.10).

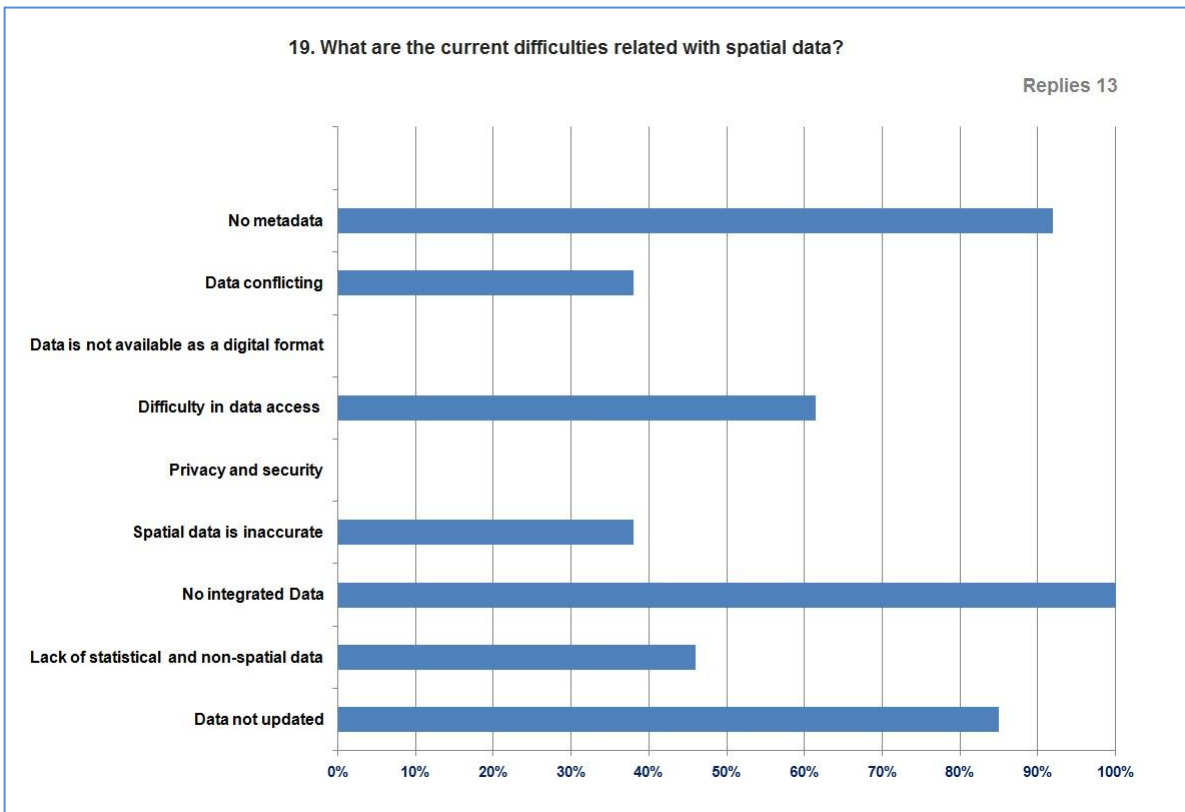


Figure 5.10: The difficulties related to spatial data

- The questionnaire group had a view on how the data homogeneity of the SDI implementation (Question 25), The highest response was Develop an interoperable framework, A unified communications environment, Use of standardized global standards, Provide metadata and Standardization of database models with scores 100%, 100%, 85%, 77%, 69% respectively.
- In general, there was a complete consensus on the municipal departments need for spatial data infrastructure (Local SDI) with score 100% (Question 24), as well as more meetings and workshops to discuss the standards and policies issues (Question 26), as well as the municipal departments, need for geo-applications for operation, maintenance and data management and sharing (Question 22).
- Finally, the findings of the questionnaire indicate that there are some geo-applications that have been developed (Question 21), but are not working in a stable manner (Management of Municipal Investment App, Management of municipal projects App, Geo- Explorer of Arar City) (See figure 5.11), and there are some e-services that based on spatial data (Question 23), But operates centrally through the ministry (MOMRA) such as Balady System to issue building permits and professional licenses.

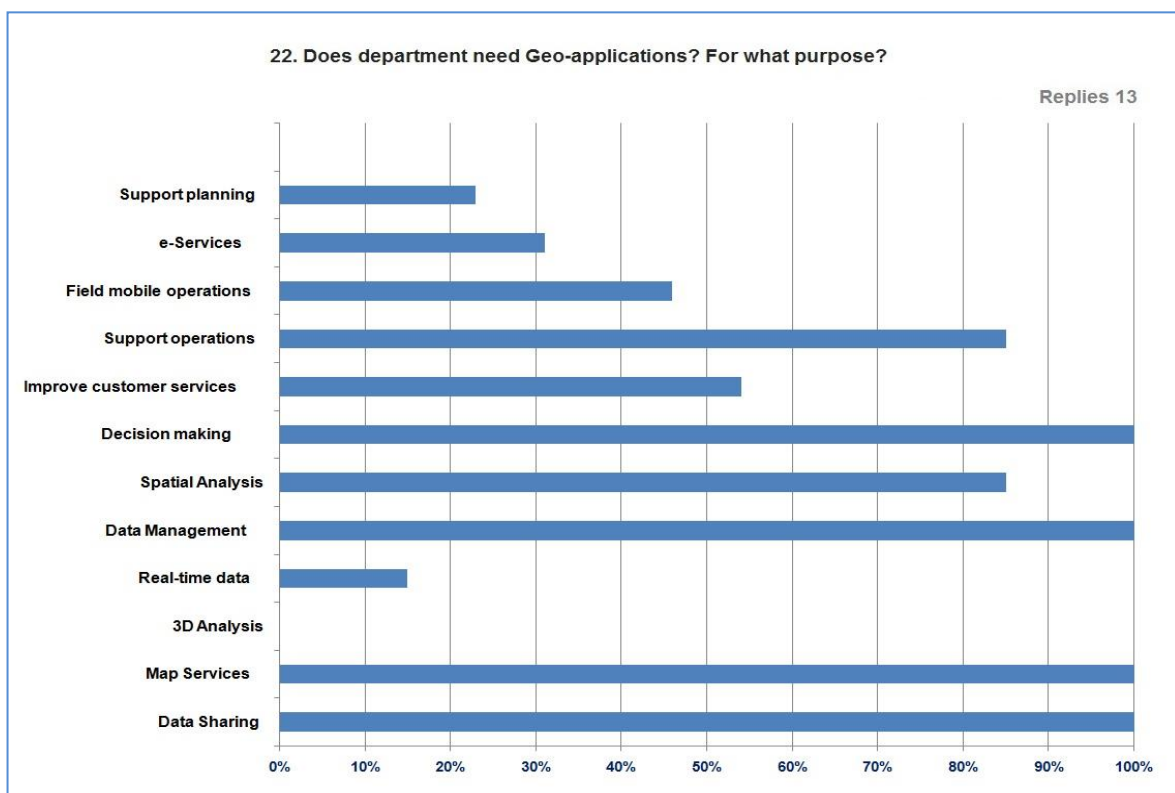


Figure 5.11: Geo-applications required

5.3.3.2. Government Agencies Questionnaire:

Three interviews were conducted in government agencies providing services to citizens:

- Branch of the Ministry of Environment, Water and Agriculture.
- Saudi Electricity Company.
- Branch of the Ministry of Transport.

The questionnaire for this purpose was filled during interviews, And we can report the findings as follows:

- One government agency of the three agencies (research sample) has a GIS unit with two GIS specialists at Saudi Electricity Company (Question 1).
- There is no fixed budget for operation and maintenance of GIS (Question 3).
- For the metadata available in the government agencies (Question 13), where the responses to the availability of metadata (Yes) scored 33%, (No) scored 67% of the total responses (Figure 5.12).

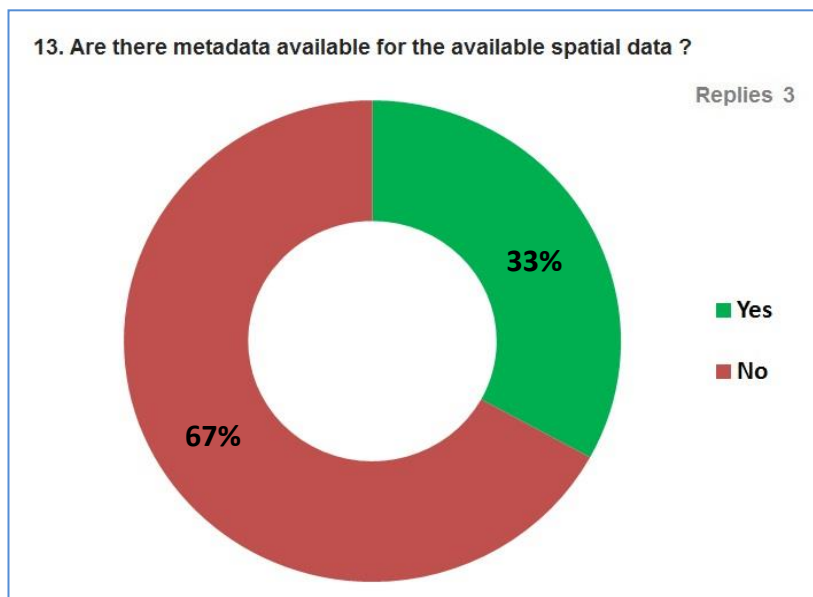


Figure 5.12: Availability of metadata

- There are no standards for database models in the three government agencies (Question 9).
- There is satisfaction in the government agency (research sample) on IT infrastructure (Question 4), at the level of hardware, network, software, and the Internet, The satisfaction rate was 67%, 67%, 100%, 67%, respectively (Figure 5.13).

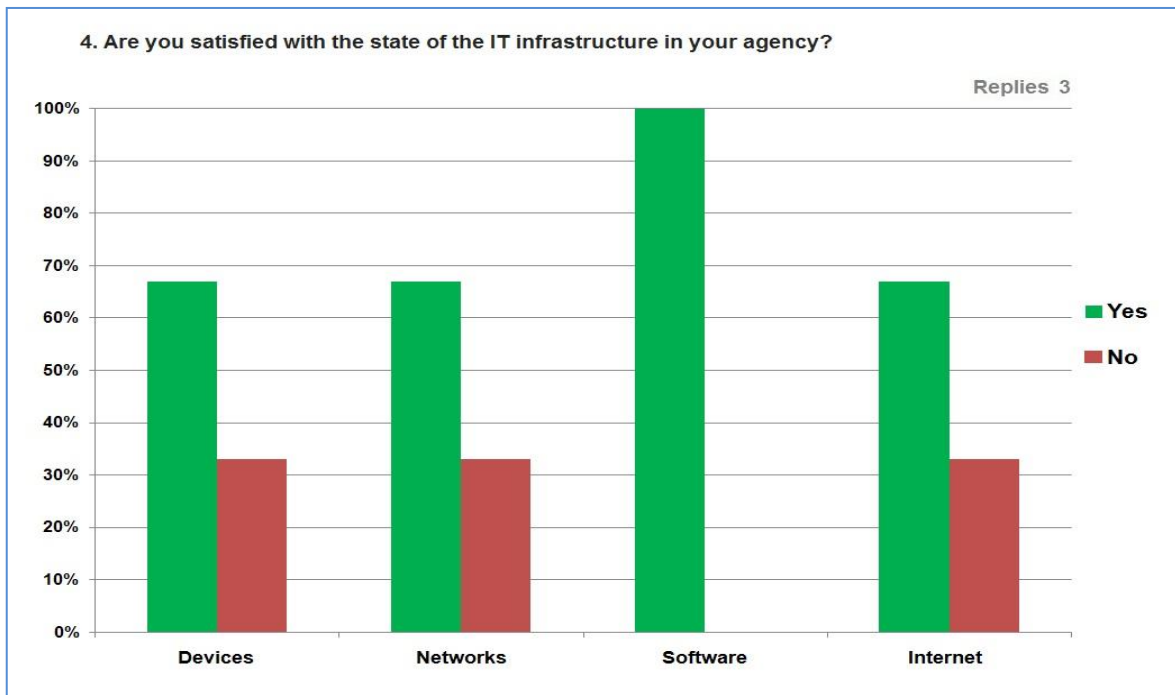


Figure 5.13: Satisfaction with the state of IT infrastructure

- For the spatial data software (Question 7), ArcGIS Desktop, Portal for ArcGIS and Microstation scored 33% of the total responses, while Google Earth and CAD scored 100% of the total responses (Figure 5.14).

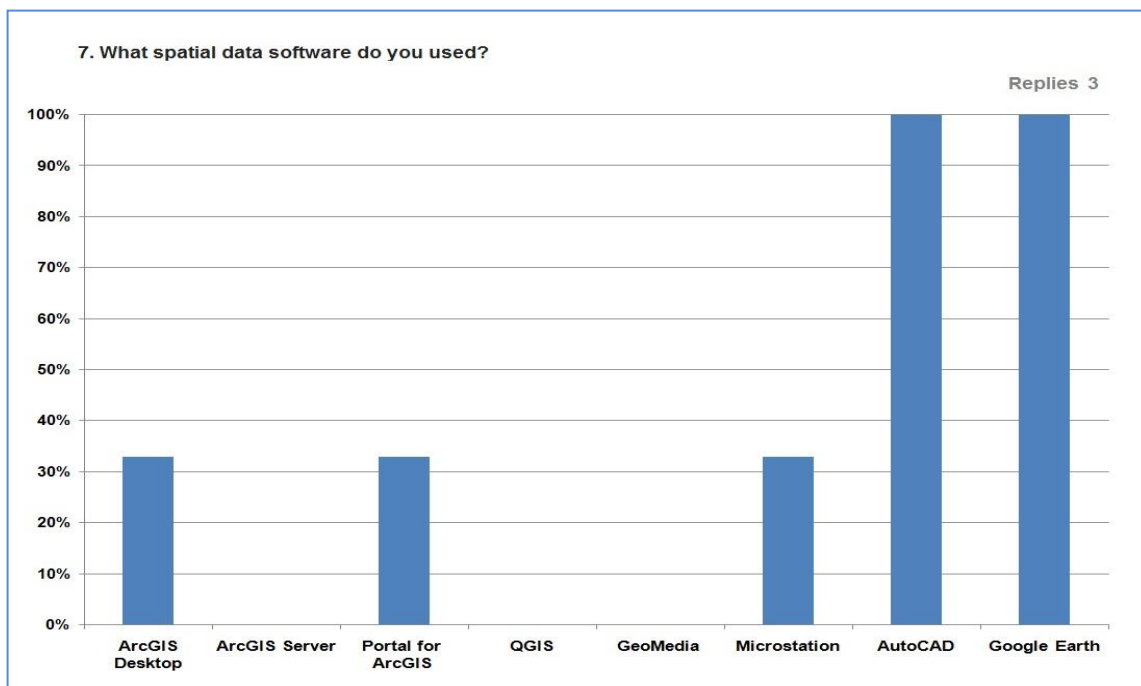


Figure 5.14: Using of the Spatial data software

- For the spatial data which required from other government agencies (Question 16), The highest response was Locations and addresses data, Land use data, Sewerage network, Administrative units, and Telecommunication network with score 100% (Figure 5.15).

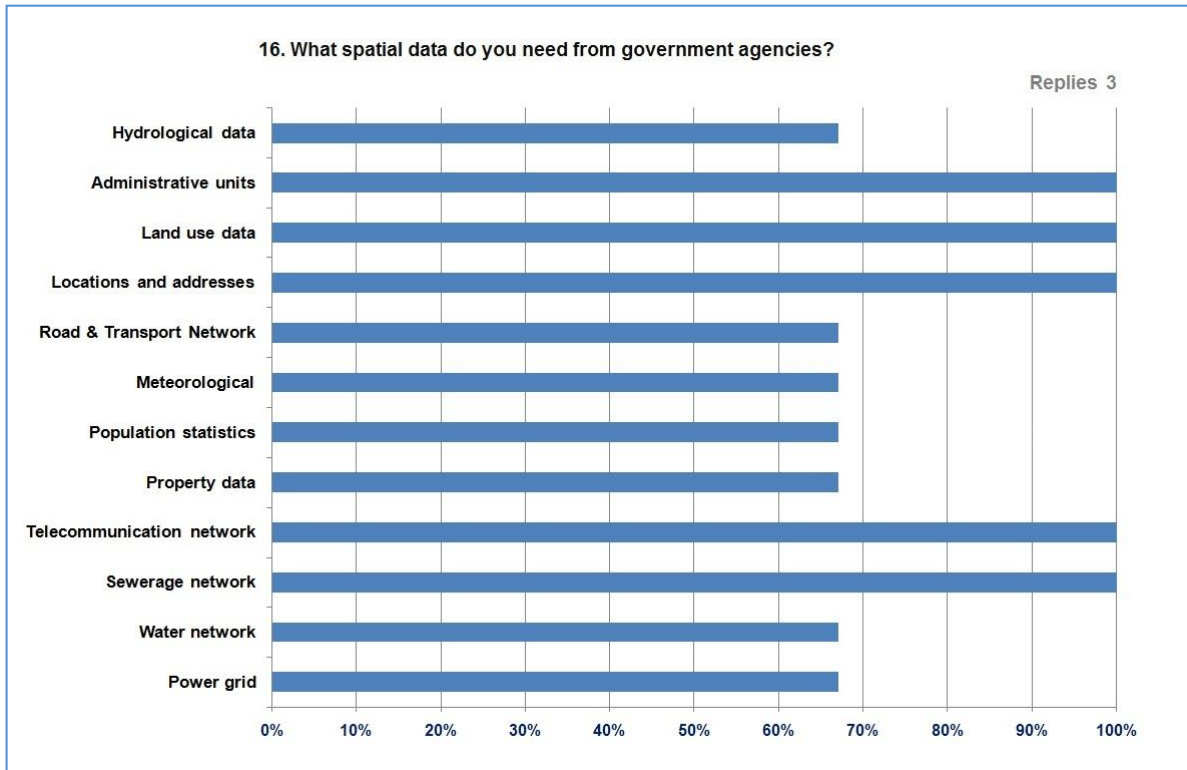


Figure 5.15: Spatial data required from other government agencies

- The findings indicated to the difficulties related to the spatial data facing the government agencies (Question 19), the responses for (No integrated Data, No metadata, and Difficulty in data access) scored 100%, and (Data not updated, Lack of statistical and non-spatial data) scored 67% of the total responses (Figure 5.16).
- About how the data homogeneity of the SDI implementation (Question 25), The highest response was Develop an interoperable framework, A unified communications environment, Use of standardized global standards and Standardization of database models with scores 100%.

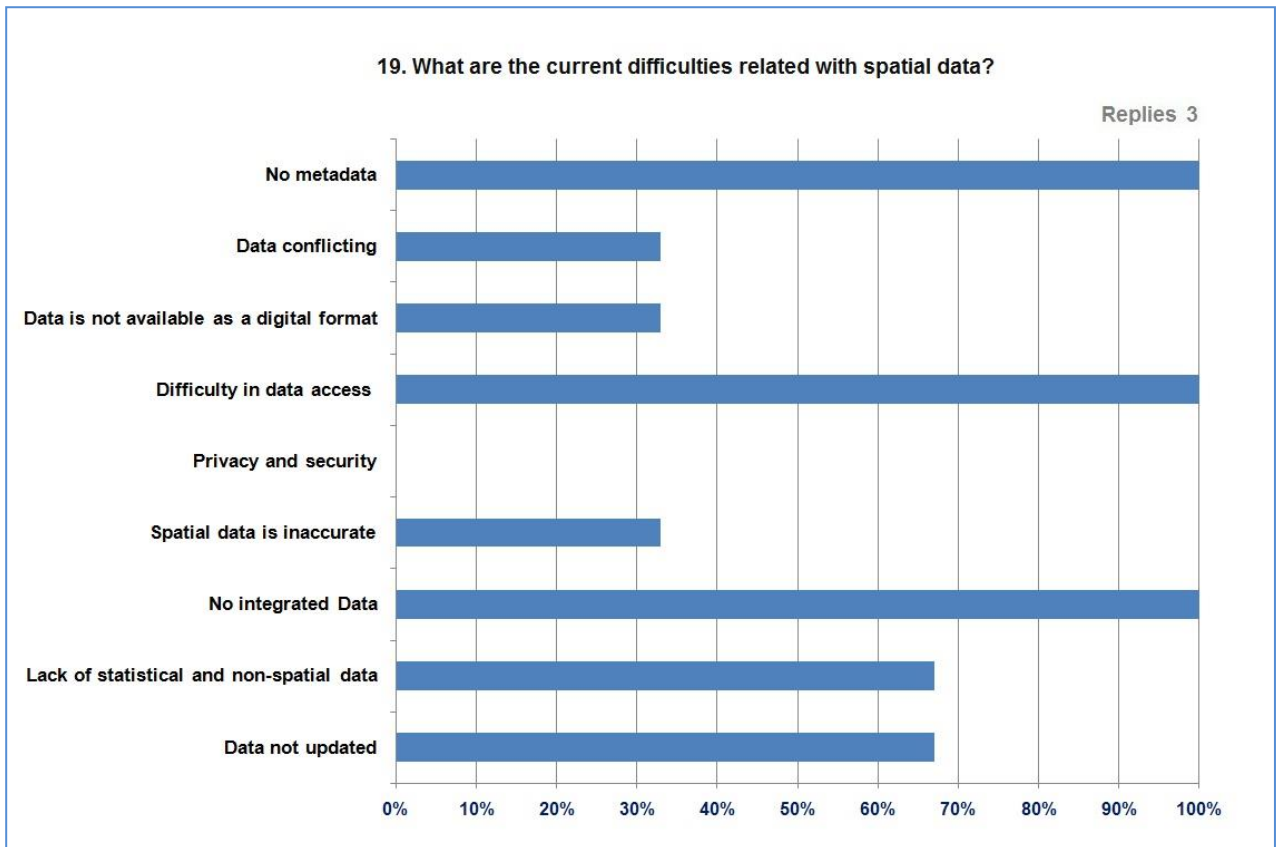


Figure 5.16: The difficulties related to spatial data

- There is a consensus on the need of government agencies to local SDI, and they also agreed that the Northern Borders Municipality is the ideal choice to host SDI in terms of spatial data quantity/qualitative and its appropriate technical and professional capacity.

5.3.3.3. SWOT Questionnaire

as mentioned before, the SWOT questionnaire targeted a wide range of GIS consultants, project managers, staff and departments manager of the municipality. It was created the questionnaire by the Google questionnaire forms service, SWOT questionnaire has been published online and sent the link to the target groups via e-mail and social media. The questionnaire was sent to 55 persons and the responses were 39 responses which representing 71%. The questionnaire consists of 7 questions Which were designed with a multiple choice system, was designed to measure the strengths and weaknesses of the GIS in the Municipality, as well as the available opportunities to build on them to improve GIS practices in the municipality, also the challenges and difficulties in using GIS in the municipality which hinder the interoperability for spatial data. We can report the questionnaire findings as follows:

- Question 1: What are the benefits of using GIS in the municipality?

The highest responses were in favor of choices (Saving time and efforts, Production of maps and reports, Ease of access to information, Digitization and storing and The ability to visualize) with scores 92.3%, 89.7, 84.6%, 82.1%, 74.4% respectively (Figure 5.17), These results reflect the uses of GIS in the municipality.

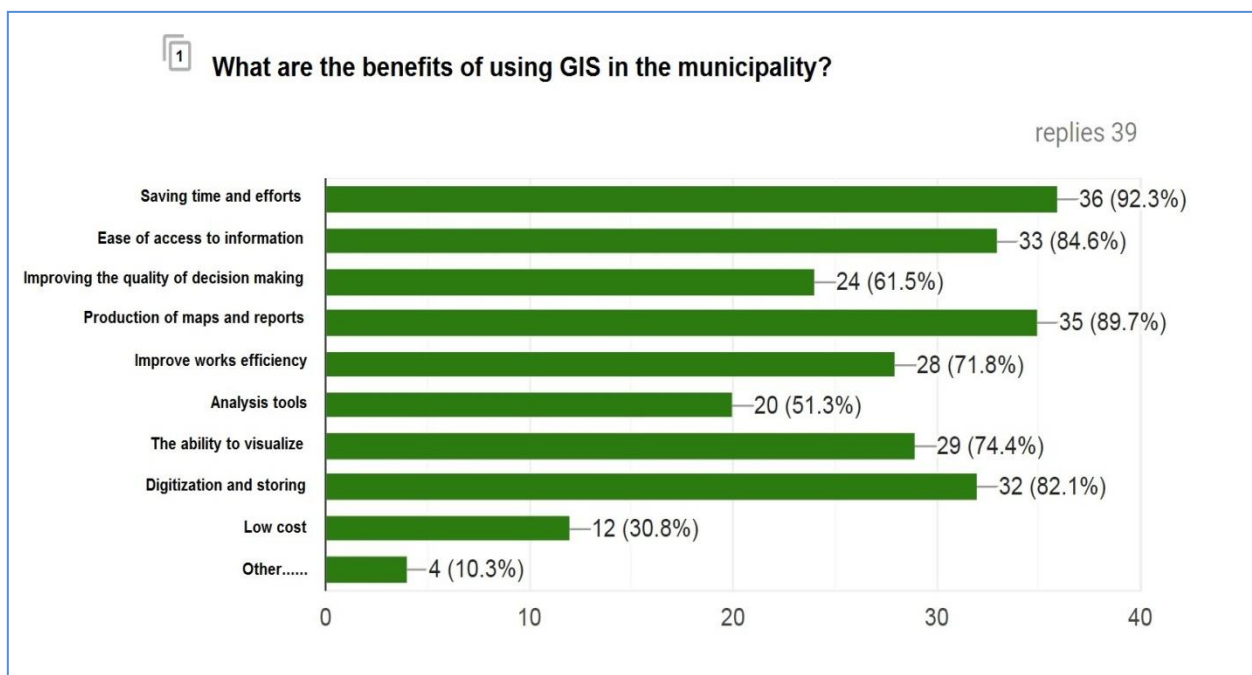


Figure 5.17: Responses of Question 1

- Question 2: What defects do you see in GIS's practices in the municipality?

The highest responses were in favor of choices (Lack of awareness of GIS, Lack of GIS specialists, No integrated Data, Lack of users experience) with scores 79.5%, 69.2%, 48.7 respectively (Figure 5.18).

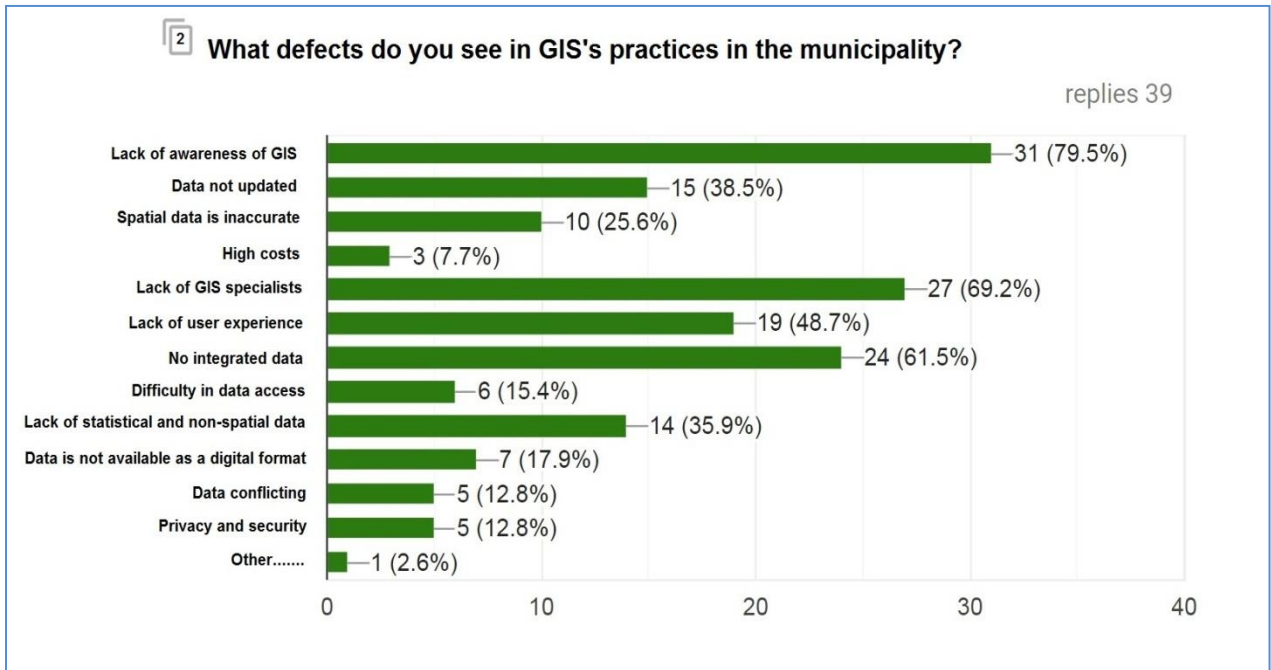


Figure 5.18: Responses of Question 2

- Question 3: What opportunities can be built upon to improve the municipal GIS?

The highest responses were in favor of choices (Availability of spatial data in a good status, Availability of appropriate IT infrastructure, National orientation towards governance and data sharing, Availability of software, GIS is a priority for upper management) with scores 79.5%, 71.8%, 66.7%, 64.1%, 53.8% respectively (Figure 5.19). The results indicate the most important opportunities available to improve GIS practices in the municipality. The results of this questionnaire are consistent with previous findings to assess the maturity model (GISCOMM) as well as a gap analysis.

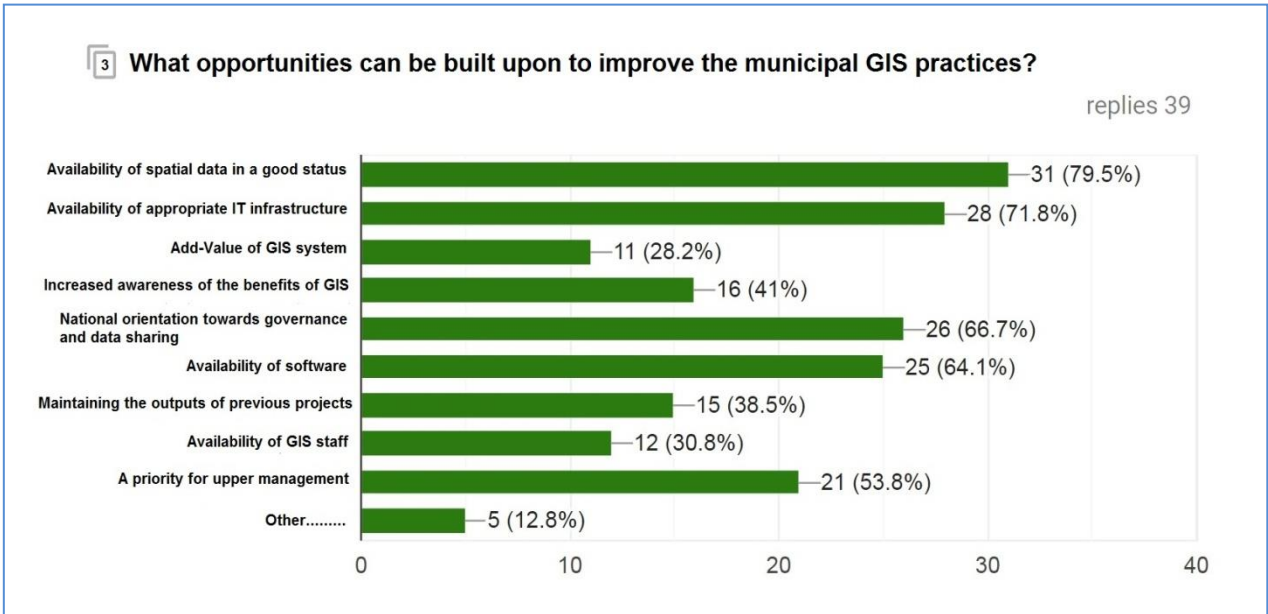


Figure 5.19: Responses of Question 3

- Question 4: What spatial data and services are you currently receiving from the GIS in the municipality?

The highest responses were in favor of choices (Printed maps, Locations, and addresses, Land use data, Measurements, Investment data, and municipal property) with scores 92.3%, 89.7%, 79.5%, 69.2%, 66.7% respectively, While the lowest responses were in favor of choices (GIS Training, Geo-Applications, Online Geo-explorer, Spatial analysis,) with scores 5.1%, 17.9%, 20.5%, 25.6% respectively (Figure 5.20). The results indicate that GIS use of the municipality is not advanced and that interoperability and data sharing services need to be improved, SDI will be an ideal solution to improve the weakness revealed by this question.

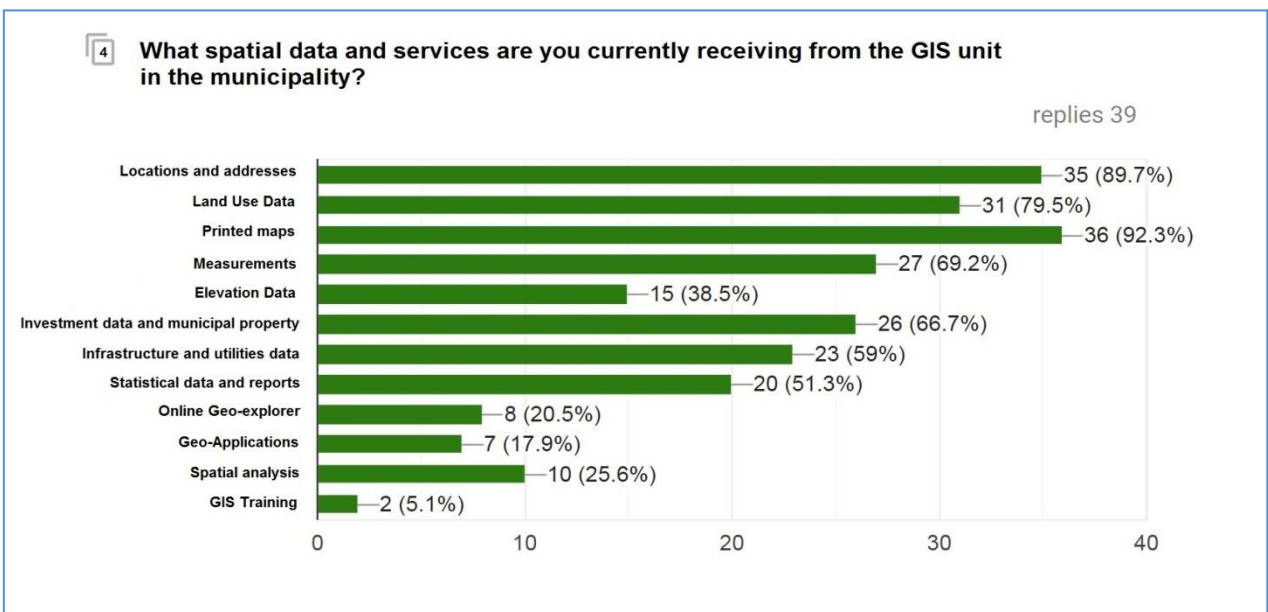


Figure 5.20: Responses of Question 4

- Question 5: How do you get spatial data?

The highest responses were in favor of choices (Hard copy (maps and reports, Digital transfer (Storage device)) with scores 74.4%, 66.7% respectively, While the lowest responses were in favor of choices (By E-mail, Central database (server)) with scores 23.1%, 46.2% respectively (Figure 5.21).

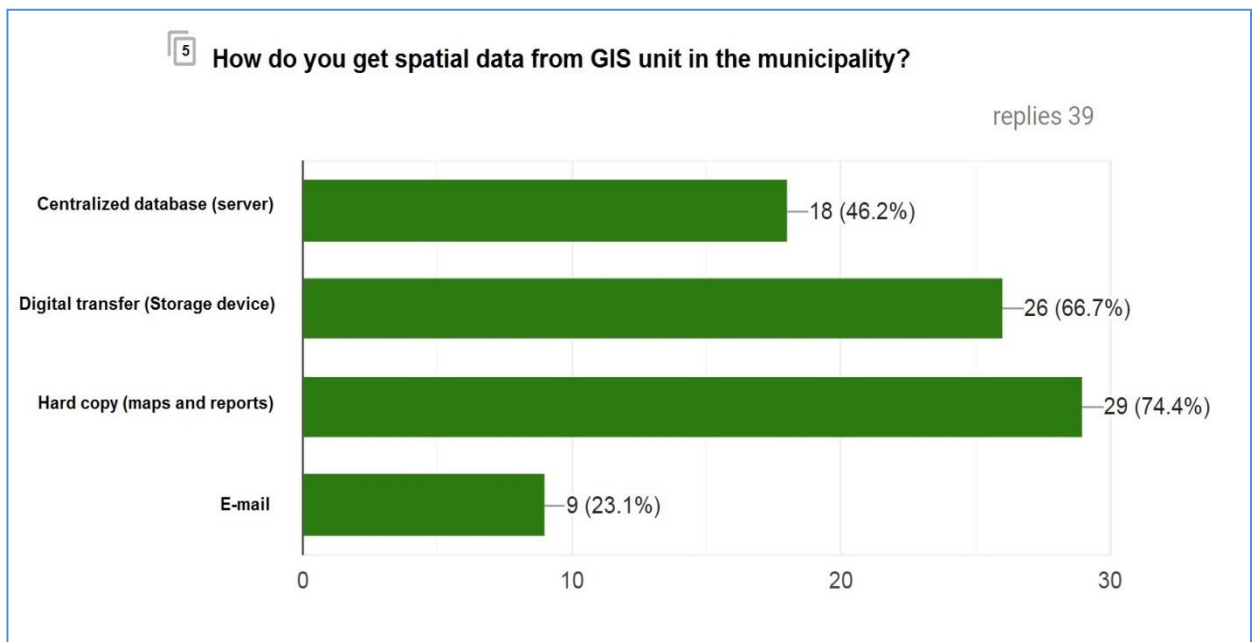


Figure 5.21: Responses of Question 5

- Question 6: In your opinion, what are the challenges that hinder the improvement of GIS practices in the municipality?

The highest responses were in favor of choices (Lack of specialized GIS staff, Lack of an organizational structure for the GIS unit, Lack of an approved development plan, there is no fixed budget for GIS, There is no exchange of data between internal departments, Lack of awareness of the advantages of GIS, No standards of data) with scores 89.7%, 82.1%, 79.5%, 76.9%, 69.2%, 66.7%, 61.5% respectively (Figure 5.22). This section of the questionnaire clearly reveals the most important challenges facing the improvement of GIS's municipal practices.

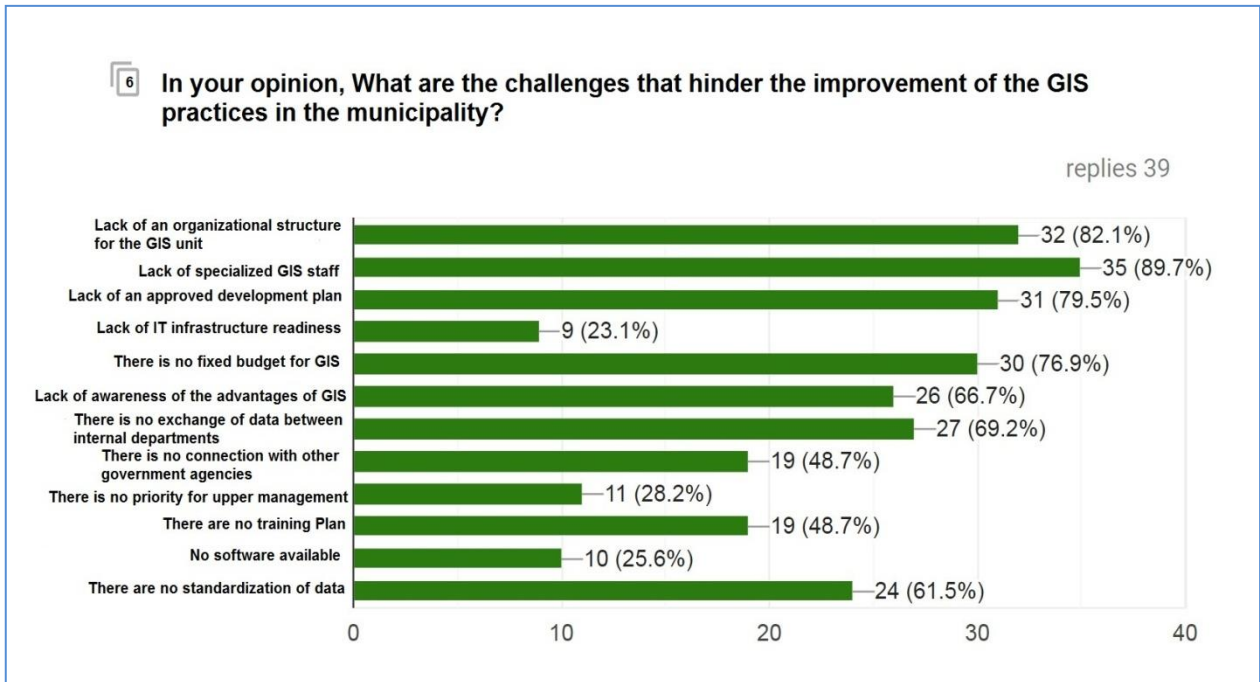


Figure 5.22: Responses of Question 6

- Question 7: In your opinion, what are the solutions and suggestions for improving the GIS practices in the municipality?

The highest responses were in favor of choices (Provide adequate GIS staff, Develop an organizational structure and define roles, Setting a defined development plan, Provision of financial resources, Interoperability through applications, Raising awareness of the advantages of GIS) with scores 97.4%, 87.2%, 82.1%, 82.1%, 71.8%, 64.1% respectively (Figure 5.23).

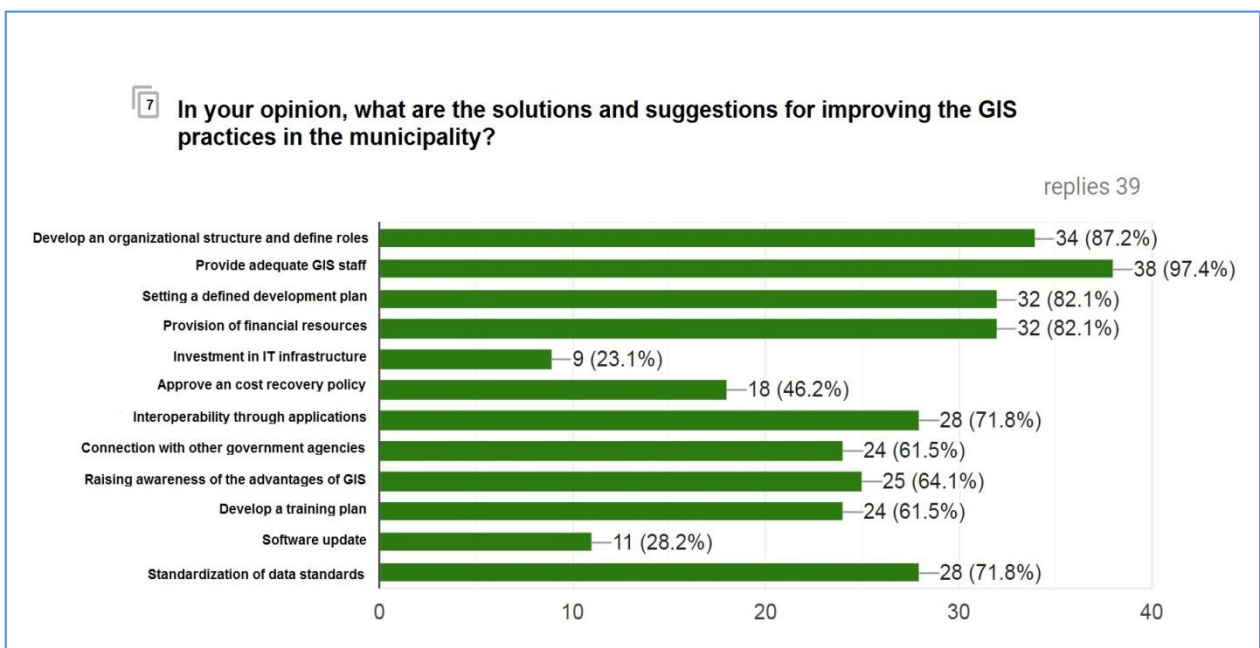


Figure 5.23: Responses of Question 7

5.3.4. Performing of GIS SWOT Analysis

The performance of SWOT analysis has required the implementation of several procedures to obtain the results and reliable information which will be relied upon (See GIS SWOT Analysis questionnaires in Appendix G). The current status of GIS practices has been assessed in terms the Spatial data, IT infrastructure, GIS staff, Financial resources, Policies and standards through several assessments and analysis tools which can be listed in the following order:

- GIS Capability Maturity Model Assessment (GISCMM)
- Data catalogue GAP Analysis
- Municipal Departments/ branches Questionnaire
- Government Agencies Questionnaire
- SWOT Questionnaire

Based on the findings and facts obtained from the implementation of these procedures we can identify of the strengths in GIS practices, and identify the opportunities and challenges of Improve GIS and transition to municipal SDI, we can perform the SWOT analysis as follows:

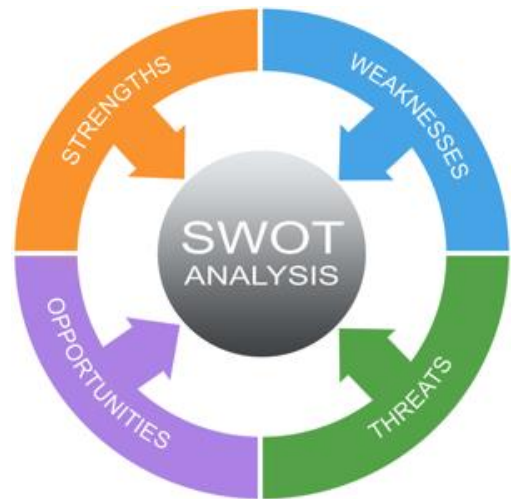


Figure 5.24: SWOT Analysis Framework

❖ STRENGTHS

The characteristics that place The Northern Borders Municipality at an advantage for Improvement GIS practice and supports the transition to municipal SDI:

- The Municipality has a good data catalogue that has been implemented in accordance with the (Data Schema) circulated by Ministry of Municipal and Rural Affairs (MOMRA), where the missing features in the municipal data catalogue do not exceed 28% of the ideal fundamental datasets catalogue according to the gap analysis conducted.

- Availability of appropriate IT infrastructure which supports the interoperability of spatial data.
- A wealth of existing Spatial data on the level of framework GIS Data and business GIS data.
- Availability of ESRI Software (Desktop, Server).
- Accumulated experiences and projects output.
- The municipality has a successful experiment with the guidance maps project in the public squares and vital places. This project has contributed to highlighting the role and importance of the municipal GIS unit and raising awareness of spatial information among the public.
- The municipality has developed an interactive web mapping application (geo-explorer) of the city, which is not working now but can easily be improved and re-published.
- The municipality has developed two applications for internal operation (municipal investment management - management and tracking of municipal projects), which can be a strong start for the municipal SDI, but the running of applications needs to update and maintenance procedures (See Arar city geo-explorer and municipal geo-applications in Appendix H).

❖ **WEAKNESSES**

The challenges which may arise for the NBM when Improvement of GIS practice and implementing a municipal SDI:

- Lack of an organizational structure for the GIS unit.
- GIS staff is inadequate.
- Lack of a development strategic plan.
- Financial resources are inadequate.
- Lack of awareness of the advantages of GIS.
- GIS operations lack defined processes and rely heavily on repeatable processes.

- Lack of metadata.
- There is no data integration.
- Lack of data standards.
- Data inaccuracies.
- There is no exchange of data between internal departments.
- Lack of training and knowledge transfer plan.
- Data update and data maintenance are not sustainable.

❖ **OPPORTUNITIES**

The items that will improve organizational effectiveness and efficiency of GIS practices, We can identify the available opportunities based on the strengths of the existing system, policies, needs, and national orientation:

- Spatial data available
- more uses of spatial data possible such as the development of applications.
- IT Infrastructure (hardware and software) is ready to support interoperability.
- Recognition of GIS advantages by department managers and users in terms of saving time, Ease of access to information, improving the quality of decision making.
- The national orientation towards governance and data sharing makes us in a great time to advance GIS and implementation of the municipal SDI.
- Develop a cost recovery plan in support of return on investment (ROI) and sustainability of the system
- Despite the modest assessment results, the Northern Borders Municipality is considered the most powerful government agency in terms of GIS practices at the spatial data, IT infrastructure, human and financial resources and previous experiences, an opportunity for the initiative to lead and manage local SDI.

- The priority of spatial information in upper management is increasing, So the development of a strategic plan to improve and develop the spatial information system will receive enthusiasm and support with adequate budgets.

❖ **THREATS**

The issues that the NBM encounter that could threaten the Improvement of GIS practice and implementing a municipal SDI:

- Not implementing an organizational structure for the GIS unit.
- Financial constraints.
- Focusing too much on other initiatives and fields at the expense of GIS (priorities shift).
- Spatial data conflicts may create chaos.
- The complexity of connecting with government agencies.
- Lack of integration between departments.
- The complexities related to data harmonization.
- Restrain department enthusiasm because of inadequate GIS staffing resources.
- Reluctance to change because of failure in culture shift.
- Legal and legislative constraints related to the cost recovery plan.
- limitations on data sharing between government agencies.

5.4. Findings Discussion And Recommendations

5.4.1. Findings Discussion

Despite the modest evaluations of some GIS components, the municipality has strengths that are the cornerstone of GIS development and improvement, in other words only a few steps away from the improved situation. The municipality has assets that have been invested in the past years such as spatial data, IT infrastructure and spatial data software,

which the constituent components or stages that receive the largest share of funding in the implementation of GIS in enterprises.

According to the findings of the gap analysis performance of the NBM data catalogue against the list of fundamental datasets, the municipality needs to restructure its data schema to add missing datasets, address the large gap in metadata and complete attribute data.

Many weaknesses and low ratings of GIS components evaluations such as GIS data maintenance, Metadata, GIS Data Coordination, Professional GIS Operations Staff, Process Event Management, GIS System Management, Operation Performance Management and User Support, Help Desk, and End-User Training were a direct result of the lack of adequate GIS specialists to meet business needs, as well as job instability of the teamwork who are working through an external contractor, which threatens the sustainability of the GIS system and the procedures of improvement, That leading to loss of the previous funding.

The questionnaires and interviews indicate that there is a big problem that the municipal GIS is unplanned, where the GIS practices in the Northern Border Municipality lack a strategic plan and a objectives business plan with a time plan. This problem is related to the problem of the absence of a specific organizational structure for the GIS unit, The municipality has also not developed a sustainable training plan to raise the professional level of the GIS team, or the users training plan.

There is a lack of awareness of the advantages of the use of spatial information in operation, maintenance and decision support, both at the municipal employees and citizens levels. More effort is needed as part of a strategic plan to raise awareness and increase the uses of GIS in order to advance GIS into the top priority of departmental managers and upper management.

The instability of budgets for the operation and maintenance of geographic systems in recent years has had a significant impact on the municipality's GIS practices, which has led to the breakdown of geo-applications and web mapping application (geo-explorer), despite

the good start of the municipality's GIS since 2006, but the situation has been temporarily frozen during the last two years .

The Ministry of Municipal and Rural Affairs (MOMRA) has developed several service applications at the national level within the framework of e-government. Most services rely on spatial data such as issuing building permits. The applications work a centralized system on the Ministry's servers. Data quality, maintenance, and updating of the data are the responsibility of the municipalities and this will be a justification for the development and improvement of the GIS practice in the municipality.

The geographic information system is fully centralized in government agencies covered by the questionnaire, where spatial data and applications are on a central server at the headquarters of the ministry. Ministry agencies do not have GIS specialists except for the Saudi Electricity Company, which has led to a lack of use of GIS in the ministry branches of the Arar city.

The results show that government agencies, in general, are not ready to be integrated into the local SDI with the municipality. The integration may be gradually agency-by-agency.

The Northern Borders Municipality is the most powerful government agency in the Northern Borders Region in terms of GIS practices in spatial data, IT infrastructure, financial and human resources, and previous experiences. Local SDI would be better to start with municipal departments/branches, then other municipalities in the Northern Borders Region (9 municipalities), then a partnership between the municipalities and the Saudi Electricity Company, where they have an appropriate situation at the moment.

5.4.2. Recommendations

Based on the above assessment of the GIS current status, outputs analysis and discussion of results we can make recommendations according to the following context:

- As an initial step, we recommend the establishment a GIS steering committee consisting of the manager of the GIS unit, the managers of the departments relevant of

the GIS or that provide services to people, financial Officer, representatives of the upper management of the municipality and government agencies. It will be the responsibility of the committee to develop an organizational structure of the GIS Unit and develop the strategic plan for the GIS and administrative supervision on the implementation of its objectives and has the responsibilities of prioritizing projects and directing investment in spatial information.

- Develop an organizational structure of the GIS Unit that includes a sufficient number of specialists and coordinators, and carefully identify and distribute roles, as well as identify and organize relationships with the municipal departments/branches and government agencies. The organizational structure must be designed according to written policies and standards, taking into account professional best practices. The organizational structures establish a consistent and efficient way to direct resources, convey information, comply with formal requirements, and ultimately accomplish the organization's mission (Croswell 2018). According to Croswell, when designing the organizational structure has to take into account the Current trends in GIS technology and services that have had a major impact on GIS program organizational structure such as cloud-based IT infrastructure, web-based mapping platforms, mobile apps and the importance of 24/7 operations and services to users. We also recommend that the department be independent and dependent directly on upper management.
- The municipality needs to increase the GIS specialists enough to meet the needs of the business and the implementation of the plan of GIS practice improvement and municipal SDI. The focusing on GIS staff growth, that is, developing and retaining GIS staff, is another key element in organizational strength and viability (ESRI 1997). Through discussions in the interviews and observations we can say that the provision of 6 GIS specialists at least with varying expertise and multiple roles consisting of three (3) specialists and technical support resources, two (2) GIS developers and one (1) GIS coordinator, with a professional director will be the engine of development and

improvement of the GIS status in the municipality, The success stories are built on champions. The objectives of the GIS strategic plan will be a key factor in determining the number and roles of the GIS staff.

- The assessment of the GIS Capability Maturity in the municipality with level 2 (Repeated Operations) indicates that the municipality urgently needs the defined processes (level 3) by establishing procedures and workflows to ensure that systems and data are well-managed, and efforts are efficient and coordinated. where the process is written down (documented) and serves to guide consistent performance within the organization, which will in turn address many weaknesses and low-rated components such as GIS Data Coordination, Replacement Plan, Service Quality Assurance, GIS System Management, GIS Governance Structure, and Operation Performance Management.
- We recommend that the Municipality take advantage of its most important opportunities: The national orientation towards governance and data sharing that makes us in perfect time to advance GIS and implementation of the municipal SDI. This is in addition to the central applications and services that work on the ministry's servers (MOMRA), which need to maintain and update the data a daily basis in the municipality, which is a great opportunity for the municipality to take responsibility and improve the GIS practices.
- The municipality should exploit the strengths of its geographic system for recovery and improvement. We recommend re-operating the web mapping application (geo-explorer) and operational geo-applications (municipal investment management - management and tracking of municipal projects) while providing a support and maintenance environment, This will be the beginning of the municipality's transition to SDI and interoperability, In addition to it would be a good publicity for the importance of spatial information and the role of GIS unit in supporting operations, Which will have an impact on the restoration of GIS to the top priority.

- According to the findings of the gap analysis performance of the NBM data catalogue against the list of fundamental datasets, The Municipality needs to improve its data schema or restructure the municipal spatial data model to address missing datasets and metadata, and need to complete missing attribute data. The data schema restructuring must abide by FGDC standards and INSPIRE data specifications based on ISO 19100 Geographic Information Standards ([See ISO 19100 Standards Series in Appendix I](#)).
- The establishment and development of a professional GIS unit at a high level of efficiency and quality to provide spatial services require good and sustainable funding. Therefore, the municipality must develop a self-financing or cost recovery plan that requires new legislation and providing marketable spatial services such as GIS Marketing, Retail, Network analysis, Hydrological analysis, Financial Services, Real Time Services, Hard & Soft copy Maps and Spatial and statistical analysis. Taking into account the balance between data sharing, which is the most important goal of SDI and the cost-recovery plan for profit from spatial services, must be balanced. The return on investment (ROI) of the use of spatial information as an added value to the national economy should also not overlook.
- According to the results of the research, the Northern Borders Municipality has a lot of defects and weaknesses such as Lack of a development strategic plan, Lack of awareness of the advantages of GIS, lack of defined processes, No data integration, Lack of data standards and Lack of training and knowledge transfer plan. It also faces many threats that may hinder the improvement of GIS practices and the dissipation of the hopes of moving to SDI. To address all these obstacles, the municipality needs to develop a geospatial Strategic Plan based on specific objectives with providing the required budgets, The strategic plans start from a survey the current situation and departmental meetings to identify needs, strengths, weaknesses, opportunities, and

threats. We recommend using the results of this research as a starting point for the development of the geospatial strategic plan of the municipality. The municipality should form a specialized committee to develop the strategic plan which focuses on the collective needs and goals of departments and the city in a coordinated fashion to maintain current investments while establishing a governance system and change management process able to respond to shifting needs and priorities. We also recommend that the municipality use experts, consultants and who have best practices from outside the municipality to participate in the development of the geospatial strategic plan, which will include spatial data, resourcing, governance, training and education, infrastructure, software and public access, and include detailed plans for the implementation of the objectives according to the following context:

➤ **GIS Strategic Plan :**

(Vision, Goals, and Objectives).

➤ **Programs:**

(GIS Work Plan, GIS Annual Needs Assessment Update and Budget).

➤ **GIS Implementation Plan:**

- GIS Capability Maturity Model
- GIS Application Strategy
- GIS Technology Strategy
- GIS Integration Strategy
- GIS Data Acquisition Strategy
- GIS Training Plan
- GIS Data Standards
- GIS Levels of Service

Chapter-6: Conclusions

Municipalities are one of the local government entities and the largest producer and provider of spatial data. It also the most in providing services to the people. GIS was applied in the municipalities of Saudi Arabia in 2003, Saudi Arabia has invested in spatial information in municipalities for 16 years. The time has come to evaluate GIS practices in municipalities to determine the current situation and move to the advanced stages. It is time to transform GIS from separated projects and isolated municipal data silos into a Spatial Data Infrastructure (SDI) that allows interoperability and exchange of spatial information among all government agencies. Maintaining the previous investment in spatial information, developing a future investment plan to move to an advanced stage, maximizing the benefits of GIS, achieving sustainability and keeping the pace of advances in spatial information technologies are the main drivers of the GIS assessment process.

This research targeted primarily the assessment of GIS practices in the municipalities as a first step to move to spatial data infrastructure (SDI) in local government (The Northern Borders Municipality as a case study). Assessing the current status and determining the maturity level of GIS practices in local government is an essential step to develop a roadmap to design and implement the of SDI in local government as well as to reap other gains from the assessment findings such as the ability to develop a strategic plan to improve GIS based on the current status to reduce the waste of funds, And help decision-makers to prioritize and promote needed GIS projects. Once strengths and weaknesses are identified, Then directing the projects towards needs.

In view of the research findings, we find that the Northern Borders Municipality at the level of (Enabling Capability) has technology components and spatial data but lack adequate professional GIS staff and an appropriate organizational structure, Is what made the municipality at the lowest level of (Execution Ability). This means that as a result of the previous projects the municipality has a good IT infrastructure, software and a large wealth of spatial data, but unfortunately does not make effective use of spatial information because of lack of organizational usage of GIS, The results of the research concluded that

the municipality needs comprehensive organizational handling, including the development of an organizational structure, geospatial strategic plan, and provision of a fixed budget for the implementation of the strategic plan, the promotion of sustainability and keeping of previous investments.

The research also concluded that the municipality must be responsible for implementation and hosting of local SDI, where the Northern Borders municipality is the most powerful government agency in the Northern Borders Region in terms of GIS practices in spatial data, IT infrastructure, financial and human resources, and previous experiences. In contrast, Other government agencies suffer from weak GIS capabilities and are not currently ready to participate in the local SDI and need to establish GIS centers.

In view of the findings and conclusions of this research, we propose recommendations for future studies and practices as follows:

- The GIS Capability Maturity Model (GISCMM) should be a component of GIS practices in municipalities and government agencies.
- The findings of this research and the recommendations of practice which presented in chapter five should be taken into account in the development of the municipal geospatial strategic plan.
- We recommend that develop programs within the strategic plan to raise awareness of the benefits of using spatial information
- Improving this research more and applying it to other municipalities and government agencies.
- We recommend further researches to address more individually detailed topics:
 - Role of geospatial strategic plans in achieving development.
 - Operational framework of local SDI.
 - Municipal SDI role in achieving municipal vision and goals.
 - Metadata role in local SDI.

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Appendix

A. Part of Municipal GIS Capability Maturity Model Questionnaire

See the full document of the GISCMM questionnaire through the link:

https://www.4shared.com/rar/fP59A3blee/GISCMM_QUESTIONNAIRE.html

MUNICIPAL GIS CAPABILITY MATURITY MODEL QUESTIONNAIRE

Organization:			
Department:		Date & Time:	
Respondents\ Name	Occupation	E-mail	

Introduction:

The purpose of the GIS maturity model is to provide a means for any organization GIS operation to gauge its maturity against a variety of standards and/or measures. Once the organization completes the questionnaire, we will have a benchmark resource for future self-assessments. The organization must be objective as possible in their self-assessment. But in any case, an accurate assessment will identify weaknesses and development priority areas. The model includes two sections to measure the capacity and Ability of the organization, in addition to the extension containing detailed questions about the framework and business GIS data.

Enabling Capability Components:

For each question in the 'Enabling Capability' section, read the brief description. Check the implementation category that best describes your agency's current status. Feel free to include any clarifying comments or questions.

EC1. Framework GIS Data

Does the agency have access to adequate framework GIS data to meet its business needs? For the GISCMM, framework data is defined as NSDI framework layers.

- 1.00 Fully implemented
- 0.80 In progress with full resources available to achieve the capability
- 0.60 In progress but with only partial resources available to achieve the capability
- 0.40 Planned and with resources available to achieve the capability
- 0.20 Planned but with no resources available to achieve the capability
- 0.00 This desired but is not planned
- Not Applicable (explanation required)

Comments:

Does your agency use recognized professional standards for this component?

Yes No

Does your agency use a formal internal standard for this component?

Yes No

Describe Documentation:

EC2. Framework GIS Data Maintenance

Are data stewards defined for each framework GIS data layer and the data is maintained (kept up to date) to meet business needs?

1.00 Fully implemented

0.80 In progress with full resources available to achieve the capability

0.60 In progress but with only partial resources available to achieve the capability

0.40 Planned and with resources available to achieve the capability

0.20 Planned but with no resources available to achieve the capability

0.00 This desired but is not planned

Not Applicable (explanation required)

Comments:

Does your agency use recognized professional standards for this component?

Yes No

Does your agency use a formal internal standard for this component?

Yes No

Describe Documentation:

EC3. Business GIS Data

Does the agency have access to adequate business data (non-framework GIS data) to meet its business needs?

1.00 Fully implemented

0.80 In progress with full resources available to achieve the capability

0.60 In progress but with only partial resources available to achieve the capability

0.40 Planned and with resources available to achieve the capability

0.20 Planned but with no resources available to achieve the capability

0.00 This desired but is not planned

Not Applicable (explanation required)

Comments:

Does your agency use recognized professional standards for this component?

Yes No

Does your agency use a formal internal standard for this component?

Yes No

Describe Documentation:

B. Part of Municipal GIS Capability Maturity Model Questionnaire Extension

See the full document of GISCMM questionnaire Extension through the link:

https://www.4shared.com/rar/fP59A3blee/GISCMM_QUESTIONNAIRE.html

QUESTIONNAIRE EXTENSION

Framework And Business GIS Data

EC1a. Framework GIS Data

Does the agency have access to adequate Geodetic Control data to meet its business needs?

[] 1.00 Fully implemented

[] 0.80 In progress with full resources available to achieve the capability

[] 0.60 In progress but with only partial resources available to achieve the capability

[] 0.40 Planned and with resources available to achieve the capability

[] 0.20 Planned but with no resources available to achieve the capability

[] 0.00 This desired but is not planned

[] Not Applicable (explanation required)

Comments:

Does your agency use recognized professional standards for this component?

Yes No

Does your agency use a formal internal standard for this component?

Yes No

Describe Documentation:

EC1b. Framework GIS Data

Does the agency have access to adequate Cadastral data to meet its business needs?

- 1.00 Fully implemented
- 0.80 In progress with full resources available to achieve the capability
- 0.60 In progress but with only partial resources available to achieve the capability
- 0.40 Planned and with resources available to achieve the capability
- 0.20 Planned but with no resources available to achieve the capability
- 0.00 This desired but is not planned
- Not Applicable (explanation required)

Comments:

Does your agency use recognized professional standards for this component? Yes No

Does your agency use a formal internal standard for this component? Yes No

Describe Documentation:

EC1c. Framework GIS Data

Does the agency have access to adequate Orthoimagery data to meet its business needs?

- 1.00 Fully implemented
- 0.80 In progress with full resources available to achieve the capability
- 0.60 In progress but with only partial resources available to achieve the capability
- 0.40 Planned and with resources available to achieve the capability
- 0.20 Planned but with no resources available to achieve the capability
- 0.00 This desired but is not planned
- Not Applicable (explanation required)

Comments:

Does your agency use recognized professional standards for this component? Yes No

Does your agency use a formal internal standard for this component? Yes No

Describe Documentation:

EC1d. Framework GIS Data

Does the agency have access to adequate Elevation data to meet its business needs?

- 1.00 Fully implemented
- 0.80 In progress with full resources available to achieve the capability
- 0.60 In progress but with only partial resources available to achieve the capability
- 0.40 Planned and with resources available to achieve the capability
- 0.20 Planned but with no resources available to achieve the capability
- 0.00 This desired but is not planned
- Not Applicable (explanation required)

Comments:

- Does your agency use recognized professional standards for this component? Yes No
- Does your agency use a formal internal standard for this component? Yes No

C. Data Catalogue of The Northern Borders Municipality

Feature Dataset	Feature Class	Abstract	Purpose	Update Frequency
Administrative Boundaries	Amanat	Area of Amanat in polygon feature class	To establish the Amanat and to be used for mapping	As needed
	Amanat_Centroids			
	City_Boundaries	Boundary of city in polygon feature class	To delineate the city region	As needed
	City_Centroids			
	District_Centroids			
	Districts	Area of District in polygon feature	To establish the District and to be used for mapping	Unknown
	Governorate	Area of Governorate in polygon feature	To establish the Governorate and to be used for mapping.	Unknown
	Governorate_centroid			
	International_Boundary	International boundary of Saudi Arabia in polygon feature class	To demarcate the international boundary of Saudi Arabia	Unknown
	International_boundry_lines			
	Municipalities	Boundary of Municipality in polygon feature class	To establish Municipality region and to be used for mapping.	Unknown
	Municipality_Centroids			
Region_Centroids				

	Regions	Area of Region in polygon feature	To delineate Region and to be used for mapping.	As needed
	Sectors	Area of Sectors in polygon feature class	To delineate different sectors in the region	As needed
	Sectors_Centroids			
	Sub_Municipality_Centroids			
	SubDistricts	Area feature class showing subdivision of district.	To establish Sub-Districts and to be used for mapping.	As needed
	SubMunicipalities	Area feature class showing subdivision of Municipalities.	To establish Sub-Municipalities and to be used for mapping.	As needed
Cadastral Dataset	Block_Centroids			
	Blocks	Area feature class depicting Block in polygon feature class	To be used for mapping application	As needed
	Building_Centroids			
	Buildings	Outline of all constructed buildings within the region	To be used for mapping applications and for graphics presentation.	Continually
	EasementRights	Feature class depicting Easement rights.	To be used for mapping.	As needed
	Parcel_Centroids			
	Parcel_lines			
	Parcels	A piece or unit of land, defined by a series of measured straight or curved lines.	To be used for mapping application	Continually
	SubParcel_Centroids			
	SubParcels	Area feature class showing subdivision of parcels .	To be used for mapping application	As needed
Climate Dataset	Climate_regions	Area feature class showing the climatic regions of Arar	To be used for mapping application and graphical representation	As needed
	Meteorology_stations	Features depicting Meteorology stations within the region	To be used for mapping application and graphical representation	As needed
Demography Dataset	Cesus_blocks	Outline of administrative blocks for census blocks.	To be used for mapping application and graphic representation.	As needed
Environmental Dataset	Air_quality_stations	Feature depicting the Air Quality Station.	To be used for mapping application and graphic representation.	As needed
	Environmental_zoning	Mapped zones that separate one environmental division to another.	To be used for mapping application and graphic representation.	As needed
	Flood_Areas	Area feature class showing flood areas	To be used for mapping.	As needed
	Land_cover	The classification of land according to the vegetation or material that covers most of its surface.	To be used for mapping.	As needed
	Noise_pollution_points	Points displaying the Noise pollution locations.	To be used for mapping.	As needed
	Protected_areas	Feature class showing the protected areas of the region.	To be used for mapping application and graphic representation.	As needed
	Solid_waste_dump	Locations showing the Solid waste dump.	To be used for mapping.	As needed
Geology Hydrography	Aquifers	Area showing the distribution of aquifers	To be used for mapping	As needed

	Catchment_areas	Area showing an extent of land where water from precipitation drains into a body of water	To be used for mapping and graphic representation.	As needed
	Dams	Feature class depicting the distribution of Dams	To be used for mapping and graphic representation.	As needed
	Desalination_stations	Point feature class showing the location of Desalination stations.	To be used for mapping	As needed
	Geology	Area showing the Geology of the region.	To be used for mapping and graphic representation.	As needed
	Geology_lines			
	Geology_point			
	Hydrogeology	Feature depicting Hydrogeology of the region	To be used for mapping and graphic representation.	As needed
	Seas	Outline of the stretch of sea	To be used for mapping.	As needed
	Shore_lines	Lines representing fringe of land at the edge of Sea.	To be used for mapping.	As needed
	Soil	The feature class showing the different kinds of soils in the region	To be used for mapping and graphic representation.	As needed
	Springs	Location showing the site where the aquifer surface meets the ground surface.	To be used for mapping and graphic representation.	As needed
	Wadi	Valley or dry Riverbed that contains water during heavy rain.	To be used for mapping and graphic representation.	As needed
	Wadi_lines	Lines showing Valley line or dry Riverbed line (Line of an intermittent stream)	To be used for mapping	As needed
	Water_courses	Area of water course in Line Feature class	To be used for mapping	Continually
	Water_tanks	Point feature class depicting the distribution of Water Tanks within the region	To be used for mapping	Continually
	Wells	Point feature class depicting the distribution of well within the region	To be used for mapping	Continually
History Dataset	N/A			
Imagery Dataset	N/A			
Land Use Dataset	Approved_landuse_plans	Feature class depicting different region where Landuse plans are approved	To be used for mapping and graphical representation	Continually
Natural Resources Dataset	Arable	Area feature class depicting regions which are suitable for growing crops	To be used for mapping and graphical representation	Continually
	Gas_fields	Area showing the distribution of Gas field	To be used for mapping and graphical representation	Continually
	Gas_wells	Point Feature class depicting the distribution of Gas wells	To be used for mapping and graphical representation	Continually
	Mineral_mines	Location depicting Mineral Mines in the region	To be used for mapping and graphical representation	Continually
	Mineral_wealth	Feature class showing the distribution of Mineral Wealth in the region	To be used for mapping.	Continually
	Oil_fields	Area representing the distribution of Oil field	To be used for mapping	Continually
	Oil_wells	Locations showing the distribution of Oil wells	To be used for mapping	Continually

References Dataset	Index_references	Area of Index References in polygon Feature class.	To be used for mapping	As needed
	Push_pin	Location of Push Pin in point Feature class.	To be used for mapping and graphical representation	As needed
Services Dataset	Educational_Facilities	Location showing the educational facilities in the region	To be used for mapping and graphical representation	As needed
	Health_centers	Point Feature class depicting the distribution of health centers of the region.	To be used for mapping and graphical representation	As needed
	Parks	Point Feature class depicting the distribution of Parks in the region.	To be used for mapping and graphical representation	As needed
	Public_services	Location depicting the list of Public Amenities in the region.	To be used for mapping.	As needed
	Religious_facilities	Location depicting the list of Religious Facilities in the region.	To be used for mapping.	As needed
	Touristic_sites	Point location showing Touristic Sites	To be used for mapping and graphical representation	As needed
Topography Dataset	Contour_lines	Line Feature class joining points(elevation) of equal height of the region	To be used for mapping and graphical representation	As needed
	Ground_controlpoints	Accurately surveyed coordinate locations for physical feature that can be identified on the ground.	To be used for mapping	As needed
	Spot_elevation_points	List of elevation measurement taken at a single location.	To be used for mapping	As needed
Transportation Dataset	AirPorts	Feature class showing the location of AirPort	To be used for mapping	As needed
	Bridges	This Feature class contains digitized bridges.	To be used for mapping and graphical representation	As needed
	Curbs	Lines representing curbs/raised pavement.	To be used for mapping and graphical representation	As needed
	Intersections	Feature class showing the location of Intersections	To be used for mapping	
	Railway_stations	Location of Railway station in Point feature class.	To be used for mapping and graphical representation	As needed
	Railways	Digitized outline of Railway line.	To be used for mapping and graphical representation	As needed
	Road_Furnitures	Feature class showing the location of Road	To be used for mapping	Continually
	Road_Polygons	Primary, Secondary and Tertiary roads of Arar in Polygon Feature class	For querying, address mapping, planning and development of road network.	Continually
	Roads	Primary, Secondary and Tertiary roads of Arar in Line Feature class	For querying, address mapping, planning and development of road network.	Continually
	Roads_Edges	Digitized outline of Roads Edges	To be used for mapping and graphical representation	As needed
	SeaPorts	Feature class showing the location of Sea Ports	To be used for mapping and graphical representation	As needed
	Tunnels	This Feature class contains digitized Tunnels	To be used for mapping	As needed
	UnderPasses	Digitized outline of Under Passes	To be used for mapping	As needed

	WalkingPasses	Digitized outline of Walking Passes	To be used for mapping	Continually
Urban Dataset	Crowded_rural	Feature class showing the location of Crowded rural	To be used for mapping and graphical representation	As needed
	Direction_of_Urban_Development	Digitized outline of Direction of Urban Development	To be used for mapping and graphical representation	As needed
	Growth_centers	Feature class showing the location of Growth centers	To be used for mapping and graphical representation	As needed
	Historical_growth	Feature class showing the region of Historical growth	To be used for mapping and graphical representation	As needed
	Industrial_centralization	Feature class showing the location of Industrial centralization	To be used for mapping and graphical representation	As needed
	Metropolitan_areas	Digitized region of Metropolitan area	To be used for mapping and graphical representation	As needed
	Structure_plan	Digitized Structure plan in polygon Feature class	To be used for mapping	Continually
	StructurePlanLines			
	Trend_extrapolation	Digitized outline of Trend extrapolation	To be used for mapping	As needed
	Urban_area_points	Feature class showing the location of Urban area points	To be used for mapping	As needed
	Urban_centers	Feature class showing the location of Urban centers	To be used for mapping and graphical representation	As needed
	Urban_constraints	Digitized region of Urban constraints	To be used for mapping	As needed
	UrbanAreaBoundaries	Boundary of Urban area in polygon feature class.	To be used for mapping and graphical representation	Continually
Utility Dataset	Electrical_facilities	Feature class showing the location of Electrical facilities	To be used for mapping and graphical representation	Continually
	Electrical_lines	Digitized outline of Electrical lines	To be used for mapping and graphical representation	Continually
	Storm_water_lines	Digitized outline of Storm water lines	To be used for mapping	Continually
	Telecom_facilities	Feature class showing the location of Telecom facilities	To be used for mapping and graphical representation	Continually
	Telecom_lines	Digitized outline of Telecom lines	To be used for mapping and graphical representation	As needed
	Waste_water_facilities	Feature class showing the location of Waste water facilities	To be used for mapping	Continually
	Waste_water_pipes	Digitized outline of Waste water pipes	To be used for mapping	Continually
	Water_facilities	Feature class showing the location of Water_facilities	To be used for mapping	Continually
	Water_pipes	Digitized outline of Water pipes	To be used for mapping and graphical representation	Continually

D. Interviews Schedule

Name	Organization/department	Occupation	Time & Date
Mr. Sultan El Hadi	NBM / Urban Planning Department	Head of Planning section	10:00 AM,31/1/2019
Mr.Taib Al Enzi	NBM / Urban Planning Department	Manager of Urban Planning Department	10:45 AM,31/1/2019
Mr.Abdallah Smayan	NBM / IT Department	IT Manager	10:15 AM, 3/2/2019
Mr.Mohamed Ahamed	NBM / IT Department	GIS Specialist	10:15 AM, 3/2/2019
Mr. Abdalziz Al hazal	NBM / IT Department	IT infrastructure Manager	11:00 AM, 3/2/2019
Mr.Ahamed Saafaq	NBM / Survey Department	Deputy Director of Survey Department	10:00 AM,4/2/2019
Mr.Sultan Kandill	NBM/Agency of Reconstruction and Projects	Manager of Reconstruction and Projects Agency	10:45 AM,4/2/2019
Mr. Khaled Al Enzi	Branch of the Ministry of Environment, Water, and Agriculture	Manager of Projects Department	10:30 AM,5/2/2019
Mr.Abd Al Majeed Mbird	Saudi Electricity Company/ GIS Unit	GIS Specialist	03:00 PM,5/2/2019
Mr.Abd Al Rahman Al Koumi	Saudi Electricity Company/ GIS Unit	GIS Specialist	03:00 PM,5/2/2019
Mr.Fahad Al-Taweeli	NBM/ Department of Municipal Investment Development	Manager of Investment Development	09:00 AM,6/2/2019
Mr.Nowaf Al Enzi	NBM/ Projects Coordination Department	Manager of Projects Coordination Department	09:45 AM,6/2/2019
Mr. Muhand al-Dakhil	NBM / Agency of Services	Manager of Services Agency	10:30 AM,6/2/2019
Mr.Jasser Dahawi	NBM / Land and Property Department	Deputy Director of Land and Property Department	10:00 AM,7/2/2019
Mr.Abdulrahman Mohamed	NBM / Land and Property Department	technical assistant	10:00 AM,7/2/2019
Mr. Ahmed Attia	NBM/ Agency of Reconstruction and Projects	Manager of Project studies and consultant on municipal projects	10:45 AM,7/2/2019
Mr. Islam Ahmed	NBM / Urban Planning Department	Manager of Project of preparing local and detailed plans	10:00 AM,10/2/2019
Mr. Mohamed Rateb	NBM / Projects and Studies Department	Manager of preparing of the strategic plans for hydrological studies project	10:45 AM,10/2/2019
Mr. Farhan al-Ruwaili	Municipality Branch - East Arar	Head of Municipality Branch - East Arar	10:00 AM,11/2/2019
Mr. Musaed Al Enzi	Municipality Branch - West Arar	Services Hall Supervisor	11:30 AM,11/2/2019
Mr. Abdul Aziz Eid	Branch of the Ministry of Transport	projects engineer	01:00 PM,11/2/2019

QUESTIONNAIRE
GIS Practices in The Government Agencies

Organization:			
Department:		Date & Time:	
Respondents\ Name	Occupation	E-mail	

Introduction

This questionnaire aims at assessing the use of geographic information systems (GIS) in government agencies and determining the readiness of government agencies to sharing and exchange spatial data through the spatial data infrastructure (SDI) in the local government. The questionnaire consists of 27 questions to measure and evaluate aspects of GIS practices in terms of human resources and spatial data, IT Infrastructure and standards and policies.

1. Does the Agency have a GIS unit? How many GIS Staff?

- Yes No
 1 employee 2 employees 3 - 5 employees More than 5 employees

2. What are the difficulties and problems related to the GIS staff?

- Lack of GIS specialists Lack of organizational structure and specific roles
 Lack of adequate equipment Difficulty in data access Other.....

3. Is there a fixed budget for the operation of GIS?

- Yes No

4. Are you satisfied with the level of IT infrastructure and communication network at your Department?

- Devices Yes No
- Networks Yes No
- Software Yes No
- Internet Yes No

5. What devices do you have?

- PC Server Scanner GPS devices laptop
- Printer Plotter Other

6. What operating systems are used?

- Windows Linux Other

7. What spatial data software do you use?

- ArcGIS Server ArcGIS Desktop QGIS Portal for ArcGIS
- GeoMedia Microstation AutoCAD Google Earth
- Other

8. What spatial database software do you use?

- Oracle SQL Server File Geodatabase MS Access
- Postgres MS Excel Other

9. Is there a model design for the (Data Model)?

- Yes No

Explanation / Documents:

.....

10. Are there any standards for the (GIS Data Model)?

- Spatial coding standards Coordinate system Land uses Label fields

Explanation / Documents:.....

11. Are there any information security standards?

- Yes No

12. What spatial data do you already have or are produced by the agency through day-to-day transactions?

- | | |
|---|---|
| <input type="checkbox"/> Locations and addresses | <input type="checkbox"/> Statistical data and reports |
| <input type="checkbox"/> Land use data | <input type="checkbox"/> Survey data |
| <input type="checkbox"/> Elevation data | <input type="checkbox"/> Satellite images |
| <input type="checkbox"/> Administrative units | <input type="checkbox"/> Hydrological data |
| <input type="checkbox"/> Investment data and municipal property | <input type="checkbox"/> Ground control points |
| <input type="checkbox"/> Infrastructure and utility data | <input type="checkbox"/> Other |

13. Are there metadata available for the available spatial data?

- Yes No

Explanation / Documents:

.....

14. What is the reference for the coordinate system used for spatial data?

- Ain el Abd WGS1984 Other

15. What spatial data or services do you need?

- | | |
|--|---|
| <input type="checkbox"/> Locations and addresses | <input type="checkbox"/> Hydrological data |
| <input type="checkbox"/> Land use data | <input type="checkbox"/> Investment data and municipal property |
| <input type="checkbox"/> Administrative units | <input type="checkbox"/> Infrastructure and utility data |
| <input type="checkbox"/> Elevation data | <input type="checkbox"/> Statistical data and reports |
| <input type="checkbox"/> Measurements | <input type="checkbox"/> Online Geo-explorer |
| <input type="checkbox"/> Printed maps | <input type="checkbox"/> Geo-Applications |
| <input type="checkbox"/> Survey data | <input type="checkbox"/> Spatial analysis |
| <input type="checkbox"/> Satellite images | <input type="checkbox"/> Other..... |

16. Do spatial data need from other government agencies? What is this data?

Yes No

Required Data	Coordinates Reference	Data Format	Data Provider
	<input type="checkbox"/> Ain el Abd <input type="checkbox"/> WGS 1984	<input type="checkbox"/> GIS <input type="checkbox"/> CAD <input type="checkbox"/> Printed Map <input type="checkbox"/> Service <input type="checkbox"/> Satellite Image <input type="checkbox"/> Other:.....	
	<input type="checkbox"/> Ain el Abd <input type="checkbox"/> WGS 1984	<input type="checkbox"/> GIS <input type="checkbox"/> CAD <input type="checkbox"/> Printed Map <input type="checkbox"/> Service <input type="checkbox"/> Satellite Image <input type="checkbox"/> Other:.....	

17. How do you get spatial data?

- Central database (server) Hard copy (maps and reports)
 Digital (Storage device) E-mail
 Other.....

18. Are there spatial data exchange agreements with agencies and institutions?

Yes No

19. What are the current difficulties related to spatial data?

- Data not updated Difficulty in data access
 Lack of statistical and non-spatial data Data is not available as a digital format
 No integrated Data Data conflicting
 Spatial data is inaccurate No metadata
 Privacy and security Other.....

20. Are there applications for GIS?

Yes No

Explanation / Documents:

.....

21. Are there geo-applications available to the public or government agencies?

Yes No

Explanation / Documents:

.....

22. Does department need Geo-applications? For what purpose?

- | | | |
|--|--|---|
| <input type="checkbox"/> Data Sharing | <input type="checkbox"/> Map Services | <input type="checkbox"/> 3D Analysis |
| <input type="checkbox"/> Real-time data | <input type="checkbox"/> Data Management | <input type="checkbox"/> Spatial Analysis |
| <input type="checkbox"/> Decision making | <input type="checkbox"/> Improve customer services | <input type="checkbox"/> Support operations |
| <input type="checkbox"/> Field mobile operations | <input type="checkbox"/> e-Services | <input type="checkbox"/> Support planning |

23. Are there e-services linked to GIS?

Yes No

Explanation / Documents:

.....

24. In your opinion, do agency need local SDI?

Yes No

25. In your opinion, how is the integration of spatial data in a unified structure of SDI?

- | | |
|---|--|
| <input type="checkbox"/> Use of standardized global standards | <input type="checkbox"/> Develop a dictionary of spatial data used |
| <input type="checkbox"/> Standardization of database models | <input type="checkbox"/> Provide metadata |
| <input type="checkbox"/> Develop an interoperable framework | <input type="checkbox"/> Standard data formats |
| <input type="checkbox"/> A unified communications environment | <input type="checkbox"/> Other..... |

26. Do you support holding more meetings and workshops among managers of government agencies to discuss SDI policy and standards issues?

- Yes No

27. In your opinion, which government agency has more spatial data, qualifications and capabilities to host SDI?

- | | |
|--|---|
| <input type="checkbox"/> Northern Borders Municipality | <input type="checkbox"/> Ministry of Transport |
| <input type="checkbox"/> Saudi Electricity Company | <input type="checkbox"/> Ministry of Environment, Water and Agriculture |
| <input type="checkbox"/> Statistics Authority | <input type="checkbox"/> Other |

Thanks for your response..

QUESTIONNAIRE

GIS Practices in Municipal Departments and Branches

Organization:			
Department:		Date & Time:	
Respondents\ Name	Occupation	E-mail	

Introduction

This questionnaire aims at assessing the use of geographic information systems (GIS) in municipal departments and branches and determining the readiness of municipal departments to sharing and exchange spatial data through the spatial data infrastructure (SDI) in local government. The questionnaire consists of 26 questions to measure and evaluate aspects of GIS practices in terms of human resources and spatial data, IT Infrastructure and standards and policies.

1. Does department have GIS specialists?

Yes No

1 employee 2 employees 3 - 5 employees More than 5 employees

2. What is the level of awareness among the staff of the department in the use of GIS?

Poor Moderate High

3. Is the department/branch connected to the IT infrastructure and municipal communication network?

Yes No

4. Are you satisfied with the level of IT infrastructure and communication network at your Department?

Devices Yes No

Networks Yes No

Software Yes No

Internet Yes No

5. What devices do you have?

- PC Server Scanner GPS devices laptop
 Printer Plotter Other

6. What operating systems are used?

- Windows Linux Other

7. What spatial data software do you use?

- ArcGIS Server ArcGIS Desktop QGIS Portal for ArcGIS
 GeoMedia Microstation AutoCAD Google Earth
 Other

8. What spatial database software do you use?

- Oracle SQL Server File Geodatabase MS Access
 Postgres MS Excel Other

9. Is there a model design for the (Data Model)?

- Yes No

Explanation / Documents:

10. Are there any standards for the (GIS Data Model)?

- Spatial coding standards Coordinate system Land uses Label fields

Explanation / Documents:

11. Are there any information security standards?

- Yes No

12. What spatial data do you already have or are produced by the department through day-to-day transactions?

- | | |
|---|---|
| <input type="checkbox"/> Locations and addresses | <input type="checkbox"/> Statistical data and reports |
| <input type="checkbox"/> Land use data | <input type="checkbox"/> Survey data |
| <input type="checkbox"/> Elevation data | <input type="checkbox"/> Satellite images |
| <input type="checkbox"/> Administrative units | <input type="checkbox"/> Hydrological data |
| <input type="checkbox"/> Investment data and municipal property | <input type="checkbox"/> Ground control points |
| <input type="checkbox"/> Infrastructure and utility data | <input type="checkbox"/> Other |

13. What spatial data formats are already in place?

- | | | | |
|-----------------------------------|-------------------------------------|---------------------------------------|------------------------------------|
| <input type="checkbox"/> GIS | <input type="checkbox"/> CAD | <input type="checkbox"/> Microstation | <input type="checkbox"/> MS Access |
| <input type="checkbox"/> MS Excel | <input type="checkbox"/> Other..... | | |

14. Are there metadata available for the available spatial data?

- Yes No

Explanation / Documents:

.....

15. What is the reference for the coordinate system used for spatial data?

- | | | |
|-------------------------------------|----------------------------------|--------------------------------------|
| <input type="checkbox"/> Ain el Abd | <input type="checkbox"/> WGS1984 | <input type="checkbox"/> Other |
|-------------------------------------|----------------------------------|--------------------------------------|

16. What spatial data or services do you need from the Municipal GIS Unit?

- | | |
|--|---|
| <input type="checkbox"/> Locations and addresses | <input type="checkbox"/> Hydrological data |
| <input type="checkbox"/> Land use data | <input type="checkbox"/> Investment data and municipal property |
| <input type="checkbox"/> Administrative units | <input type="checkbox"/> Infrastructure and utility data |
| <input type="checkbox"/> Elevation data | <input type="checkbox"/> Statistical data and reports |
| <input type="checkbox"/> Measurements | <input type="checkbox"/> Online Geo-explorer |
| <input type="checkbox"/> Printed maps | <input type="checkbox"/> Geo-Applications |
| <input type="checkbox"/> Survey data | <input type="checkbox"/> Spatial analysis |
| <input type="checkbox"/> Satellite images | <input type="checkbox"/> Other..... |

17. Do spatial data need from other government agencies? What is this data?

Yes No

Required Data	Coordinates Reference	Data Format	Data Provider
	<input type="checkbox"/> Ain el Abd <input type="checkbox"/> WGS 1984	<input type="checkbox"/> GIS <input type="checkbox"/> CAD <input type="checkbox"/> Printed Map <input type="checkbox"/> Service <input type="checkbox"/> Satellite Image <input type="checkbox"/> Other:.....	
	<input type="checkbox"/> Ain el Abd <input type="checkbox"/> WGS 1984	<input type="checkbox"/> GIS <input type="checkbox"/> CAD <input type="checkbox"/> Printed Map <input type="checkbox"/> Service <input type="checkbox"/> Satellite Image <input type="checkbox"/> Other:.....	

18. How do you get spatial data?

- Central database (server) Hard copy (maps and reports)
 Digital (Storage device) E-mail
 Other.....

19. What are the current difficulties related to spatial data?

- Data not updated Difficulty in data access
 Lack of statistical and non-spatial data Data is not available as a digital format
 No integrated Data Data conflicting
 Spatial data is inaccurate No metadata
 Privacy and security Other.....

20. Are there applications for GIS?

Yes No

Explanation / Documents:

21. Are there geo-applications available to the public or government agencies?

Yes No

Explanation / Documents:

22. Does department need Geo-applications? For what purpose?

- | | | |
|---|--|---|
| <input type="checkbox"/> Data Sharing | <input type="checkbox"/> Map Services | <input type="checkbox"/> 3D Analysis |
| <input type="checkbox"/> Real-time data | <input type="checkbox"/> Data Management | <input type="checkbox"/> Spatial Analysis |
| <input type="checkbox"/> Decision making | <input type="checkbox"/> Improve customer services | <input type="checkbox"/> Support operations |
| <input type="checkbox"/> Support planning | <input type="checkbox"/> Field mobile operations | <input type="checkbox"/> e-Services |

23. Are there e-services linked to GIS?

- Yes No

Explanation / Documents:

24. In your opinion, do departments and sections in the municipality need a municipal SDI?

- Yes No

Explanation / Documents:

25. In your opinion, how is the integration of spatial data in a unified structure of SDI?

- | | |
|---|--|
| <input type="checkbox"/> Use of standardized global standards | <input type="checkbox"/> Develop a dictionary of spatial data used |
| <input type="checkbox"/> Standardization of database models | <input type="checkbox"/> Provide metadata |
| <input type="checkbox"/> Develop an interoperable framework | <input type="checkbox"/> Standard data formats |
| <input type="checkbox"/> A unified communications environment | <input type="checkbox"/> Other..... |

26. Do you support holding more meetings and workshops among department managers to discuss SDI policy and standards issues?

- Yes No

Thanks for your response..

G. SWOT Questionnaire.

(Translated into English)

Questionnaire link in Google:

<https://docs.google.com/forms/d/e/1FAIpQLSdlqdMqwBS2PokkQfXfmgwKDWWbKqNdve3NhnareHDN9Glaiw/viewform?vc=0&c=0&w=1>

SWOT QUESTIONNAIRE
GIS's Practices in The Northern Borders Municipality

1-What are the benefits of using GIS in the municipality?

- | | |
|---|---|
| <input type="checkbox"/> Saving time and efforts | <input type="checkbox"/> Digitization and storing |
| <input type="checkbox"/> Ease of access to information | <input type="checkbox"/> Improve work efficiency |
| <input type="checkbox"/> The ability to visualize | <input type="checkbox"/> Production of maps and reports |
| <input type="checkbox"/> Improving the quality of decision making | <input type="checkbox"/> Low cost |
| <input type="checkbox"/> Analysis tools | <input type="checkbox"/> Other..... |

2-What defects do you see in the use of GIS's practices in the municipality?

- | | |
|---|--|
| <input type="checkbox"/> Lack of awareness of GIS | <input type="checkbox"/> No integrated Data |
| <input type="checkbox"/> High costs | <input type="checkbox"/> Spatial data is inaccurate |
| <input type="checkbox"/> Lack of user experience | <input type="checkbox"/> Privacy and security |
| <input type="checkbox"/> Lack of statistical and non-spatial data | <input type="checkbox"/> Difficulty in data access |
| <input type="checkbox"/> Data, not updated | <input type="checkbox"/> Data is not available as a digital format |
| <input type="checkbox"/> Lack of GIS specialists | <input type="checkbox"/> Data conflicting |
| <input type="checkbox"/> Other..... | |

3-What opportunities can be built upon to improve the municipal GIS practices?

- | | |
|---|---|
| <input type="checkbox"/> Availability of spatial data in a good status | <input type="checkbox"/> Increased awareness of the benefits of GIS |
| <input type="checkbox"/> Availability of appropriate IT infrastructure | <input type="checkbox"/> Availability of GIS staff |
| <input type="checkbox"/> Add-Value of GIS system | <input type="checkbox"/> A priority for upper management |
| <input type="checkbox"/> National orientation towards governance and data sharing | <input type="checkbox"/> Availability of software |
| <input type="checkbox"/> Maintaining the outputs of previous projects | <input type="checkbox"/> Other..... |

4-What spatial data and services are you currently receiving from GIS unit in the municipality?

- | | |
|---|--|
| <input type="checkbox"/> Locations and addresses | <input type="checkbox"/> Infrastructure and utilities data |
| <input type="checkbox"/> Land use data | <input type="checkbox"/> Statistical data and reports |
| <input type="checkbox"/> Elevation data | <input type="checkbox"/> Online Geo-explorer |
| <input type="checkbox"/> Measurements | <input type="checkbox"/> Geo-Applications |
| <input type="checkbox"/> Printed maps | <input type="checkbox"/> Spatial analysis |
| <input type="checkbox"/> Investment data and municipal property | <input type="checkbox"/> GIS Training |

5-How do you get spatial data from GIS unit in the municipality?

- | | |
|--|---|
| <input type="checkbox"/> Central database (server) | <input type="checkbox"/> Hard copy (maps and reports) |
| <input type="checkbox"/> Digital (Storage device) | <input type="checkbox"/> E-mail |
| <input type="checkbox"/> Other..... | |

6-In your opinion, what are the challenges that hinder the improvement of GIS's practices in the municipality?

- | | |
|--|---|
| <input type="checkbox"/> Lack of an organizational structure for the GIS unit | <input type="checkbox"/> There is no fixed budget for GIS |
| <input type="checkbox"/> Lack of an approved development plan | <input type="checkbox"/> Lack of specialized GIS staff |
| <input type="checkbox"/> There is no exchange of data between internal departments | <input type="checkbox"/> There are no training Plan |
| <input type="checkbox"/> Lack of IT infrastructure readiness | <input type="checkbox"/> No software available |
| <input type="checkbox"/> There is no priority for upper management | <input type="checkbox"/> Other..... |
| <input type="checkbox"/> There is no connection with other government agencies | |
| <input type="checkbox"/> Lack of awareness of the advantages of GIS | |
| <input type="checkbox"/> There are no standardization of data | |

7-In your opinion, what are the solutions and suggestions for improving the GIS's practices in the municipality?

- | | |
|---|--|
| <input type="checkbox"/> Develop an organizational structure and define roles | <input type="checkbox"/> Software update |
| <input type="checkbox"/> Setting a defined development plan | <input type="checkbox"/> Approve a cost recovery policy |
| <input type="checkbox"/> Provision of financial resources | <input type="checkbox"/> Standardization of data standards |
| <input type="checkbox"/> Interoperability through applications | <input type="checkbox"/> Develop a training plan |
| <input type="checkbox"/> Provide adequate GIS staff | <input type="checkbox"/> Other..... |
| <input type="checkbox"/> Investment in IT infrastructure | |
| <input type="checkbox"/> Raising awareness of the advantages of GIS | |
| <input type="checkbox"/> Connection with other government agencies | |

Thanks for your response..

H. Arar City Geo-explorer and Municipal Geo-applications.

Web Mapping Application (Arar city geo-explorer).



Application of Municipal Investment Management.



Application of Management and Tracking of Municipal Projects.



I. ISO 19100 Geographic Information Standards

ISO 19100 Geographic Information Standards

The ISO/TC211 is responsible for the development of international standards in the area of digital Geographic Information. The standards specify methods, tools, and services for data management, acquiring, processing, analyzing, accessing, presenting and transferring such data between different users, systems and locations.

These standards can be organised into themes for a Geographic Information Technology Framework.

Architecture & Framework

ISO 19101 – Reference Model

ISO 19101-2 – Reference Model-Imagery

ISO 19103 – Conceptual Schema Language

ISO 19104 – Terminology
ISO 19105 – Conformance and Testing
ISO 19106 – Profiles
ISO 19146 – Cross-domain Vocabularies
ISO 19150 – Ontology
ISO 19155 – Place Identifier Architecture

Metadata, Data Content & Definitions

ISO 19110 – Methodology for Feature Cataloguing
ISO 19115 – Metadata
ISO 19115-2 – Metadata for Imagery and Gridded Data
ISO 19126 – Feature Concept Dictionaries and Registers
ISO 19131 – Data Product Specifications
ISO 19139 – Metadata XML Schema Implementation
ISO 19144-1 – Classification Systems-Part 1: Classification System Structure
ISO 19144-2 – Classification Systems-Part 2: Land Cover Classification System

Core Data Model

ISO 19107 – Spatial Schema
ISO 19108 – Temporal Schema
ISO 19109 – Rules for Application Schema
ISO 19115 – Metadata
ISO 19137 – Core Profile of the Spatial Schema
ISO 19141 – Schema for Moving Features
ISO 19149 – Rights Expression Language for Geographic Information
ISO 19152 – Land Administration Domain Model
ISO 19153 – Geospatial Digital Rights Management Reference Model
ISO 19156 – Observations & Measurements

Data Exchange Formats

ISO 19115 – Metadata
ISO 19115-2 – Metadata for Imagery and Gridded Data
ISO 19118 – Encoding
ISO 19136 – Geography Markup Language

Data Interchange and Services

ISO 19116 – Positioning Services

ISO 19117 – Portrayal

ISO 19119 – Services

ISO 19125-1 – Simple Feature Access-Common Architecture

ISO 19125-2 – Simple Feature Access-SQL Option

ISO 19128 – Web Map Server Interface

ISO 19132 – Location Based Service-Reference Model

ISO 19133 – Location Based Service-Tracking and Navigation

ISO 19134 – Location Based Services-Multimodal Routing and Navigation

ISO 19135 – Procedures for Item Registration

ISO 19142 – Web Feature Service

ISO 19143 – Filter Encoding

ISO 19145 – Registry of Representations of Geographic Point Locations

ISO 19147 – Location Based Services-Transfer Nodes

Data Quality

ISO 19113 – Quality Principles

ISO 19114 – Quality Evaluation Procedures

ISO 19115 – Metadata

ISO 19138 – Data Quality Measures

ISO 19157 – Data Quality

ISO 19158 – Quality Assurance of Data Supply

Spatial Referencing

ISO 19111 – Spatial Referencing by Coordinates

ISO 19112 – Spatial Referencing by Geographic Identifiers

ISO 19127 – Geodetic Codes and Parameters

ISO 19130 – Imagery Sensor Models for Geopositioning

ISO 19148 – Linear Referencing System

ISO 19151 – Dynamic Position Identification Scheme for Ubiquitous Spa

Imagery

ISO 19101-2 – Reference Model-Imagery

ISO 19115-2 – Metadata for Imagery and Gridded Data

ISO 19123 – Schema for Coverage Geometry and Functions

ISO 19129 – Imagery, Gridded and Coverage Data Framework

ISO 19130 – Imagery Sensor Models for Geopositioning

ISO 19159 – Calibration and Validation of Remote Sensing Imagery Sensors & Data