

Sri Lanka National
Spatial Data Infrastructure
*Supporting Sustainable National
and Local Development*

REQUIREMENTS STUDY International Case Studies

FINAL REPORT
30 December 2016



Sri Lanka National Spatial Data Infrastructure

**REQUIREMENTS STUDY
International Case Studies Report**

FINAL REPORT
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ABBREVIATIONS

3DGIS	Three Dimensional Geographic information System
AD-SDI	Abu Dhabi Spatial Data Infrastructure
ADSIC	Abu Dhabi Systems and Information Centre
ArcGIS	Brand name of a Software for GIS from ESRI
ESRI	Environment Systems Research Institute
EU	European Union
FGDC	Federal Geographic Data Committee
FGDS	Fundamental Geospatial Data Sets
GIS	Geographic Information Systems
GSDI	Global Spatial Data Infrastructure Association
IDA	Information Communication Development Authority Singapore
INSPIRE	INfrastructure for SPatial InfoRmation in Europe
LDH	Land data Hub
NSDI	National Spatial Data Infrastructure
NSGIC	National States Geographic Information Council
OGC/ISO.	Open Geospatial Standards
QCGIS	Qatar Center for Geographic Information Systems
QNGDI	Qatar National Geospatial Information Data Infrastructure
QNGSC	Qatar National GIS Steering Committee
SDI	Spatial Data Infrastructure
SGD	Singapore Dollar
SG-	
SPACE	Singapore Geospatial Collaborative Environment
SLA	Singapore Land Authority
SL-NSDI	Sri Lanka National Spatial Data Infrastructure
TC	Technical Committee
UN GGIM	United Nations -Global Geospatial Information Management
USA	United States of America
USGS	United States of America -Geological Survey

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1 INTRODUCTION

This National Spatial Data Infrastructure (NSDI) Case Study Report summarizes the findings of case study research that was undertaken to explore international best practices and lessons learned that could help to inform and shape the further development of the Sri Lanka NSDI. This report is one of several outputs of the “Requirements Study” portion of the Sri Lanka NSDI (SL-NSDI) development programme that is underway. This is one of several components being carried out by different teams in parallel, intended to expedite the planning, design and development of the foundation programme and system for the Sri Lanka NSDI. The various parallel activities and their interdependencies are illustrated in the figure below.

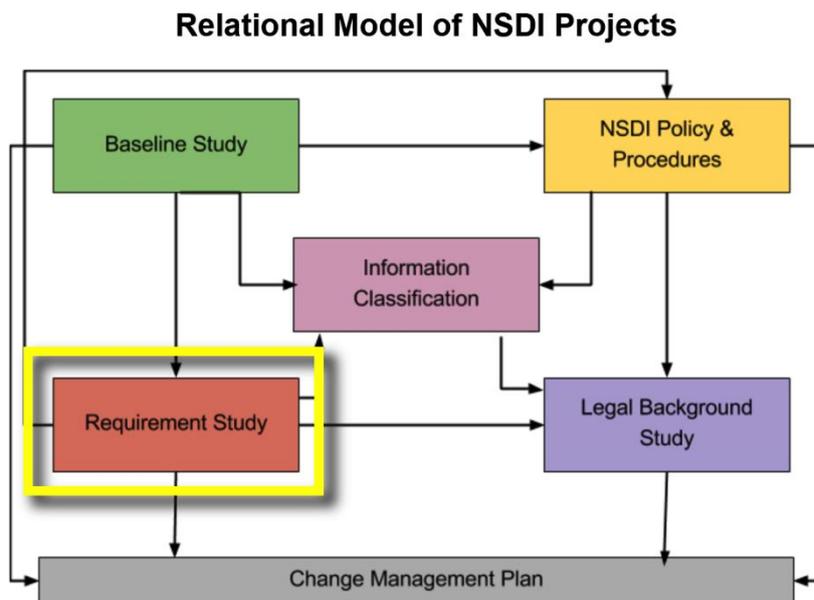


Figure 1 – Relationship Model of SL-NSDI Projects

The Requirements Study portion of the SL-NSDI development programme, is itself broken down into several activities. The current activity is one of several individual Tracks within the Requirements Study that include the following:

Track 1 – Program Organization and Mobilization

Track 2 – Case Studies

Track 3 – Requirements Study

Track 4 – GeoPortal and NSDI Foundation System Specification

Track 5 – Tender Support

For the Case Study effort, five specific countries were systematically chosen for focused research based on specific criteria that were discussed and refined in collaboration with Government of Sri Lanka representatives. Most of the information collected for this study was available through online sources. In some cases, personal contact was made with sponsoring organizations in each Country or other individuals who are known to be knowledgeable about the history, current status and future plans for each initiative.

1.1 Case Study Purpose and Approach

The purpose of the national spatial data infrastructure (NSDI) case studies within the Sri Lanka NSDI Requirements Assessment component is to provide a reference framework of similar initiatives for comparison and lessons learned that can help to inform the Sri Lanka effort. There are today many countries internationally that have either developed or are in the process of developing NSDI or equivalent programmes. While these initiatives share much in common structurally, experience has confirmed that each must be shaped to the particulars and priorities of each country. For the Sri Lanka NSDI case studies to be useful for the current purpose it is therefore important to choose those that are most likely to yield insights that are comparable in terms of national conditions and future aspirations. Once the candidate national efforts have been chosen it is also important to identify those aspects of each programme that will be most insightful in informing the Sri Lanka programme. Both the criteria for country case study selection and the aspects of each programme to be studied are outlined below.

The candidate countries listed in this document have been selected based upon the Consultants knowledge and experience in this field as well as a broad canvassing of resources available through various online channels. These have included both general Internet search queries as well as regional newsletters and other sources of information available through the Global Spatial Data Infrastructure Association (GSDI) and United Nations Initiative On Global Geospatial Information Management (UN GGIM) websites

1.2 Case Study Selection Criteria

The following are criteria that have been identified as the basis for choosing the appropriate case study examples to best inform the Sri Lanka NSDI programme. It is not necessary that candidate initiatives meet all the listed criteria, but rather that they are aligned with a sufficient number of them to provide examples and ideas that may be relevant and useful to the Sri Lanka programme.

Longevity of the initiative. NSDI and national GIS efforts have been underway since the 1980's. There are many lessons learned from earlier efforts that have had the time to mature and evolve through a series of developmental stages, including the adaptation to the context of rapidly changing technological advances over the years.

International reputation. Not all NSDI efforts are created equal and some have received special international attention for their achievements, level of government support, approach to continuous innovation, and other attributes. Whether such attention is due to an active outreach and marketing campaign or more substantive achievements can usually be discerned through supporting materials.

Regional relevance. The South Asia Region shares many cultural and socioeconomic conditions that influence how a country thinks about development priorities and the role of geospatial and related information in policy and decision making processes.

National similarities. Similarly, there are a variety of common characteristics that suggest levels of physical and population size and socioeconomic development that may influence attitudes and priorities regarding geospatial information and decision making processes.

Information Availability. Not all NSDI programmes have made extensive or detailed information publicly available. Given the tight timeframe of the current Requirements Analysis component of the Sri Lanka NSDI it is important to focus on those for which there is sufficient information available

The following is the initial list of NSDI programmes that were considered as potential candidates for the SL- NSDI case study effort:

Table 1 - Candidate Case Study Countries

N	Candidate Countries	Longevity	Reputation	Regional Relevance	National Similarities	Info Availability
1	India	2000	Medium	Large Nation adjacent to Sri Lanka Central Government initiative	Cultural and social conditions similar	2006 Act of parliament was passed for NSDI. National Centre for coordination, dissemination, development, capacity building, data layers etc. Geoportals available. Supporting documentation available.
2	Malaysia	Commenced 1997 and revised in 2002	Medium	South Asian Country Central Government initiative	Cultural and Social conditions similar	Geoportals available on web, and a variety of academic and technical studies have been conducted and are available.
3	Singapore	Initiated in late 1980 but officially commissioned in 2007-2009	Good	South Asian Country Central Government initiative	Cultural and Social conditions similar	Well recognized internationally and there is significant information available regarding most aspects of the programme.
4	Japan	2007	Medium	East Asian Country Central Government initiative	Cultural conditions similar but social conditions differ	In 2007 legislation establishing the NSDI was enacted. Still developing the process of obtaining full coverage of data.
5	Korea	1995-2010	Medium	East Asian Country Central Government initiative	Cultural conditions similar but social conditions differ	The current Korean SDI has following considerations, GIS applications, Policy issues, legislation, funding, data, standards, software and networking, education and research
6	Australia and New Zealand	2003	Good	East Asian Country Government initiative	Developed nation	Supported by many Government institutions. ANZLIC is the Government body in Australia and New Zealand responsible for the NSDI – Australia 2014 map warehouse of data available
7	Europe	2007 European parliament forced the INSPIRE directive	Medium	European countries	Developed nations	The INSPIRE programme is a pan-European initiative covering all members of the EU. Member states provide integration of information. Geo Portal has been established. The vision is to serve interests of the EU in promoting sharing of data

8	United States	1990 -1994	Good	American	Developed nation	1994 the NSDI was formally launched by Executive Order titled "Coordinating Geographical Data Acquisition and Access. Federal Geographic Data Committee (FGDC) coordinated the NSDI activities. This is one of the oldest, largest and most developed NSDI programmes and now going through a renewal process.
9	Qatar	Commenced in 1987 but refined in 90's	Good	Arabic Country	Cultural conditions similar but social and economic conditions differ	This programme is positioned as the National GIS for the country. GIS is a key component of e-government of Qatar. This is one of the oldest national efforts and has survived political transitions and other challenges.
10	Abu Dhabi	2010-2014	Good	Arabic Country	Cultural conditions similar but social and economic conditions differ	Geo-portal available. Abu Dhabi Spatial Infrastructure (AD-SDI) networks across the entire society of Government, business and public. This initiative has won several international awards. Detailed information about the programme widely available.
11	Canada	2010 renewed	Good	Canadian	Developed nation	Geo Connections, through a partnership with the Government of Canada, has established 5 major policy directions to support the development of the CGDI. Geo-portal available.
12	Indonesia	2000 & renewed in 2007	Medium	South Asian Country	Cultural and Social conditions similar	Map portal available. Japanese Government used to initiate the foundation programme. Geospatial information Act in 2011.

All of the countries listed have experiences and lessons learned that would be relevant to the Sri Lanka NSDI, however given the available time and resources available for this exercise it was necessary to limit the more detailed exploration to a total of 5 countries. The final five NSDI initiatives chosen for more detailed study include the following:

1. Singapore
2. EU INSPIRE
3. Qatar
4. Abu Dhabi
5. United States

1.3 Case Study Program Components for Comparison

The following are the components of each case study that have been identified as the basis for comparing and contrasting these initiatives to derive insights that are useful considerations for the Sri Lanka NSDI programme.

Catalyst and Implementation Approach. Why was the NSDI initiated? What were the issues that drove this initiation and what organization(s) was given the responsibility to move the programme forward and what implementation approach was used?

Policy. Framework of policies for enabling NSDI development and priorities. This includes how the NSDI was initiated and has been positioned relative to national policy strategies and priorities.

Organization. The organizational framework used to administer the NSDI within the government. This also includes the formulation and governance of various interdisciplinary working groups, special interest groups and other representative forums for solving issues across multiple agency administrative lines and interests.

Finance. NSDI is intended to be a permanent element within a country's government. Financing such infrastructure requires an initial investment to establish the foundation programme and system, followed by sustained funding for continuous operations and routine maintenance and upgrading of the system over time. There are a variety of approaches to this matter that have been applied by various countries.

Data. Status and condition of fundamental data set development. The selection of what Fundamental Geospatial Data Sets (FGDS) are most important to the community and which of these have been prioritized for early development. This segment also includes how the logical custodians were chosen for each priority layer and what process is being used to ensure this information is managed in a manner that meets community needs.

Access. Mechanisms for access to data and application services. This component addresses how open or narrowly confined are the policies dictating who can access information and for what purposes, across government and other institutional, civil society and private sectors. This also includes the charging of fees for data and/or services.

Capacity. Human and institutional capacity building for development, management and use of GIS. How has the country measured and addressed the need for human capacity building both within the team that is providing central facilitation and support as well as the stakeholder organizations that are the essential "building blocks" of the initiative?

This segment will also consider how this issue is reflected at multiple levels, from the end users, to the GIS technicians and analysts who ensure the infrastructure is operating effectively to the managers, policy and decision-makers define priorities and strategic directions.

Technology. Technology framework that supports SDI development and operations. This component addresses what technology was used to launch an initial NSDI and how that may have changed over the years in response to an ever rapidly evolving technological context globally and locally within each Country.

The above components for each case study have been compiled and documented to a standard form for presentation in the sections following.

2 CASE STUDY REVIEW

This section provides a summary of each of the selected NSDI case study initiatives.

2.1 Case Study 1 – Singapore

Since the inception of the Singapore Geospatial Collaborative Environment (SG-SPACE) in 2008, the Whole-of-Government and its agencies have made a concerted effort to cooperate closely on implementing the National Spatial Data Infrastructure (NSDI) in Singapore. SG-SPACE's vision is "Towards a spatially enabled nation", where the nation, including its government, businesses and citizens make use and benefit from geospatial information in all activities. SG-SPACE's vision is to provide a mechanism to make available the interoperable, organized, and authoritative geospatial information for national level decision making; public security; cost effective businesses and build location awareness among citizens.¹ SG-SPACE is jointly driven by the Singapore Land Authority (SLA) and the Infocomm Development Authority (IDA) of Singapore.²

2.1.1 Catalyst and Implementation Approach

Singapore's geospatial story started in the late 1980s, with the establishment of the Land Data Hub (LDH), spearheaded by the Singapore Land Authority (SLA). LDH, the fore-runner of the national spatial data infrastructure, is a one-stop national repository of land data to facilitate sharing of data across the public sector. All spatial data are collated and presented in SLA's Land Information Network and clearinghouse, which was its LandNet system. Today, LandNet has 15 participating public agencies sharing more than 200 layers of geospatial information. Some of this land information was also bought on by SLA's Integrated Land Information System (INLIS), a one-stop land information portal, which provides all land and property ownership information.

In the 1990s, many Singapore government agencies had begun moving away from manual paper records towards using Geographic Information Systems (GIS). The benefits were countless – enhanced data quality, user-friendly systems, building of knowledge repositories that can be shared and passed down the years, not to mention the saving of tonnes of paper required for manual paper filing. More importantly, the use of GIS allowed consistent and faster analysis of spatial data that is important for policy and decision-making.³

Jointly spearheaded by the Ministry of Law/SLA and Ministry of Information, Communication and the Arts/Infocomm Development Authority (IDA) of Singapore, the

¹http://ggim.un.org/2nd%20Session/country%20reports/Country_Report_Singapore.pdf

² <http://www.sla.gov.sg/Portals/0/Newsletter/landAug09/sgspace.htm>

³<https://www.geospatialworld.net/article/leading-singapore-on-growth-path/>

national initiative initially received a development fund of \$12 million over 3 years. The key deliverables of SG-SPACE include data, policies, institutional arrangements, standards, clearinghouse and applications. Over an evolving three-year master plan, key projects

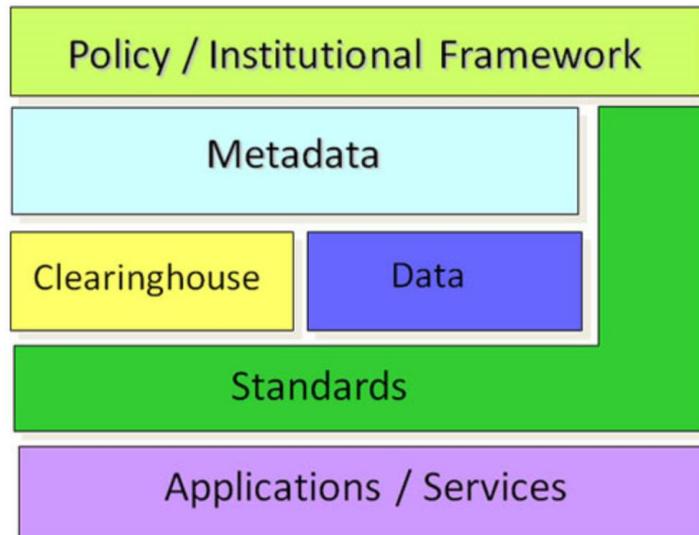


Figure 2 - SG-SPACE Conceptual Framework

spanning government agencies and tapping shared geospatial data will change the way public sector makes policies, creates new knowledge, tackles crises and manages incidents. With land and authoritative land information as the strong foundation, SLA is well-poised to take on the leadership role in building and implementing a strong governance and culture of leveraging on geospatial information amongst public and private sectors. As geospatial industry in Singapore gains prominence, SLA has embarked on several geospatial initiatives to help support this fast-growing industry both within the public and private sectors. At the same time, it is also promoting the prolific use of GIS in day-to-day operations of the public sector, to increase efficiency and productivity through seamless workflows.

2.1.2 Policy

SG-SPACE is guided by a suite of policies and best practices which guide the operation of SG-SPACE through governance of data collection, data management, data access, data ownership, data utilisation and data dissemination. There were no details concerning these policies found online and inquiries to the SLA have, as of the date of this report, not been responded to.

2.1.3 Organization

TSG-SPACE is guided by a number of governing committees, which comprise the Government Data Steering Committee and SG-SPACE Coordinating Committee. These

committees oversee and coordinate the development work for SG-SPACE carried out by the Technical Committees (TCs), and approve SG-SPACE projects and activities.



Broadly, TC1 looks at the issues concerning Data Standards and Management. TC2 supports Infrastructure and Technology Facilitation and TC3 facilitates Capacity Building. These committees comprise of members from the developmental, planning, environmental, security, statistical, healthcare and economic government agencies. The multi-agency collaborative approach is critical to the robust implementation of SG-SPACE.

2.1.4 Finance

The government of Singapore realized from the beginning that geospatial information needs to be constantly updated and refreshed for meaningful representation and analyses. Sustainable funding is required to support the development of geospatial projects, data content, capacity and architecture. In this regard, the Government provides financial support to public agencies in the range of SGD \$40M (\$29.2M USD) to support Singapore's infrastructure development and promoting adoption.

2.1.5 Data

The SG-SPACE Secretariat, in consultation with the governing committees, has identified the Fundamental Datasets which are the authoritative sets of core data that provide spatial reference, enable interoperability of geospatial data and applications for Singapore. Looking ahead, SG-SPACE seeks to improve their accessibility and ensure their continued availability. The LandNet provides a web based that allows view, access, perform spatial analysis, upload and download directly from Land Data Hub.

Singapore is in the process of adopting international standards as set out in the ISO 19100 series, with some local adaptation to help ensure data quality and interoperability. Two levels of geospatial data standards are under development and adoption by all agencies in Singapore. The first level is Common Standards which touch on general aspects of data management that

are applicable to all datasets. The second level involves Content Standards that are under development by the various working groups formed under TC1. SG-SPACE assisted public agencies to implement Common Standards for Fundamental Datasets under Phase 1 of the implementation plan.

The numbers of spatial data contributed (371 layers) and the contributing agencies (29 public agencies) have increased steadily over the years (2012).

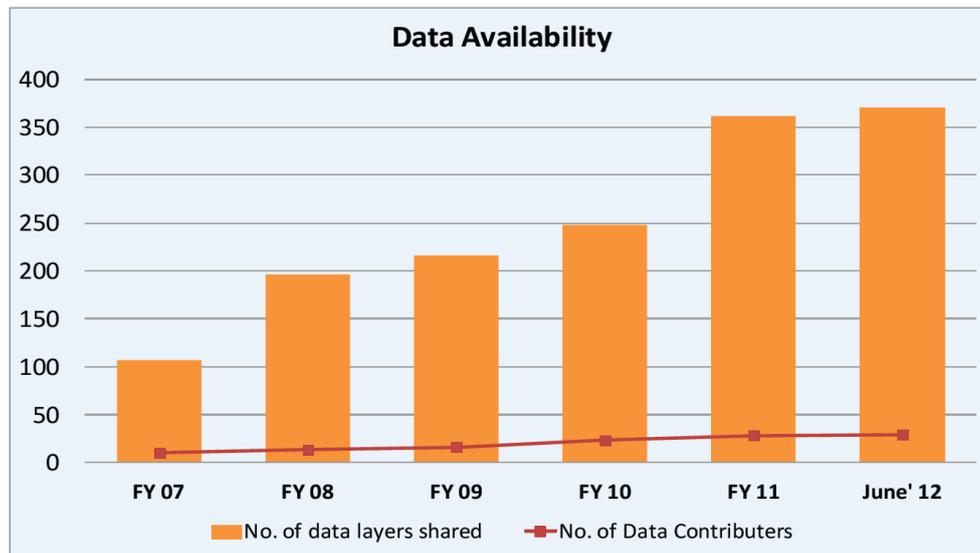


Figure 3 - SG-SPACE Data Availability Trend Since 2007

This trend reflects the increasing importance agencies placed on the value towards data sharing. To this end, traditionally textual information such as business data and population statistics have also been geo-coded to support a wide variety of public functions. Public officers can now discover and make use of geospatial data in their planning, operations and public service delivery.

Since early 2012, SLA is leading a whole-of-government initiative to develop and maintain a largescale 3D National Topographic Map. Today, separate agencies produce and keep the topographic plan separately for their specific needs. Given the increasing need for cross-sharing of information for better planning of public infrastructure such as roads, drains and parks; there is a strong need to coordinate the approach in integrating existing and future topographic data. This initiative will integrate the localised topographic survey plan data into a 3D GIS.

2.1.6 Access

GeoSpace was launched in Feb 2011 as the government's clearinghouse for geospatial data and metadata. Through this intranet, public agencies are able to share data from the various data hubs, discover and use data for planning, analysis, operations, decision making and public service delivery.

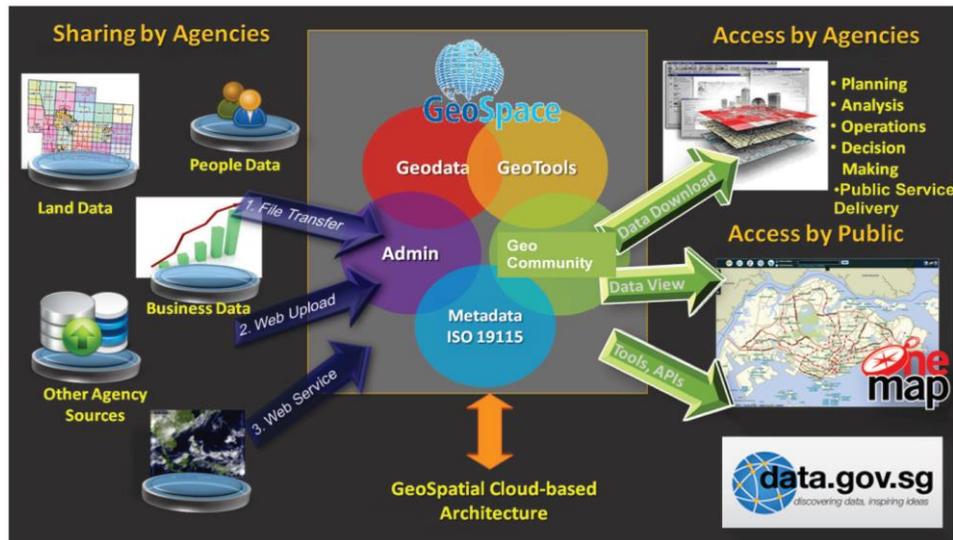


Figure 4 - GeoSpace Framework

GeoSpace allows agencies to upload their data directly through file transfers, web uploads or web service. Clearinghouse GeoSpace was launched in Feb 2011 as the government's clearinghouse for geospatial data and metadata. Through this intranet, public agencies are able to share data from the various data hubs, discover and use data for planning, analysis, operations, decision making and public service delivery. GeoSpace allows agencies to upload their data directly through file transfers, web uploads or web service. Geospatial data from the government is also shared with the public through the internet portal, OneMap (www.onemap.sg). OneMap an integrated map system which government agencies use to deliver thematic data and location based services. The private sector also utilizes OneMap and the wealth of government geospatial information to develop value-added map-based services for the public.

Geospatial data from the government is also shared with the public through the Internet portal OneMap (www.onemap.sg). OneMap is an integrated online mapping system that government agencies use to deliver thematic data and location based services. The private sector also uses OneMap and the wealth of government geospatial information to develop value-added map-based services for the public.

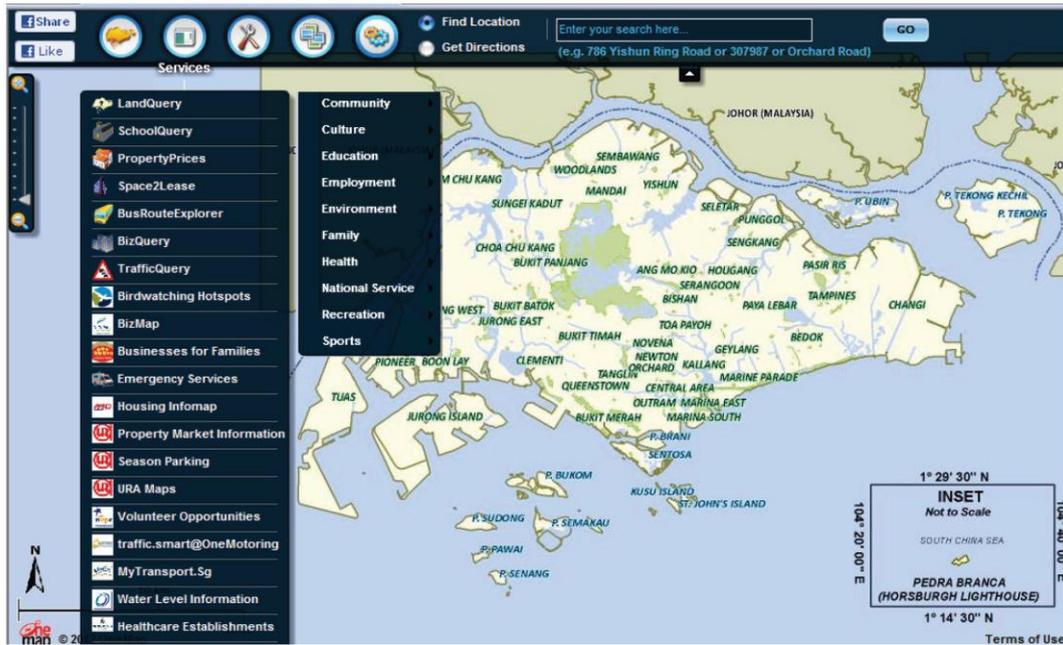


Figure 5 - OneMap Services and Themes

Since the launch of OneMap in March 2010, the number of participating government agencies has steadily increased and today comprises more than 30 public agencies contributing information and more than 50 agencies using OneMap to develop and supply public services. Today there are over 50 map themes and 30 services made available for free to the public through web portals and access via OneMap API's.

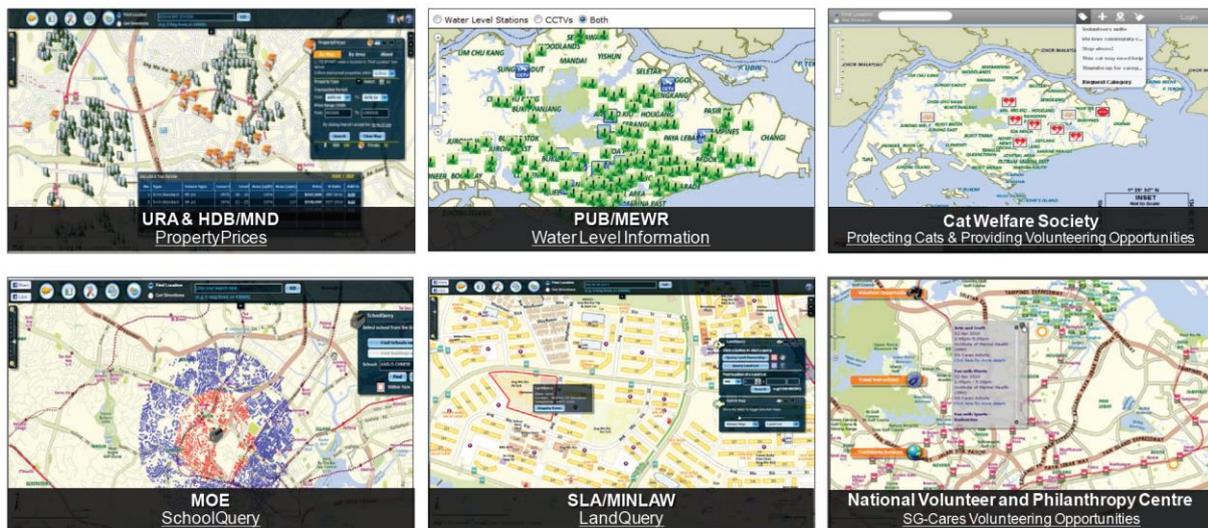


Figure 6 - OneMap Based Applications

In early 2012, the “OneMap Crowd Sourcing Tools” service was launched to take advantage of volunteered geographic information from various communities of interest. The first adopter was the Cat Welfare Society who used crowd-sourcing to better manage stray cats, as well as other cat-relevant issues.



Figure 7 - Crowd Sourcing API

2.1.7 Capacity

Beyond putting in place geospatial policies and provision of infrastructure, SG-SPACE plays a more fundamental role in developing SG-SPACE long-term capabilities in GIT. This involves investment in capacity development in areas such as education, outreach and adoption, so as to lay the basis for sustainable development in the future.

SG-SPACE is collaborating with three local tertiary institutions to run introductory GIS courses to equip public officers with basic GIS knowledge and an understanding of how it is applied in different sectors. Trainings are also conducted to familiarize officers with the use of the data clearinghouse. SG-SPACE is also working with the Ministry of Education and other educational institutions to introduce geospatial topics in to curricula and certification programmes.

SG-SPACE is also involved in various outreach activities, including an annual “OneMap Challenge” and the “Spatial Challenge”. The OneMap Challenge is intended to increase public awareness of the use of spatial data through the development and provision of access to desktop and mobile applications.

The government previously set aside SFD\$15.5M (\$11.3M USD) through a “GeoFund” to encourage public agencies to adopt GIS. Examples include the National Parks Board that utilized the GeoFund to develop a GIS-based system for tree management and trend analysis. Other examples include the development of an information system to study climate change and to prototype the use of open-source remote sensors to collect real-time data. SG-SPACE also carries out pilot projects with various public agencies and NGO’s to catalyze further development of GIS within these organizations.

SG-SPACE has also recognized the importance of the private sector as a key partner in driving the use of GIS in the Country. The programme is taking steps to create an overall environment that encourages innovation and growth in the commercial use of GIS. The i-Singapore@work Call-for-Collaboration Initiative was launched to encourage commercial enterprises to adopt geospatial applications to create new business opportunities, improve

workforce productivity and support better decision making. Projects that have received special note include applications involving live traffic mashups, location analytics, and location based services in areas of retail, real estate and logistics.

2.1.8 Technology

A longtime user of Esri GIS technology, SLA uses ArcGIS for Desktop and ArcGIS for Server to provide maps and applications over the web, for example, through OneMap.

OneMap is one of the successful outcomes of the SG-SPACE initiative. It is a collaborative, common platform for public agencies to share geospatial data and deliver services to the public. Built on Web 2.0 technologies, OneMap is user-friendly and convenient to leverage. ArcGIS provides the ability to manage and store data that can be leveraged in many different applications. It opens information sharing by providing SLA with the opportunity to rapidly create lightweight, focused applications using JavaScript. As a result, SLA and its data customers have deployed innovative mashups, combining internal and external data sources to create an array of applications on their own public-facing websites.⁴

2.2 Case Study 2 – European Union INSPIRE

The INSPIRE Directive aims to create a European Union-wide spatial data infrastructure for the purpose of supporting EU environmental policies, or activities which may have an impact on the environment. This European Spatial Data Infrastructure will enable the sharing of environmental spatial information among public sector organisations, facilitate public access to spatial information across Europe and assist in policy-making across boundaries.

INSPIRE is based on the infrastructures for spatial information established and operated by the Member States of the European Union. The Directive addresses 34 spatial data themes needed for environmental applications.

The Directive came into force on 15 May 2007 and will be implemented in various stages, with full implementation required by 2021.⁵



<https://youtu.be/xew6qI-6wNk>

⁴<http://www.esri.com/news/arcnews/winter1112/articles/connecting-a-community.html>

⁵ <http://inspire.ec.europa.eu/about-inspire/563>

2.2.1 Catalyst and Implementation Approach

The commencement of a European Spatial Infrastructure idea was originally proposed in Brussels in 2001 when an expert group nominated by member states on environment and geographic communities met to discuss issues related to spatial data. This group was then referred as E-ESDI Expert Group.

In 2004, the INSPIRE Proposal for a Directive was adopted by the Commission. This was a major milestone for the use of geographical information in Europe as a contribution to environmental policy and sustainable development. It was the first step in a co-decision procedure that led to the formal adoption of Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE), which then had to be implemented in every EU Member State.

The basic idea of the European INSPIRE was to lay down rules for the use of Spatial Data in Europe. It defined 34 themes ranging from cadastre parcels to habitat and the directive binds public institutions which hold data related to the above themes to make the data accessible. It does not require the collection of new data from the respective countries.

To ensure that the spatial data infrastructures of the Member States are compatible and usable in a community and trans-boundary context, the directive required that common implementing rules are adopted in a number of specific areas (Metadata, Data Specifications, Network Services, Data and Service Sharing and Monitoring and Reporting). These rules were adopted as Commission decisions, and were binding in their entirety. The Commission was assisted in the process of adopting such rules by a regulatory committee composed by representatives of the Member States.

The INSPIRE Directive is being implemented in stages with the INSPIRE roadmap setting out target dates for implementation of these stages, involving 18 milestone dates between 2010 and 2021.

2.2.2 Policy

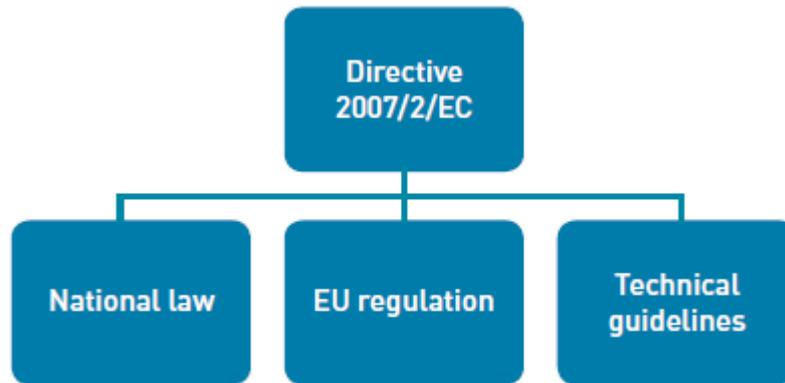


Fig:7 Policy of the European INSPIRE

INSPIRE is largely a policy driven initiative, utilizes and builds upon the EU framework. It seeks to establish linkage among highly fragmented SDIs within the EU and to establish incremental integration over time. The European Parliament in 2007 entered into force the INSPIRE Directive aimed to establish a common European SDI. The Implementing Rules for Monitoring and Reporting are strictly related to the implementation of the INSPIRE Directive.

In order to achieve certain level of interoperability, which is needed to bring all national or regional SDIs together, INSPIRE lays down a number of technical specifications which regulate the Technology and the standards the involved data providers should use. By doing so it enables everybody to communicate in the same way using terminology and models everybody understands.

The Policy of INSPIRE is to see that data need be collected only once and kept where it can be maintained most effectively. It should be possible to combine seamless spatial information from different sources across Europe and share it with many users and applications. It should be possible for information collected at one level/scale to be shared with all levels/scales. Geographic information needed for good governance at all levels should be readily and transparently available and easy to find what geographic information is available.

Extensive fact-finding and public consultations undertaken in the course of the preparation of the INSPIRE directive (2001-2004), identified a number of important obstacles preventing the widespread use of spatial data needed for environmental policies and policies having an impact on the environment. For example, 97% of the participants in a public consultation agreed that at all levels, from local to European:

1. Spatial data is often missing or incomplete.
2. The description (documentation) of available spatial data is often incomplete.
3. Spatial datasets can often not be combined with other spatial datasets.
4. The systems to find, access and use spatial data often function in isolation only and are not compatible with each other.

5. Cultural, institutional, financial and legal barriers prevent or delay the sharing and re-use of existing spatial data.⁶

The policy of INSPIRE is well documented in the directive 2007/2/ec of the European parliament and of the council of 14 march 2007, establishing an infrastructure for spatial information in the European community⁷.

2.2.3 Organization

INSPIRE is structured as a directive and programme within the EU framework. Each member state is obliged to ensure that appropriate structures and mechanisms are designated for coordination across the different levels of government, the contributions of all those with an interest in their infrastructures for spatial information.⁸

INSPIRE lays down a number of technical specifications which regulate the technology and the standards the involved data providers should use. By doing so it enables everybody to communicate in the same way using terminology and models everybody understands. The INSPIRE implementation is organized and steered by the so called Group of Four which includes the DG Environment, the Joint Research Centre, the European Environment Agency and Eurostat.

As is the case with all EU directives, the INSPIRE Directive has to be transposed into national law. This has led to the development and update of several SDI acts which already changed the way and attitude of data sharing in Europe. If the SDIs are big as a whole it is even more difficult with INSPIRE, as this European SDI is designed as a 'system of systems' with a much more centralized approach. It builds on the establishment of smaller SDIs on national level, the so called NSDIs and understands itself as sum of all smaller pieces in Europe.

The INSPIRE Directive requires that additional legislation or common Implementing Rules (IR) are adopted for a number of specific areas (metadata, interoperability of spatial data sets and services, network services, data and service sharing and monitoring and reporting). These are published either as Commission Regulations, or as Decisions. The Commission is assisted in the process of adopting such rules by a regulatory committee, INSPIRE Committee, composed of representatives of the member states and chaired by a representative of the Commission (this is known as the Comitology procedure).

2.2.4 Finance

The European INSPIRE works on the basis that each country builds their own spatial data and the SDI's and hence the finances need to be met by the respective governments. INSPIRE

⁶ <http://inspire.ec.europa.eu/inspire-policy-background/27902>

⁷ <http://inspire.ec.europa.eu>

⁸ <http://inspire.ec.europa.eu/quick-overview-implementers/57528>

does not enforce that new data should be collected, and it would only contain the data of each country which are produced for the development of the respective country.

2.2.5 Data

To ensure that the spatial data infrastructures of the Member States are compatible and usable in a community on trans-boundary context, the INSPIRE Directive required that common Implementing Rules were adopted in a number of specific areas such as Metadata, Data Specifications, Network Services, Interoperability of Data and Service Sharing. These rules were adopted as Commission Regulations/Decisions. The Commission was assisted in the process of adopting such rules by a regulatory committee composed by representatives of the Member States.

The ISO 19100 series of standards was adopted as the technical base for INSPIRE by the European standardization organization Comité Européen Normalisation - CEN TC/211. Their implementation included 34 themes. The themes are subdivided into three groups and included into the INSPIRE directive in three appendices. Member States were to make the metadata available for the themes in Appendices I and II in 2010, and for the themes in Appendix III in 2013:

Appendix I

1. Reference systems using coordinates
2. Geographical grid system
3. Geographical names
4. Administrative units
5. Addresses
6. Land Registry plots
7. Transport networks
8. Hydrography
9. Protected areas

Appendix II

1. Height
2. Soil use
3. Ortho-image production
4. Geology

Appendix III

1. Statistical units
2. Buildings
3. Soil
4. Land use
5. Human health and safety
6. Utilities and public sector services
7. Environmental protection services
8. Facilities for manufacture and industry
9. Facilities agriculture and aquaculture

10. Population distribution — demography
11. Area management, areas where limitations apply, regulated areas and reporting units
12. Areas with risks to the natural environment
13. Atmospheric conditions
14. Meteorological and geographic characteristics
15. Oceanographic, geographic characteristics
16. Maritime regions
17. Bio-geographic areas
18. Habitats and biotopes
19. Distribution of species
20. Energy sources
21. Mineral sources⁹

The INSPIRE Directive required the Commission to establish a community geo-portal and the Member States to provide access to their infrastructures through the geo-portal as well as through any access points they themselves decide to operate. The INSPIRE Geoportal provides the means to search for spatial data sets and spatial data services, and subject to access restrictions, to view spatial data sets from the EU Member States within the framework of the INSPIRE Directive.

Standardization of spatial data is actively pursued. Standards exist in most countries, in order to achieve certain level of interoperability, which is needed to bring all national or regional SDIs together. INSPIRE lays down a number of technical specifications which regulate the technology and the standards the involved data providers should use. By doing it enables everybody to communicate in the same way using terminology and models everybody understands.

Main principles of the INSPIRE directive - Data should be collected only once. It should be possible to combine seamless spatial information from different sources across Europe and share it with many users and applications and also easy way to find what geographic information is available.

Principles for sharing of spatial data sets and services between public authorities within and Member States, on the other hand, are contained directly in the Directive; the definition of the concrete measures to be implemented to this end is left to the responsibility of each Member State and is not within the scope of these implementing rules.

The Draft Regulation on INSPIRE Data and Service Sharing was adopted by the INSPIRE Committee. The main points of the Regulation are the following:

- (a) Metadata must include the conditions applying to access and use for community institutions and bodies; this will facilitate their evaluation of the available specific conditions already at the discovery stage.
- (b) Member States are requested to provide access to spatial data sets.

⁹ Bartha, Gabor et al. European Journal of Geography 2 2: 79-89, 2011

- (c) While fully safe-guarding the right of Member States to limit sharing when this would compromise the course of justice, public security, national defense or international relations, Member States was encouraged to find the means to still give access to sensitive data under restricted conditions, (e.g. providing generalized datasets) upon request, Member States need to give reasons for these limitations to sharing.¹⁰

2.2.6 Access

Access to spatial data and services constitutes an important basis for environmental policies for all public authorities and is therefore a central aspect of the Infrastructure for spatial information in the European Community. Since the community institutions and bodies in most cases have to integrate and assess spatial information from all the Member States, INSPIRE recognized the need to be able to gain access to and use spatial data and spatial data services in accordance with an agreed set of harmonized conditions.

Article 17(8) of INSPIRE Directive requires the development of implementing rules to regulate the provision of access to spatial data sets and services from Member States to the institutions and bodies of the community. Access policies vary across the countries in Europe. Most countries provide access to information held by public sector. Most European countries have specific laws on Access to Information. In order to assist with the integration of national infrastructures into INSPIRE, Member States need to provide access to their infrastructures through the INSPIRE Geoportal, managed by the European Commission, as well as through other access points which Member States decide to manage. For more information on the INSPIRE Geoportal, go to <http://www.INSPIRE-geoportal.eu/>

2.2.7 Capacity

INSPIRE seeks to build on existing capacity and capacity building efforts in Europe. It will help to build additional awareness and support across the EU and accession countries. Spatial Data Interest Communities provide expertise and capacity building opportunities for spatial data management and the development and operation of spatial information services.

To create an operating capability, the European Commission proposed the creation of the Task Force consisting of representatives, from all Member States, responsible for the architecture design and the service implementation of the National Spatial Data Infrastructures. The purpose of setting up the Initial Operating Capability Task Force was to help and support the implementation of INSPIRE in the Member States.

Individual countries have their own capacity building programmes for the optimum usage of spatial data.

¹⁰ <http://inspire.ec.europa.eu>.

2.2.8 Technology

INSPIRE GeoPortal has been deployed allowing for discovery and viewing of spatial data sets and services. Currently, the main functionality is to view datasets, however, additional functionality will be incorporated in future releases.



Figure 8 - INSPIRE GeoPortal Provides Access to National Geoportals of the Members

Technical framework for the INSPIRE network is available online and a working group has been established to determine the definition and scope of the services to be delivered. The initial prototype INSPIRE metadata geoportal was developed by the EU Joint Research Centre (JRC), utilizing open-source components. An expanded geoportal was commissioned through competitive tender in 2011. The expanded geoportal was built using open-source components and according to Open Geospatial Consortium (OGC) standards. The INSPIRE Geoportal can be accessed at <http://inspire-geoportal.ec.europa.eu/>.

2.3 Case Study 3 – Qatar

The state of Qatar located in the Arabian Gulf was one of the first countries in the world to fully adopt and implement a comprehensive nationwide GIS. Starting with a 1989 national user needs study and the subsequent establishment of the Qatar National GIS Steering Committee (QNGSC) and the Qatar Center for Geographic Information Systems (QCGIS), the initiative pre-dated what has become to be known as National Spatial Data Infrastructure (NSDI). The initiative has continued to evolve and today is known as the Qatar National Geospatial Data Infrastructure (QNGDI). Today there are more than 60 Government and Semi-Government agencies integrated with this system sharing GIS information and using in their day to day work.

2.3.1 Catalyst and Implementation Approach

During the early to mid-1980's there were many large land use planning projects underway in the Gulf Region, responding to anticipated rapid growth fueled by rapidly expanding economies driven by petroleum revenues. Although computerized mapping was in its infancy at the time, several countries decided to switch from manual mapping to digital mapping as a means of better capturing and utilize the vast amounts of information that was needed to manage such rapid growth. While at least one other Gulf Region country initiated digital mapping 2-3 years earlier using Computer Aided Drafting (CAD) software, Qatar was the first to utilize true GIS.

In 1989, and with the specific patronage and direct involvement of a prominent Sheikh, a nationwide user need study was conducted to assess the benefit of deploying such a system throughout the government of Qatar. As per the recommendations of the study, as a first priority, Qatar established the Qatar National GIS Steering Committee (QNGSC) and the Qatar Center for Geographic Information Systems (QCGIS). The major responsibility of the QNGSC is to coordinate and monitor the development of a GIS in government agencies in an integrated fashion based on common standards and practices.

The first job of the QCGIS was the development and adoption of common data standards, the development of a national GIS database containing all the key topographic, land and infrastructure layers, and a framework of agreements and procedures for sharing data into the future.

2.3.2 Policy

The establishment of the Qatar National GIS Steering Committee (QNGSC) and the Qatar Center for Geographic Information Systems (CGIS) was formalized by Emiri decree number 36 for the year 2009. According to the decree, the CGIS reports to the under-secretary of Ministry of Municipality & Urban Planning and comprises Planning & Projects, Mapping & Archives, Topographic Survey, Systems Services and Coordination & Training Divisions. Its roles and responsibilities are:

- Creating and updating Qatar's Topographic Database and all related services for the entire country in coordination with other related agencies.
- Maintaining Qatar's Geodetic Network and all related services.
- Providing the connection to Qatar's Topographic Database and maintaining it.
- Conducting studies and research required for developing the implementation of Geographic Information Systems and Global Positioning Systems in Qatar.
- Creating, developing and monitoring National GIS and GPS standards and specifications.
- Establishing and maintaining Qatar's high speed GIS data sharing network (GISnet), linking it with agencies GIS databases and securing its data.
- Providing technical assistance and consultation to ministries and government agencies

with issues related to GIS and GPS implementation.

- National level coordination between all ministries and government agencies implementing GIS.
- Cooperating with Arab, Regional and international bodies associated with Geographic Information Systems.
- Analyzing the requirements of GIS software licenses for all government agencies in addition to providing, and maintaining those licenses.
- Providing GIS e-services for Qatar.
- Managing and administering Qatar's GIS infrastructure.
- Designing and implementing plans and procedures for maintaining the safety and security of Qatar's GIS databases connected to GISnet in addition to initiating disaster recovery plans

As Qatar pursued a fast-paced development and growth, a National Vision for the country was laid out for the year 2030 and beyond. At that time, the need arose for an assessment of the existing advantages of Qatar's geospatial setup, capitalizing on them and laying out a long term strategy that goes along the country's vision. Emerging international directions and initiatives such as NSDI, UN-GGIM, issues of data capturing, data updating, demand for processed data, trends in data concepts, data sharing, data security, and trained and motivated manpower trends also had to be considered. These factors all signified a need for an updated programme strategy for a Qatar National Geospatial Information Data Infrastructure (QNGDI).

A team representing major agencies in Qatar using GIS was formed with the task of formulating the Vision, Mission, Strategy for QNGDI. A document was produced that included implementation recommendations for QNGDI to be successful.

The Vision of the QNGDI is "To develop a state of the art and efficient national geospatial infrastructure that is capable of supporting social, economic and human development towards a thriving and sustainable society".

The Mission of the QNGDI is "To guarantee the availability of secured, timely and reliable geospatial information and services to all stakeholders involved in the process of nation building in line with national aspirations by framing appropriate policies, developing infrastructure and building national capacity".

2.3.3 Organization

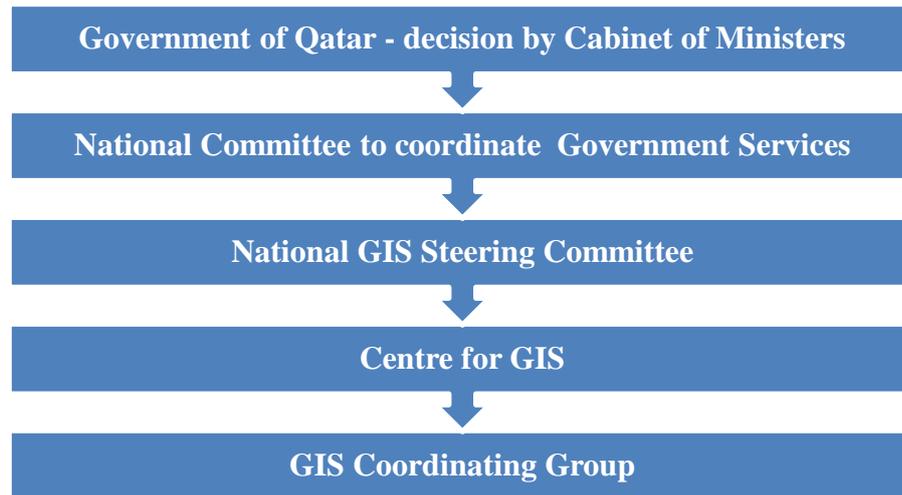


Fig:8 Organization structure of Qatar National Geospatial Data Infrastructure (QNGDI)

On the Technical Level the Coordinators Group meetings are held on a regular basis with representatives from every agency to encouraging cooperation, coordination and sharing of GIS activities and to ensuring adherence to uniform standards and compatibility. On the managerial Level GIS sub-committee meetings on regular basis which consists of GIS managers.

In Qatar, it was mandatorily all specifications and data dictionaries adopted and approved by the National GIS Committee in order that compatibility of data is maintained.¹¹

2.3.4 Finance

The Government has provided the finances for setting up the National GIS. The Center for GIS manages the basemap information that provides the spatial frame of reference for all other thematic layers. The cost for maintaining each thematic layer is borne within the budgets of the custodian organizations.

2.3.5 Data

One of the objectives of a nation-wide GIS implementation is to ensure that everybody uses a common geospatial framework. Qatar, to its credit, identified the data needed for decision-making at all levels, including where most decisions are made - locally - and developed the highest resolution data to support these types of applications. Their small size allowed them to consider this a National Spatial Data Infrastructure. A National Data base has been developed. Meta Data and Data Standards have been developed.

¹¹ GIS data sharing lessons from Qatar National GIS by R.C.S.Taragi and P.Balakrishnan

Since all agencies' the public data is available over the GISNet by 24x7, decision makers can analyze and use data by accessing GIS data of all agencies. The high speed network (GISnet) links over agencies using GIS in their day-to-day activities. The National GIS interconnects the distributed spatial databases throughout Qatar, by allowing every user, in every agency, immediate access to all publicly available GIS data in the country. The Qatar GIS is greatly appreciated by all ministries and organizations which are actively updating and sharing their data with the community.

2.3.6 Access

In order that agencies were able to access the data Qatar GIS ensured that every agency used a common spatial reference or a base map. For this to happen Qatar GIS maintained a digital topographic map of the country was made available for the users. Other data is made available to government agencies, private sector and the public according to need and government policies for data access.

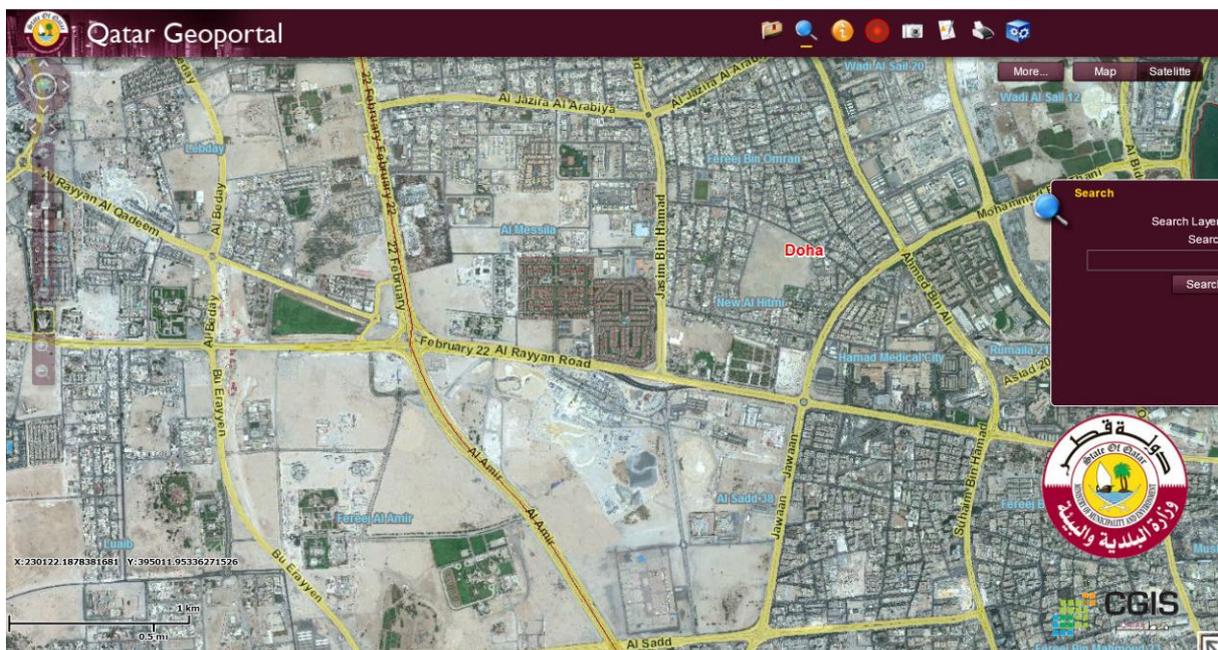


Figure 9 - Qatar Geoportal interface

The Centre also provides public access to selected information via the online Qatar Geoportal. This mapping portal developed by the QCGIS aims to become a comprehensive reference for various GIS services. Currently, it supports:

- Display of Aerial/Satellite imagery and vector maps.;
- Display of street names, landmarks, districts, geographic names;
- Allows user to Search/Locate address through Qatar Area Referencing System (QARS) data i.e. Building Number, Street Number, Zone Number;
- Search/Locate zones, streets and districts by name or number;
- Search/Locate Landmarks through entering whole or part of landmark name;

- Search/Locate Geographic names through entering whole or part of Geographic name. It includes photos, descriptions and pronunciation audio of geographic names in Qatari dialect;
- Search/Locate user personal geographic bookmarks;
- Printing and exporting maps;
- Street routing between two or more points with turn-by-turn instructions.

The Qatar Geoportal can be accessed at <<http://geoportal.gisqatar.org.qa>>.

2.3.7 Capacity

Much of the original Qatar GIS was developed with outsource contractor and expatriate workforce at the QCGIS. There was significant attention given to the building of management and technical skillsets of local nationals who today play the major role in the management and operations of the Center.

Recognizing the ongoing need for qualified GIS technicians and managers throughout government, the Centre for GIS has implemented a comprehensive training programme, which provides beginning, intermediate and advanced courses in all aspects of GIS operation and management. The Centre has established modern training facilities consist of training halls with advanced audiovisual facilities and other equipment, a conference room and a specialized GIS library that carries Video tapes, Maps and periodicals in addition to several book titles

The Centre for GIS has adopted a modular approach to training, allowing staff to attain a certain level of proficiency and then practice and develop those skills before moving on to more advanced classes. In addition to holding regularly scheduled classes, CGIS regional training sponsors seminars, workshops and special training courses. The development of the curriculum is ongoing and courses can range in length from a few days to several months, depending on the needs of the trainees and their agencies.

As a result of the world renowned position held by Qatar's GIS, The Centre for GIS reached an agreement with Environmental Systems Research Institute (ESRI) to establish an authorized regional training programme.¹²

2.3.8 Technology

Most Government Agencies in Qatar have been connected with a high-speed network. National GIS is supported by the Government e-initiative. A National Data base has been developed in Qatar. Metadata and Data Standards have been developed. The document

¹² http://www.gisqatar.org.qa/links/brochure_E.pdf

entitled “National GIS Database Specifications and Data Dictionary – Topographic” [www.gisqatar.org.qa] contains the digital mapping specifications and standards for the production of Qatar’s National Geographic database.

Qatar GIS has established a high speed fiber optic network GISnet connecting all the key stakeholder organizations.

Qatar National Spatial Data Infrastructure is looking at increased adoption of web and cloud services, which cuts down cost, increases and diversifies the range of users. It is also trying to increase adoption of mobile applications, which delivers geospatial services to the masses. Their system is centered around an Esri ArcGIS platform¹³.

2.4 Case Study 4 – Abu Dhabi

Abu Dhabi is the largest of the seven Emirates comprising the United Arab Emirates (UAE). Established in 2007, the Abu Dhabi Spatial Data Infrastructure (AD-SDI) is a programme of the Government of Abu Dhabi, administered within the Abu Dhabi Systems and Information Centre (ADSIC) e-government programme to facilitate the sharing of geospatial data among government agencies and other stakeholders.

As depicted in the AD-SDI Strategic Plan 2010-2014, the AD-SDI Program provided a common platform for the spatial enablement of government services which reduces investment risks and costs while enabling innovative applications and added value information products. Concurrently, the sound strategic direction of the AD-SDI Program is realized through the constant proactive and internationally acknowledged drive by the AD-SDI.

The Abu Dhabi Spatial Data Infrastructure empowers government and society with the use of spatial information and innovation. Location is integral to day-to-day activities and a majority of government services use spatial information. Spatial Data acts as a framework to unlock spatial innovation. The AD-SDI vision is to empower government and society with open access to spatial information & geo spatial e-services.

Now in its thirds stage of development, the AD-SDI stakeholder community has expanded to more than 80 entities sharing over 800 layers of information. The initiative has attracted international attraction and has won several awards.

2.4.1 Catalyst and Implementation Approach

¹³ <https://www.arcgis.com/home/item.html?id=3e37adf6abc54f6587a38bffe6cd66b6>

In 2002, what was then called the Environmental Resources and Wildlife Development Authority (ERWDA) promoted the notion of an Emirate-wide Environmental Data Base (EDB) that would bring together environmental and other data from all the key stakeholder organizations in a common data repository. In 2004 the government formed a Committee to study the potential for an organized programme for sharing GIS information across government. A study was commissioned to assess the needs of the stakeholders and to recommend a way forward.

The establishment of a “geographic information infrastructure (GII)” was subsequently included as a component of the implementation plan for the Abu Dhabi e-Government Programme, administered by what was then the Abu Dhabi Systems and Information Committee (ADSIC). The first stage of the AD-SDI was initiated in mid-2007 with the development of a new detailed programme design, implementation plan and the establishment of the initial Geoportal and data repository foundation system. While the field of potential participants was very broad, a decision was made to restrict initial participation to the 9 key stakeholders that produce a majority of the geospatial data needed by others. The development of the initial Roadmap and Foundation System had several components, including:

Baseline Situation Assessment. Systematic survey and analysis of the SDI situation and readiness of original 9 stakeholder organizations, subsequently applied incrementally to the nearly 80 organizations that are involved today. Orientation seminars were conducted with key stakeholders to ensure that they were aware of the purpose of the programme, the process to be followed, and the information that they would be expected to provide. The investigation involved direct interviews with managers and senior staff in all sections that could be affected by GIS and the AD-SDI to holistically cover the business, technical and institutional factors involved to gain a complete understanding of each organization’s current situation, capabilities, opportunities, constraints and plans for the near future.

Data Inventory and Assessment. Identification, inspection, assessment and documentation of all the existing geospatial and geospatial related information either generated or used by all the stakeholder organizations. This document is maintained on a periodic basis as new information becomes available.

Requirements Analysis. Aggregate analysis of all aspects of the Baseline Situation Assessment as needed to inform the development of a detailed programme design. This included identification and characterization of Business Framework (functional business clusters, data flow among organizations, interdependencies, gaps, etc.); Technical Framework (computing infrastructure, common applications software, Data and technical staff capacities); and, Institutional Framework (related policies, regulations, norms and inter-institutional mechanisms that could affect the functioning of the AD-SDI programme).

Strategic Plan. High level strategy originally outlining various possible ways forward. These were socialized with senior leadership within the government, following which a fully articulated strategy was developed around leadership priorities and direction. We have assisted the client in refreshing the AD-SDI Strategic Plan twice in the intervening years.

Program Design. A detailed Program Design was prepared establishing all of the target states to be achieved across all the major programme framework components (Business, Technical, Institutional).

Implementation Plan. The Program Design was reviewed with senior leadership and priorities identified. This input was then used to prepare a detailed Implementation Plan for each Stage of the programme. The implementation plan has been re-assessed and updated for each new year of the programme.

In addition to the above planning documents, the initial stage involved the establishment of the essential community engagement and governance mechanisms, including:

Working Groups and Special Interest Groups Engagement. This involved the ongoing and periodic formation and coordination of various groups of stakeholders as needed to address a variety of issues including but not limited to common data standards, community facility data standardization, entity GIS roadmap development and other issues.

Data Content Standards Development. This involved the SDC team collaborating with the community in the development of common data content standards for all fundamental geographic data sets (FGDS), based on international best practices and standards.

Data Projects Alignment and Coordination. Initially identified over 35 independent projects creating geospatial data across government that were not coordinated. Developed a plan for aligning these projects and established a programme to ensure ongoing alignment across government in the future.

Public Relations and Communications. This involved the planning and implementation of a public relations and communications function to ensure that stakeholders, leadership and the public were kept informed about the AD-SDI programme and its benefits across society.

In addition to facilitating the development of the processes, methods and tools to support data sharing across the community, the SDC also provides a variety of support services as needed by the community. These have included:

Applications Programming. The SDI either conducted or managed the development of a variety of application software for the AD-SDI programme. This included multiple iterations of refinements of the GeoPortal as well as a variety of common application software modules for mobile mapping and spatial enabling of various eGovernment services.

Technical Operations Support. SDC was responsible for setting up and operating the initial technical operations for the AD-SDI. A process was adopted to train or recruit local national staff to take over a majority of this function over time.

Help Desk. The SDC was responsible for setting up and operating the Help Desk for the AD-SDI.

The AD-SDI Program was initially conceived as a staged implementation starting with a foundation (stage 1), moving into institutionalizing and strengthening (stage 2) and finally into ongoing monitoring, assessment and adaptive management (stage 3). The foundation stage, which was a six-month fast track, was successfully completed between June and December, 2007. It established the basic foundation elements of the AD-SDI including refinement of the previous stakeholder situation assessment regarding GIS development in all the key agencies, development of an AD-SDI Strategic Plan that delineates data, technical and institutional target states, and alignment of existing major data development projects. It established also a Geospatial Portal and Data Clearinghouse, populated the Clearinghouse with representative data from all the participating agencies, leveraged existing data for visible results, established representative Technical Committee to participate in and guide the AD-SDI development process, and ensured that capacity building programmes are in place for all participating agencies that need to be responsible custodians and users of the AD-SDI. The first stage culminated in the development and distribution of an AD-SDI Program Design, Implementation Plan, and an Operations Plan for the Spatial Data Center (SDC).

The second stage of AD-SDI started formally on April 14, 2008 and was completed by March 2010. Stage 2 involved the expansion, refinement, and institutionalizing of the AD-SDI infrastructure foundations established in Stage 1, including the addition of data and metadata, coordinating with selected agencies to develop their own Geospatial nodes, monitoring data and capacity building projects, continuing to provide analyst support to the Executive Council and others, deploying the latest technology based AD-SDI Geospatial Portal 2.1, and adding integration and spatially enabled applications to the e-Government portal and government agency websites where appropriate. During this stage, the AD-SDI project team supported the initial operations of the AD-SDI Spatial Data Centre (SDC) and assisted ADSIC in carrying out a capacity building programme for permanent staff that will ultimately take over the operations and administration of the AD-SDI programme.

The third stage of AD-SDI started formally on March 2010. Stage 3 targets the evolution of the AD-SDI programme into adaptive management, monitoring and continuous innovation. This period will focus on strengthening the AD-SDI foundation by: expanding the stakeholder community (currently more than 50 entities); completing the formalization of data sharing arrangements; aligning and tracking all major data projects and initiating any additional projects needed to fill remaining gaps; continuing the development and enforcement of standards and interoperability best practices with the community; leveraging AD-SDI data and

infrastructure to support wide range of high value, high impact services and products; and institutionalizing the data maintenance and expansion of the Data Clearinghouse to include all fundamental data layers that are needed in common by the stakeholder community; and work toward the data flow automation between the individual nodes and the central AD-SDI nodes where necessary.

2.4.2 Policy

The Abu Dhabi, SDI vision was to empower government and society with open access to spatial information & geo spatial e-services. The AD-SDI Program supports inter-governmental and multi-stakeholder collaboration for better planning, analysis and decision-making. AD-SDI is enabled by geo-governance with defined policies and strategies. The AD-SDI Master Plan and 2010-2014 Strategy are in line with and contribute to the Abu Dhabi Government Vision and Policy agenda. The Abu Dhabi Spatial Data Infrastructure (AD-SDI) a programme of the Government of Abu Dhabi, administered within the Abu Dhabi Systems and Information Centre (ADSIC) e-government programme to facilitate the sharing of geospatial data among government agencies and other stakeholders.

As mentioned earlier, the AD-SDI was initiated and formulated under the Abu Dhabi Systems and Information Committee (ADSIC). In later years, the “Committee” evolved to become the Abu Dhabi Systems and Information Centre (acronym also ADSIC), a formalized entity reporting directly to the Executive Council. The AD-SDI was established as a programme under the Committee which was then migrated to the Centre. The programme was previously not documented as a formal policy of the government, but rather was treated as a more or less voluntary participation programme. The fact that the community over 7 years grew from 9 entities sharing 140 layers of information to over 80 entities and a common data repository of over 800 layers of information without a formalized policy is a testament to the recognition of value by the stakeholder community and the leadership. In 2016 it was decided to further formalize the programme with an adopted policy. A draft policy has been developed and is under review at the time of this writing.

2.4.3 Organization

The AD-SDI has been structured as a programme administered by ADSIC but supported by a wide range of stakeholders across Abu Dhabi society. The programme is managed by a Spatial Data Center (SDC). The administrative position of the SDC within the ADSIC organizational structure has changed over the years and today is positioned as one of several important “shared services” associated with the e-Government programme. The current position of the SDC in the ADSIC organization structure is illustrated in the following figure:

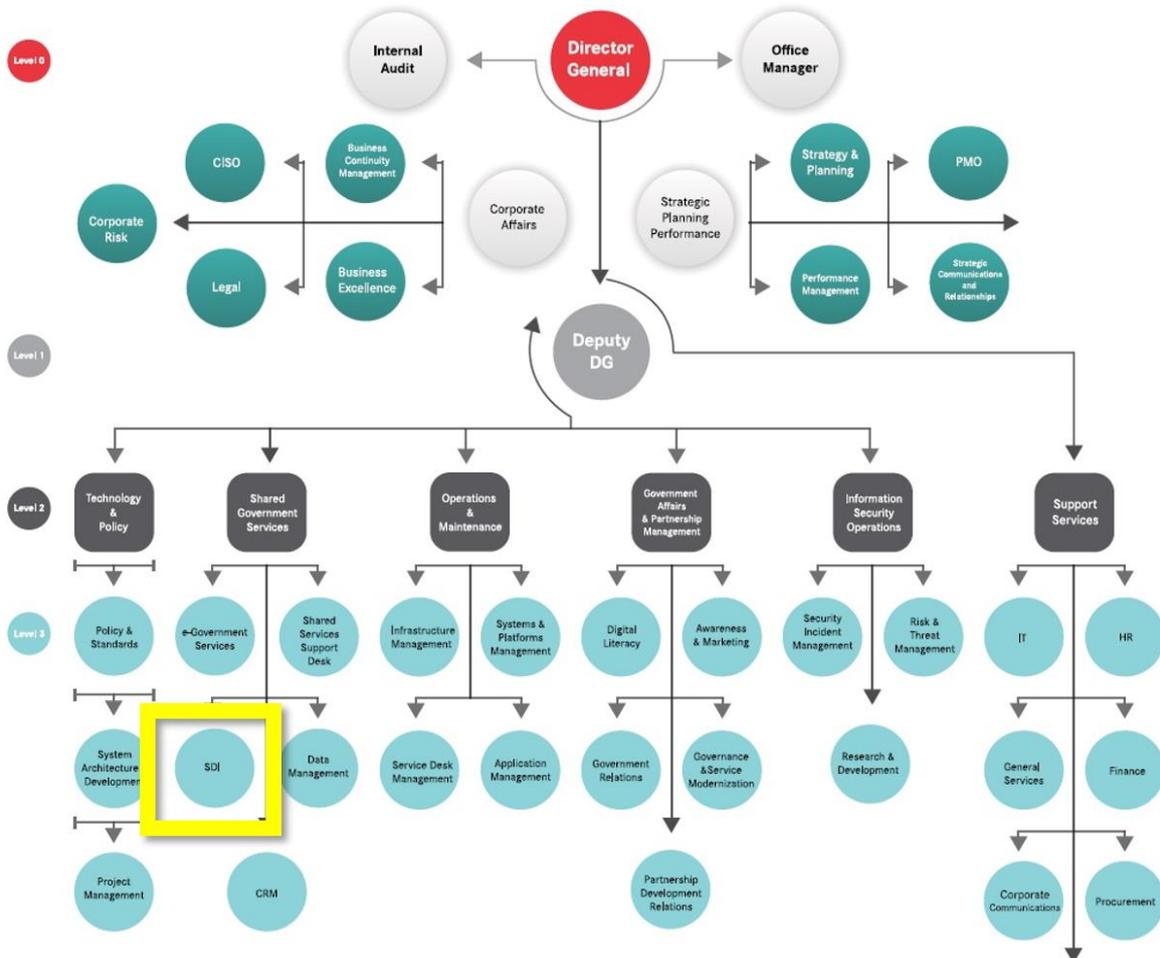


Figure 10 - Position of the SDC in ADSIC Organization Chart

A Spatial Data Center (SDC) provides support for the governance structures and sits within the Abu Dhabi Systems and Information Center to maintain strong ties to the Abu Dhabi eGovernment programme. The SDC: Facilitates, coordinates, promotes and supports the development and operations of the AD-SDI; Forms a coordinating point to facilitate and coordinate individual initiatives as needed; Provides secretarial services to working groups and special interest groups; Facilitates stakeholder liaison forum. Coordination and Strategic Planning Committee ensures that the wider geospatial interests of the government addressed.

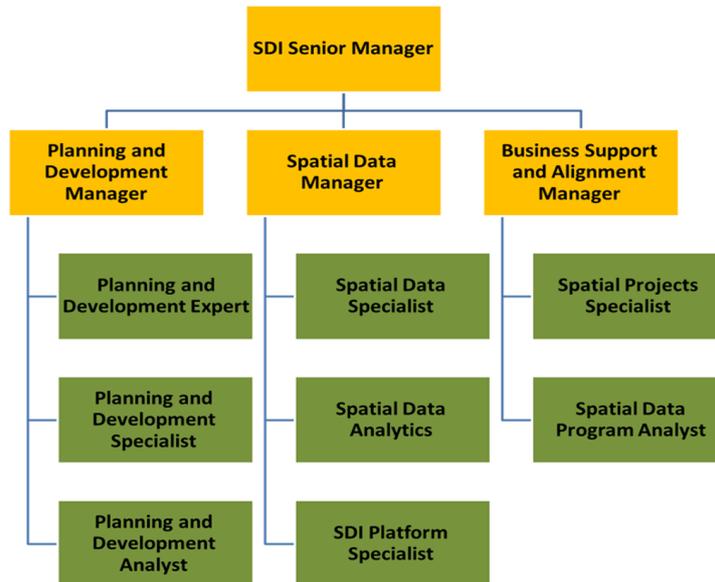


Figure 11 - SDC Organizational Structure

The SDC coordinates with an AD-SDI Technical Committee (TC) that is made up of representatives of all the involved stakeholder entities. The TC meets on a quarterly basis to cover areas of mutual interest across the community and to encourage networking and information sharing among the members.

Stakeholder engagement also occurs through two other channels, including Working Groups and Special Interest Groups. Working Groups are temporary associations, convened for the purpose of addressing a specific subject, such as the development of a data standard. Special Interest Groups (SIG's) are more or less permanent associations that are formulated around community-of-practice themes such as "environment" or "utilities". The purpose of these SIG's is to converge the common interests of the sub-community segments for coordination, collaboration and information sharing around subjects of common interest to the group.

2.4.4 Finance

The AD-SDI Spatial Data Center (SDC) is funded by the government of Abu Dhabi, within the operational and capital expenditure budgets of ADSIC. The development and maintenance of all data layers is funded through the budgets of the responsible custodians. The exception to this rule is the acquisition of orthophotography and satellite earth observation imagery which is managed by the SDC as a centralized programme on behalf of the entire AD-SDI community, and the Esri Enterprise License Agreement that is funded centrally through ADSIC.

At present there is no charging of fees by the SDC for access to data and provision of limited technical support services. However, budget constraints in the Emirate are today forcing a reevaluation of this position to determine if there might be a feasible basis for fee-based cost

recovery for selected data products and services. This issue is currently being explored under the new proposed policy framework that is currently under review at the time of this writing.

2.4.5 Data

An inventory of fundamental geographic data sets acts as the information source feeding multiple levels. These data enable common services across government, private sector and the general public. Over 800 data layers are included in the AD-SDI data holdings today. As pointed out previously, with the exception of orthophotography and satellite imagery, all of the GIS data layers are maintained by responsible custodians. The data standards for each layer are developed through a community engagement process involving all organizations with an interest in each layer. The final content standard and updating period information is codified to a Service Level Agreement (SLA) between the custodian entity and ADSIC. This is complemented with a licensing agreement that lays out the terms and conditions for usage of said data.

Originally there was no consistent or commonly available topographic or imagery basemap for the entire Emirate of Abu Dhabi. Today, the three municipalities that fall under the auspices of the Department of Municipal Affairs and Transport (DMAT) are each responsible for maintaining more or less standardized vector and imagery basemap data for each of their jurisdictions, which together cover the entire Emirate. While there has been some spatial variation and lack of alignment in themes that were developed at different times by different organizations in the past, now that there is a standardized basemap that is accessible to the entire community, new thematic information tends to be better aligned.

There are now programmes coming on line, such as the electronic No-Objection Certificate (NOC) initiative that require highly accurate information for such things as site clearance, or “call before you dig” functions. Such programmes are causing the re-evaluation of any remaining inconsistencies in legacy data and the formulation of data alignment projects to help raise the general quality, consistency and compatibility of data across all thematic areas.

2.4.6 Access

The AD-SDI Geospatial Portal provides capability for data and metadata search, discovery and viewing <<https://geoportal.abudhabi.ae/mapviewer/index.html>>. The majority of stakeholder data access is via web map services (WMS) and web feature services (WFS). The distribution of physical copies of data is generally discouraged as it creates a situation within which data lineage cannot be easily traced. The stakeholder community has access to common services for spatially enabled e-Services and e-Forums. The Abu Dhabi Explorer provides information on community facilities and points of interest. Mobile applications allow users to access geospatial information on the move.

In addition to data services, the SDC has also led the development of common applications services and the spatial-enablement of selected eGovernment services. This has included the development of such things as mobile mapping application services that can be consumed by end-user applications, and the “CityGuard” application that allows citizens to report issues to the government call center, inclusive of the precise mapped location of a complaint or incident.

The vast majority of the information contained in the AD-SDI data repository is available to all registered government users. Access to sensitive data is restricted to selected entities and the Abu Dhabi Executive Council, the Abu Dhabi Police and the Army General Headquarters (GHQ). The level of data sensitivity is determined through a systematic assessment of the nature of each theme, and/or through direct instruction of the Abu Dhabi Executive Council.

2.4.7 Capacity

An incremental capacity building process was used to initially staff the SDCC with consultants and limited local staff that transitioned into an increase in local staff as the internal capacity increased. AD-SDI capacity and breadth increased through partnerships and interdisciplinary planning. In 2007, the AD-SDI community started with 8 entities, and today includes over 50. AD-SDI established a strong Capacity Building programme that rests on three pillars: spatial thinking, planning and implementation.

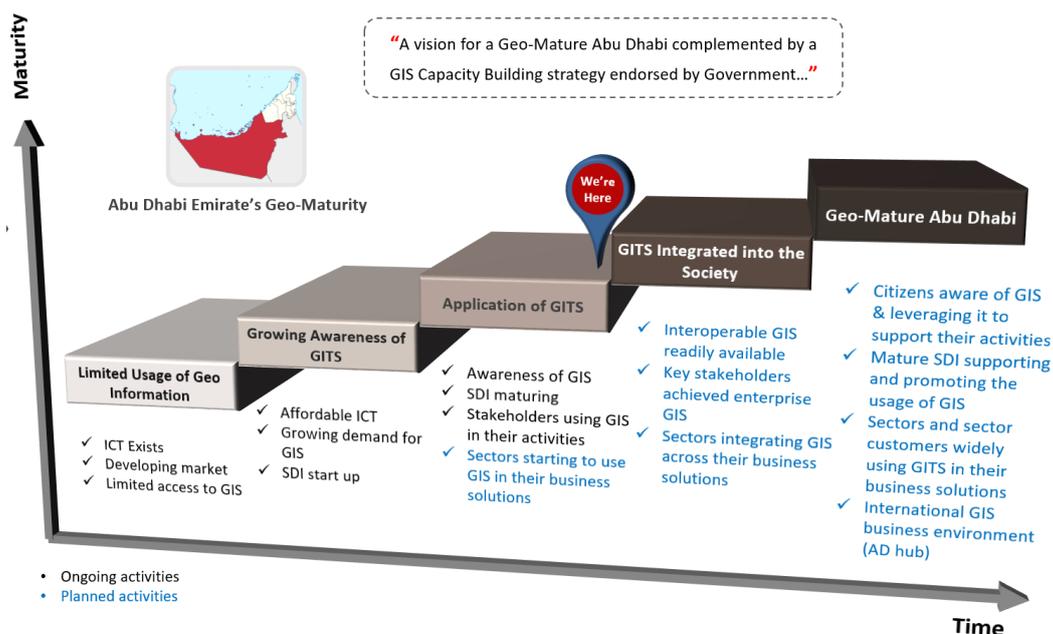


Figure 12 - AD-SDI GeoMaturity Levels

Abu Dhabi has pioneered the development and application of the concept of “GeoMaturity” measurement within the community. This involves a systematic assessment of over 40 factors and is applied at both the level of individual stakeholder entities and Sectors to determine the

level of development of GIS capacity and the areas that need to be addressed for future improvement.

2.4.8 Technology

Several technologies provide common services through AD-SDI including a GeoPortal for geospatial information discovery, Explorer for information on community facilities and points, and Mobile Applications for geospatial information on the move. Strong leadership, community collaboration and sustained technical capacity building is driving innovation towards an Abu Dhabi eSociety.

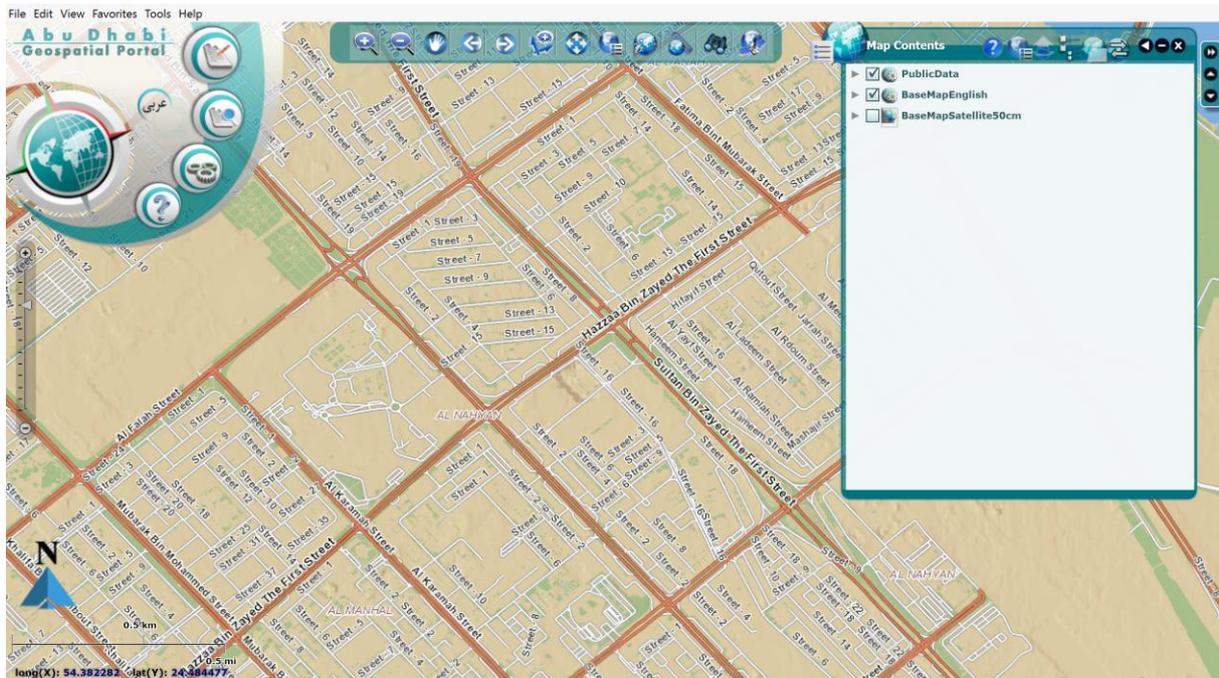


Figure 13 - The AD-SDI GeoPortal provides access to information based upon user authority

At the Technical Level, the AD-SDI technical services e.g. Geoportal, spatial services, data clearinghouse and others are being constantly adapted to the business solutions of the Sectors using interoperability standards i.e. OGC/ISO.

Abu Dhabi established a Master Licensing Agreement with the leading GIS vendor ESRI, for central software/services procurement for entire Abu Dhabi government. This arrangement allows most government agencies to access GIS software licenses and some training and selected technical support services.

The Abu Dhabi Spatial Data Infrastructure (AD-SDI) network of information nodes seamlessly confers the value networks across the entire society i.e. of the government, businesses, and the public. Assessing the extent of AD-SDI impact across the community in order to assess the value of SDI is a highly collaborative and synergistic process, given the level of complexity of the AD-SDI Community, which comprises more than fifty

organizations with federal and emirate-wide government entities, businesses, and academia. ESRI ArcGIS technology was used in developing the GIS activities and AD-SDI infrastructure.¹⁴

2.5 Case Study 5 – United States

The United States National Spatial Data Infrastructure (NSDI) is described by Executive Order 12906 (“Coordinating Geographic Data Acquisition and Access”) as **“the technology, policies, standards, and human resources necessary to acquire, process, store, distribute, and improve utilization of geospatial data.”** The NSDI has become a critical vehicle for facilitating seamless data development, information sharing, and collaborative decision making across multiple sectors of the economy.¹⁵

The NSDI leverages investments in people, technology, data, and procedures to create and provide the geospatial knowledge required to understand, protect, and promote the national and global interests of the U.S. Stakeholders from multiple levels of government, academia, and the private sector collaborate on the NSDI.

The Federal Geographic Data Committee (FGDC) is the U.S. interagency coordinating body for NSDI-related activities. Led by the Department of Interior and Office of Management and Budget, the FGDC is composed of representatives from the Executive Office of the President, Cabinet-level departments, and independent Federal agencies. The FGDC develops policies and partnerships to advance the development of the NSDI and promote Federal and national geospatial initiatives.

2.5.1 Catalyst and Implementation Approach

Discussions regarding a national GIS in the United States began in the late 1980’s. The Federal Geographic Data Committee (FGDC) was initiated in 1990 by the Office of Management and Budget (OMB) to help align federal government geospatial activities (OMB, 1990). The FGDC was initially tasked to coordinate the development of specific themes of geographic data across the federal government. As part of its responsibilities it was also charged with collaborating with state and local governments, academia, non-profit organizations and the private sector to align with their interests and needs. In the early 1990’s the National Academy of Sciences began to use the term “National Spatial Data Infrastructure” and the FGDC soon agreed to adopt the same phrase to avoid confusion.

In 1993, the Clinton Administration, under the guidance of vice-president Al Gore initiated a programme to “reinvent federal government”, in part by devolving more responsibility to

¹⁴ <http://www.esri.com/library/bestpractices/spatial-data-infrastructure.pdf>

¹⁵ <https://www.fgdc.gov/nsdi/nsdi.html>

States and Counties. The FGDC promoted the inclusion of the NSDI into the re-invention programme and it was featured prominently in the National Performance Review Report (Gore, 1993).

The U.S. National Spatial Data Infrastructure programme was established by President Clinton through Executive Order 12906 of April 11, 1994 titled “Coordinating Geographic Data Acquisition and Access: The National Spatial Data Infrastructure”. The Federal Geographic Data Committee (FGDC) was assigned to coordinate the NSDI activities.

The FGDC has also led the development of the OMB Circular A-16 Supplemental Guidance, initiated the implementation of a geospatial portfolio management approach, and led the development of the Geospatial Platform initiative. The OMB Circular A-16 Supplemental Guidance addresses portfolio management for the coordination of Federal geospatial data assets and investments to more efficiently support national priorities and government missions. Portfolio management will apply consistent management approaches to help increase the quality of data through best practices and documentation in a manner that reduces duplication and cost and provides greater accessibility. The Geospatial Platform will provide a suite of shared services and capabilities to Federal agencies and partners. These developments build upon the previous processes and accomplishments of the FGDC and will provide a means to more efficiently manage and deliver Federal geospatial products and services in the coming years.

While originally focused on the federal level, the FGDC vision is now reflected in many state and local governments. The Geospatial One-Stop (GOS) portal initiative grew from this vision and provides another means of accelerating NSDI development by building a framework of data standards, improve portal development, increase the quantity and quality of available data and promote more utilization of GIS and GIS data across the marketplace.

“Concurrently, the FGDC, the NSDI and GOS began to look strategically at the next steps in the evolution of the NSDI. International examples of infrastructure development have been examined and the strategy has been formulated with three principal goals: creating partnerships with purpose, making framework real, and communicating the message. The major message is that in order to create a truly national spatial data infrastructure, one needs to involve the people and data at the day-to-day working level – cities, counties, and utilities. New and different policies and partnerships need to be developed before all meaningful data can be made available for critical decision making. This massive effort involves components of the US Federal Government as well as State, County, City, and community Governments. The team also has considerable input from NGOs and the private sector. Early findings indicate that it is critical to build a formal national council involving all potential generators,

users, and distributors in the public and private sectors. This plan is being reviewed at the current time and will yield a completely new approach to building the US NSDI”.¹⁶

2.5.2 Policy

The U.S. NSDI was launched by the signing of Executive Order 12906 of April 11, 1994 titled “Coordinating Geographic Data Acquisition and Access: The National Spatial Data Infrastructure”.

The U.S. Office of Management and Budget and the U.S. Congress set policy for Federal agencies. The Federal Geographic Data Committee, a Federal interagency coordinating committee, is guided by those policies in the design of programmes, activities and technologies. The FGDC sets geospatial information policy in harmony with overall information policy.

The FGDC engages in on-going strategic planning to ensure continued investment of resources in high value programmes, activities and technologies for the advancement of the NSDI.

A policy is an official plan or course of action intended to influence and determine decisions, actions and other matters. Guidelines denote one or more rules that describe a process. There are five sets of policies and guidelines that shape the U.S. NSDI:

- OMB Circular A-16 and Supplemental Guidance;
- OMB Circulars that guide the FGDC policies;
- Executive Order establishing the NSDI;
- FGDC Policies;
- FGDC Guidelines;¹⁷

The tremendous growth and evolution of geospatial technologies, industries, and applications in recent years highlighted the need to update and modernize the strategic direction of Federal geospatial programmes to align with and leverage these advancements. The Federal Geographic Data Committee’s (FGDC) 2014–2016 Strategic Plan for the National Spatial Data Infrastructure (NSDI) sets priorities and describes the actions the FGDC community will take, in collaboration with partners, to develop and maintain the Nation’s critical geospatial infrastructure.

NSDI Strategic Plan 2014–2016



¹⁶ Steven, Alan. THE US NATIONAL SPATIAL DATA INFRASTRUCTURE: WHAT IS NEW?. ISPRS Workshop on Service and Application of Spatial Data Infrastructure, XXXVI(4/W6), Oct.14-16, Hangzhou, China.

¹⁷ <https://www.fgdc.gov/policyandplanning>

The 2014-2016 strategic plan envisaged to develop geospatial interoperability reference architecture, establish the Geospatial Platform as the Federal Fig 9 – NSDI Strategic plan 2014-applications Web-based service environment, expand the use of cloud computing and promote the use of geospatial multiagency acquisition vehicles for interagency and intergovernmental purchases.

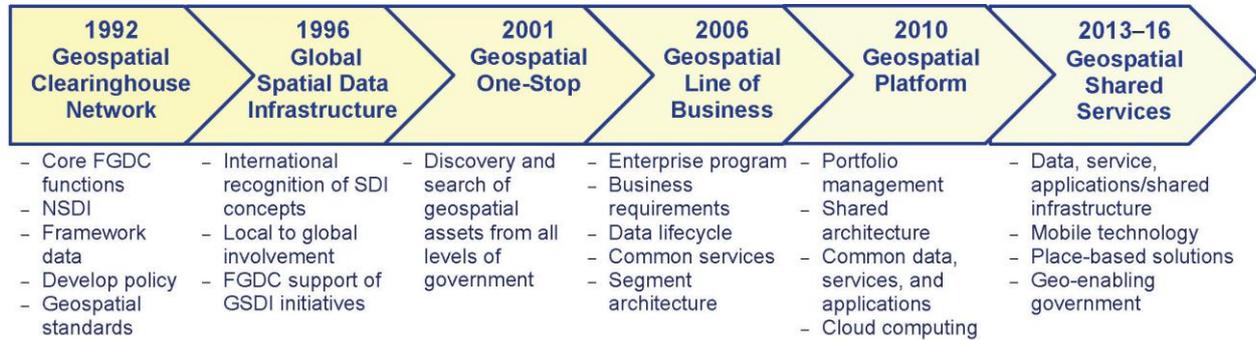


Fig 10 – NSDI Historic Development and Strategic Plan 2014-16¹⁸

The Vision of the FGDC was worked with partners and stakeholders, including the members and organizations represented on the National Geospatial Advisory Committee, to collaboratively define a shared national vision that describes the value that the NSDI will bring to its stakeholders and partners. The vision statement states “The NSDI leverages investments in people, technology, data and procedures to create and provide the geospatial knowledge required to understand, protect and promote our national and global interests”.

2.5.3 Organization

The Federal Geographic Data Committee (FGDC) is a United States government committee which promotes the coordinated development, use, sharing, and dissemination of geospatial data on a national basis. Its 32 members are representatives from the Executive Office of the President, and Cabinet level and independent Federal agencies. The Secretary of the Department of the Interior chairs the FGDC, with the Deputy Director for Management, Office of Management and Budget (OMB) as Vice-Chair.¹⁹

While the FGDC has the responsibility to promote the NSDI, it is the individual Federal Agencies, and by extension other state and local government entities that are responsible for the day-to-day operations of building, sharing and using the infrastructure.

2.5.4 Finance

The FGDC is funded through the Department of Interior. Each Federal Government agency is responsible to fund the preparation of spatial data required for carrying out its mandate. The Freedom of Information Act (FOIA) generally provides that any person has the right to

¹⁸ National Spatial Data Infrastructure Strategic Plan 2014–2016 by Federal Geographic Data Committee, -December 2013.

¹⁹ Federal Geographic Data Committee Retrieved 2010-08-24.

request access to federal agency records or information except to the extent the records are protected from disclosure by any of nine exemptions contained in the law or by one of three special law enforcement record exclusions. In general, the law dictates that such information should be provided at the cost of research and reproduction.

2.5.5 Data

The Geographic Information Framework Data Standard establishes common requirements for data exchange for seven data themes of geospatial data that are of critical importance to the National Spatial Data Infrastructure (NSDI), as they are fundamental to many different Geographic Information Systems (GIS) applications. It specifies a minimal level of data content that data producers, consumers, and vendors are expected to use for the interchange of data for these themes, including through Web services.

The standard includes a base document and parts that correspond to following data themes:

- Cadaster;
- Imagery;
- Elevation;
- Geodetic control;
- Government units;
- Administrative and statistical boundaries;
- Water - inland, and
- Transportation. The transportation part consists of a base sub-part and sub-parts that correspond to different modes of transportation: airport facilities; rail; roads; transit; and waterways.

The draft standards were initially developed through the Geospatial One-Stop e-Government initiative; however, the FGDC assumed leadership for continued standards activities.

As the Geographic Information Framework Data Content Standard was developed using public funds, the U.S. Government is free to publish and distribute its contents to the public, as provided through the Freedom of Information Act (FOIA), Part 5 United States Code, Section 552, as amended by Public Law No. 104-231, “Electronic Freedom of Information Act Amendments of 1996”.²⁰

The US NSDI is based on an open data approach. Information resources of federal government are put into public domain. Federal agencies are not allowed to secure copyright of their work. Only security and other sensitive data is exempted. Government held data is generally made available at the cost of replication. Pricing of value added services are market determined. USGS and several other agencies are tasked to make base map, census and other data conveniently available at low or no cost per an executive order.

²⁰ <https://www.fgdc.gov/standards/projects/framework-data-standard/framework-data-standard>

Many federal government agencies have the mandate to collect data for the whole of the United States and those agencies almost always are required to comply with the variety of federal information policies. These can best be summarized as a strong freedom of information act, no government copyright or database right, fees limited to the recouping the cost of dissemination, and no restrictions on reuse. In this respect, the policies in the United States are remarkably different from the policies in most other countries.

2.5.6 Access

FGDC ensured that spatial data from multiple sources were available and easily integrated to enhance the understanding of the physical, natural, and cultural systems. The Committee has facilitated the development of authoritative National Geospatial Data Assets that are complete, accurate, current, standards-compliant, and at the scale needed for shared uses. Provisions are made to protect the privacy and security of citizens' personal data and ensure the accuracy of statistical information about people. It has enabled access for all citizens to spatial data, information, and derivative and interpretive products in accordance to the Open Data Policy. Protected proprietary interests related to licensed information and data.

The screenshot displays the GEOPLATFORM.gov website interface. At the top, there is a navigation bar with links for Overview, Data, Communities/Agencies, Resources, and Marketplace, along with a search bar and Sign In/Help options. The main content area is divided into a left sidebar and a main panel. The sidebar includes a 'Filter By Location' section with a map of San Diego and a 'Dataset Type' filter set to 'Geospatial (125434)'. The main panel features a 'Dataset Catalog' section with a search bar and a 'Search' button. Below the search bar, it displays '125,434 datasets found' and an 'Order by: Popular' dropdown menu. Two featured datasets are shown: 'U.S. Hourly Precipitation Data' and 'USGS National Elevation Dataset (NED) 1 Meter Downloadable Data Collection', both marked as 'Federal' data assets.

Figure 14 – FGDC Geospatial Platform provides access to many thousands of data sets

The Geospatial Platform is an FGDC initiative that provides shared and trusted geospatial data, services, and applications. Users can search a massive catalog of geospatial data and tools provided by a multitude of federal agencies. The Platform supports any combination of the following filter and sort tools:

- Filter by location
- Search by geospatial area

- Filter by search facet
- Filter by key words
- Sorting search results

Within the FGDC Geospatial Platform only datasets marked as "Federal" are subject to the U.S. Federal Government and Data.gov's Data Policy. Non-federal participants (e.g., universities, organizations, and tribal, state, and local governments) maintain their own data policies. It is important that users understand the data policies of participating entities in order to best utilize these datasets.²¹

2.5.7 Capacity

Capacity building of clearinghouse nodes is supported by the Federal Government Technical capacity building within organizations according to their own needs, Some States, Counties and Regions assuming active coordination role, and various geographic communities are also assuming active roles in the expansion and refinement of SDI framework.

FGDC and its partners have developed a strategic plan for the NSDI that describes a shared national vision of the NSDI and includes a set of goals and objectives for the role of Federal agencies in achieving the following vision: "The NSDI leverages investments in to create and provide the geospatial knowledge required to understand, protect, and promote our national and global interests."²² The Strategic Plan places a heavy emphasis on the development of technical capacities across the stakeholder community to optimize the utilization of the technology and the most important and needed data resources.

2.5.8 Technology

The US NSDI consists of a distributed network of interoperable geospatial server nodes that are all connected and communicating with a central clearinghouse using common metadata standards and specialized protocols. These interconnections and standards make it possible for a user to access the central FGDC Geospatial Platform clearinghouse and search across the entire network of nodes, as depicted in the figure below.

²¹ <https://www.fgdc.gov/dataandservices>

²² <https://www.fgdc.gov/nsdi/nsdi.html>

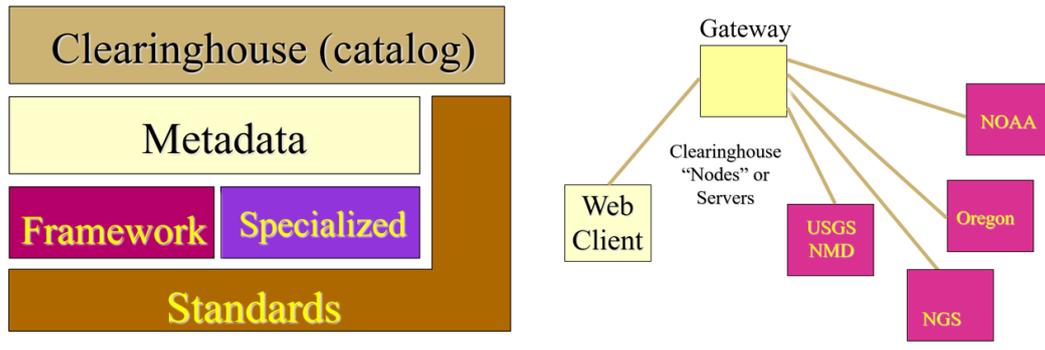


Figure 15 - NSDI Clearinghouse connects distributed network of interoperable nodes

The Geospatial Platform initiative is a critical component for the continued development of the NSDI. The Platform is a Web-based first generation service environment that provides access to a suite of well-managed, highly available, and trusted geospatial data, services, applications, and tools for use by Federal agencies and their State, Tribal, regional, and local partners. In addition, the FGDC community and its partners utilize common cloud computing and enterprise acquisition approaches as mechanisms to leverage technology, close productivity gaps, and combine buying power across agencies for similar needs

Initial clearinghouse framework built around pre-existing protocols. The policy of growth of broadband Internet access infrastructure reduced barriers and opening of new opportunities. Advances in Internet architectures and web-based mapping services provide new opportunities for data access, exploration and use.

The 2014-2016 FGDC Strategic Plan specifically identified the expanded use of Cloud computing as a key component of the way forward. Within Goal 1 of the Strategic Plan is stated that “..the FGDC community and its partners will utilize common cloud computing and enterprise acquisition approaches as mechanisms to leverage technology, close productivity gaps, and combine buying power across agencies for similar needs.”²³ The anticipated output of this objective states “Cost savings through expanded use of commodity cloud-hosting capabilities for the benefit of all NSDI partners”.

²³ National Spatial Data Infrastructure Strategic Plan • 2014–2016, www.fgdc.gov

3 CONCLUSIONS

The purpose in conducting the Case Study assessment as part of the SL-NSDI Requirements Assessment activity is to explore approaches and lessons learned elsewhere that have relevance to Sri Lanka. While many of the outcome targets are similar across most NSDI programmes around the world, experience has suggested that the ultimate form of an initiative and the best path for achieving priority targets, must be carefully crafted to fit a Country's specific conditions, needs and priorities. It will therefore be important that the approaches and lessons learned described in this report are carefully considered against those factors that are unique to Sri Lanka and that will ultimately influence the form and function of a successful SL-NSDI.

Key findings and conclusions from this study that have special significance in the Sri Lanka context are summarized below:

Leadership awareness and active support is critical to the initiation and advancement of any NSDI initiative. Leaders need to be aware of the fundamental structural and policy-relevant implications of a well-developed and utilized NSDI programme. Ongoing executive awareness and guidance is critical to ensuring that the programme continues to align with national strategies and priorities. This has been a fundamental prerequisite for every successful NSDI.

Substantial "ownership" of the NSDI initiative by the participating stakeholder organizations is important to its relevance and persistence. Stakeholders at both executive and technical levels must be comfortable that they have a substantial level of control and input to the form, function and priorities of the programme. Every successful NSDI has had some form of stakeholder representative bodies, typically structured as Executive and Technical Committees, Working Groups and Special Interest Groups or some variation thereof. Ideally these bodies are folded into the governance framework for the programme with each body assigned the appropriate roles, authorities and responsibilities.

A dedicated team focused on supporting the NSDI is critical to the development and sustainment of the programme. The facilitation, promotion and support of an NSDI requires a dedicated, full-time team. This team needs to be completely focused on carrying out a series of key functions that include, at a minimum the following:

- Program management and administration;
- NSDI computing infrastructure management and operations;
- Stakeholder communications and outreach;
- Formulation, proliferation and management of standards adoption across the community;
- Maintain and operate NSDI data clearinghouse;

- Maintain and administer common application software modules;
- Support special project requests.

A strong policy foundation is important to sustaining NSDI over time, but not necessarily an absolute prerequisite to getting started. The bureaucratic processes required to formalize an NSDI policy can take significant time and effort, depending on the form and nature of government. In some cases, NSDI initiatives have been stalled for months or years as the process of policy-making was underway. In such cases the benefits of the NSDI were likewise postponed. In some cases, such as Abu Dhabi, the NSDI was implemented purely as a program with no accompanying policy in place for several years but this was due to the nature of the government and the leadership of a strong, central eGovernment organization.

NSDI is more about governance and less about technology. While a basic computing infrastructure is essential to providing an operating environment for an NSDI, the majority of the effort required to establish and manage such initiative is largely dedicated to outreach, coordination and governance. The technical work of building and maintaining GIS data and most applications is carried out at the level of individual organizations. The NSDI is focused on providing the platform and procedures by which the utilization of that data investment can be leveraged across many organizations.

Most successful NSDI initiatives start with a core group of critical stakeholders that together create a strong foundation programme that can be built upon incrementally. NSDI initiatives that try to be everything for everybody often get bogged down in complexities and too diffused to focus where tangible results and outcomes are most critical. Those that have been more practically inclusive of the broader community while focusing actionable attention on those primary data custodians and high impact users that will make the most difference in the beginning. This focused foundation can then be incrementally expanded over time based on a systematic process of successive stakeholder community engagement.

NSDI initiatives must actively evolve to stay relevant and thrive. Some older NSDI initiatives have remained relatively unchanged over many years while others have made a point of a process of continuous improvement and innovation. The latter approach is more likely to take advantage of emerging technological opportunities and more agile adaptation to changing political and institutional contexts.

Any NSDI foundation programme is only as strong as the stakeholder units that comprise it. Equal attention must be paid to the development of Enterprise GIS capacity within each NSDI stakeholder organization to carry out their own work. The bulk of the return on GIS investment is gained at the enterprise level. The NSDI can only enhance and extend the efficiencies and benefits, but should not overlap or duplicated Agency work.

Technical staff training is an ongoing requirement to keep both enterprise GIS and NSDI level efforts moving forward. The technology field is constantly evolving and it is critical that the NSDI facilitation team stays abreast of such developments and takes a leadership role in encouraging early adoption where appropriate. It is likewise important that technical staff in the stakeholder organizations also actively seek to leverage new technological opportunities as they arise.

NSDI must continuously demonstrate a compelling return on investment in both tangible and intangible results. There are very few NSDI initiatives that have ever “failed”, but some have slipped into a static complacency that ultimately loses momentum. One of the key drivers of NSDI success is the dependence that comes from effective utilization. Measuring this in terms of quantifiable tangible benefits and compellingly recognizable intangible benefits is important to ensure that these are well recognized and appreciated as an essential cornerstone to government and society. This includes economic return on investment as well as social and environmental returns.

Web-based mapping is the foundation for all contemporary NSDI efforts. Early NSDI initiatives relied upon inter-connected wide area networks and servers for communicating and sharing data. The environment for massively interconnected communities globally has completely revolutionized the world and provided an entire new enabling environment for NSDI. Web-based mapping has already become the norm and this will only expand as the world moves towards an Internet of Things and sensor networks that are increasingly location-aware.

Cloud Computing provides the efficiency and scalability that is required for any growing NSDI initiative. Several initiatives around the world are implementing or investigating the use of a Cloud Computing environment as an efficient and scalable architecture for supporting their national and regional spatial data infrastructure initiatives. All of those investigated as part of the current study were opting to set up a dedicated government cloud due to control and security issues. In at least one study (Bahrain), the cost for utilization of Cloud resources was calculated to be 50% of the cost of a more traditional on-premise dedicated system.

Traditional NSDI has been focused on a “supply-side” perspective for data coordination and sharing – a new perspective connecting data more directly to “demand side” utilization of this information for impact is needed to maximize the investment and benefits. The intention of NSDI is to make authoritative data more accessible to support better policy and decision-making. Much of the NSDI concept has been traditionally focused on streamlining the supply of data to the community. Experience has shown however that NSDI information is often under-utilized because the persons involved in ensuring supply may not be proactively tied into the people and processes that can need that information. Conversely those people that are driving those processes are often not fully aware of what is available through the NSDI. It is clear that there is a need for re-thinking the relationship between the supply of data and how to connect it more directly and proactively into key processes, most notably

those involved in information supply (national statistics, national mapping, eGovernment), physical planning (land use, infrastructure, resource management, biodiversity), development investment (project requirements and feasibility, investment support, monitoring and evaluation) and national reporting (Nationally Determined Contributions (NDC's) to carbon emission reduction, Sustainable Development Goals (SDG's), national strategic key performance indicators (KPI's).

There is significant agreement in what data themes most NSDI initiatives have prioritized for early focus. Experience in multiple NSDI initiatives has suggested that at the national level there are specific data topics that are most often needed in common. These included but are not limited to:

- Geodetic control;
- Elevation (topography, bathymetry, etc.);
- Hydrology (rivers, streams, springs, etc.);
- Land ownership and tenure;
- Imagery;
- Gazetteer and points of interest;
- Political/administrative units;
- Transportation (roads, bridges, rail, etc.);
- Utilities;
- Population census;
- Soils;
- Geology;
- Land use and land cover;

The adoption of standards has been critical to ensuring the interoperability needed for any NSDI to function. For information to be developed, shared and used in common by a diverse community, it is essential that the community adopt a suite of common standards. Standards ensure that information meets the needs of the community, is reliable and consistent, and can be used across multiple systems. Technology standards also ensure that systems can communicate to one another and work in interoperable ways. The International Standards Organisation (ISO) and the Open Geospatial Consortium (OGC) are the most influential organizations in this regard within the geospatial sector.

The relationship between NSDI and eGovernment is not always clear. Many NSDI initiatives are implemented within or closely aligned with eGovernment, but these are often run as parallel, loosely-integrated initiatives. In such cases the potential synergy and optimization of geospatial technology within eGovernment is not easily achieved. The more effective NSDI initiatives have been implemented within, or closely aligned with eGovernment thus enabling more integration of geospatial information and functionality within eGovernment applications and services.

Most existing NSDI efforts have focused on government and have not effectively leveraged non-government sectors or private industry. Many early NSDI efforts have focused on serving the business needs of government. Most of these have acknowledged the need to provide access to the non-government sectors and public, but often this access is provided in a very limited manner or in a way that is not particularly usable by a non-technical person. Some national governments have emphasized access to public information to support more transparency in government, to empower the private sector to build new businesses, to support research efforts and other uses. The provision of increased access has proven to pay dividends in societal benefits and increased confidence in government.

Some NSDI efforts have relied on initial external support while building the internal staff and institutional capacity needed to manage and administer the programme. NSDI is a specialized discipline. Institutions and companies that are directly involved in the planning, design and implementation of NSDI initiatives are very familiar with the range and details of lessons learned across dozens of programs worldwide. Many countries have chosen to commission support in the planning, design, implementation and initial operations of their NSDI initiative to take advantage of this knowledge and experience. In most cases, teams of specialists are used in a surgical manner to help set up the infrastructure, policies and procedures for a period of time, during which permanent staff are recruited and trained to take over responsibility for all functions as they gain the knowledge needed to do so.

A majority of cost and return on investment in GIS is made at the Enterprise GIS level in the participating stakeholder organizations. Major part of related financing is initially in the conversion of manual map data to a digital GIS form. Once converted, business processes and tools need to be structured to capture data updates as part of day to day operations wherever feasible. This ensures that data available to the community are kept as up to date and accurate as practically possible.