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SPATIAL DATA INFRASTRUCTURE. BENEFITS AND STRATEGY

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Abstract: Nowadays, the geoscience data have become widely available in different organizations, which play a very important role in decisions-making at different levels (social, economic, political…). However, these organizations use standards, technologies and policies that differ from one to another. Therefore, this information is increasingly being distributed widely and become divorced from their original context or had remained limited to a small scale. Hence, the need for a spatial data infrastructure (SDI) becomes a necessity in order to facilitate the creation, sharing, and access to geospatial data, thus the exchange of knowledge between them, using a minimum set of standard practices, protocols, and specifications. The establishment of a spatial data infrastructure is to create conditions to ensure free access of public authorities, local authorities, organizations and citizens to spatial data. This paper presents a preliminary study of implementation of a spatial data infrastructure. It introduced the SDI developments in USA, Canada and Europe and summarized the relevant benefits.

Keywords: *Geoscience; SDI; Standards*

I. INTRODUCTION

Spatial data of considerable value to governments and organizations is to make daily decisions in modern society. In fact, these data are essential for making the right decisions, they can ensure sustainable development, environmental

protection and also include the understanding of the elements that influence the management of energy resources and human health, etc (GEO 2005) .

In addition, it is important for governments when it comes to developing and implementing action plans and evaluates its policies to provide efficient service to citizens (Janssen 2010). Moreover, it is also the values of the organizations that are still seen enormous profitability of these data for their own background. For example: they can precisely determine strategic locations for new branches by analysing spatial data in combination with consumption statistics, environmental regulation and possible public transport modality in a given place to attract the vital amount of the investment. By cons, use and access to these data are difficult or impossible between sectors (public-private) for a particular location because of these problems:

- The distribution of spatial information on the various organizations and the unavailability of external users.
- Lack of mechanisms for research and the collection of the required information.
- The inconsistency of data from different sources with the others, making it difficult or impossible for them to use or must result in additional labour costs.
- The lack of available metadata to search for the required data.
- The incompatibility of the legislation in the field of geodesy, cartography, licensing activities, copyrights, the information technology.
- The limitation of standards to an organization or country(Laxton and Duffy 2011).
- The use of different formats(Steiniger and Hunter 2012).

An awareness of these problems has created the need to overcome these obstacles to fully experience the benefits of Geoscientific information, and that began to grow between the municipalities to find ways to accomplish their principal functions and achieve a minimum level of cost recovery. Which led many sectors and countries to create their own spatial data infrastructure (SDI) (Rezaee and Malek 2015), to promote economic development and environmental sustainability, so that it stimulates better government. Furthermore, the main objectives of the initiatives are to ensure the harmonization of spatial data and make them available via a geoportal using web services for exploring, viewing, editing and analysis. This infrastructure includes a set of concepts that are generally based on technologies, policies, standards, human resources (J.Clinton

1994, Janssen 2010) and these are related to activities necessary to process, distribute, use and preserve spatial data (Coetzee 2008).

The first use of the term SDI goes back to 1990 (Budhathoki and Nedovic-Budic 2008, Tumba and Ahmad 2014) it was used by United States National research Council (US-NRC) to describe a framework that consists of institutional arrangements, policies and technologies to better manage and share spatial data community (Crompvoets, Bregt et al. 2004) which have different meanings and applications based on users' field.

II. INTERNATIONAL EXPERIENCE

There are a significant number of nations that are either developing as Namibia (Sinvula, Coetzee et al. 2014) or planning to develop spatial data infrastructures as the Arctic (SDI 2015). These initiatives reflect the immense and specific needs of each country to create a spatial data infrastructure. The examples will show how the SDI has become an essential part of their national program of e-government:

II.1. United states of America:

One of the first countries having set up a national spatial data infrastructure (NSDI) was the United States in 1994 (Rautenbach, Coetzee et al. 2013, Cutter, Richardson et al. 2014) by the Federal Geographic Data Committee (FGDC) (http://www.fgdc.gov/index.htmlit was the first Center of exchange of space data known as part of an effort to fight redundant data collection efforts. This establishment includes two important parts, Geospatial One - Stop (GOS) sponsored by the E-Government initiative that helps to organize, expand and accelerate plans for the federal Government to geospatial data (Larson, Siliceo et al. 2006, Goodchild 2007) and The National Map (TNM), which is designed to provide, a set of transparent update of geographic data and frequently monitor changes on the surface of the Earth (Kelmelis 2003). Indeed access to geospatial data would be available at multiple levels between the Government and the private sector, which facilitates its exchange and sharing.

II.2. Canada:

The project for the establishment of a Canadian Geospatial Data Infrastructure (CGDI) was launched in 1996; it was an initiative of the Canadian Government that aims to meet the challenge of providing Canadians with better access to information digital geospatial so that decisions of social and economic order are taken by leveraging the best and most complete information. Indeed,

CGDI is considered to be the technology, standards, access systems and protocols necessary to harmonize all spatial databases from Canada and make them available on the Internet (Warnest 2005) (https://www.rncan.gc.ca), and that includes public safety, public health, the environment and Indigenous Affairs (Bank 2011).

II.3. Europe:

In Europe, the INSPIRE Directive (INSPIRE 2007, Yalcin 2014) was launched by the European Commission in 2001 (Kok and Crompvoets 2010, Rautenbach, Coetzee et al. 2013). INSPIRE is implemented by the 28 members of the European Union (Bank 2011), and aims to make relevant data available to support environmental and social policies. And to achieve that, Five drafting teams have been nominated to develop and implement rules in the following 5 components of INSPIRE: 1) Interoperability of Spatial Data Sets and Services; 2) Metadata; 3) Network Services 4) Data Sharing; 5) Coordination and Complementary Measures (Bartha 2012). Add to this its geoportal was created in 2005 (http://inspire.ec.europa.eu).

A second example is the ESPON program (http://www.espon.eu) was initiated by the European commission and deals primarily with current trends in spatial development at the European level (Pallagst 2010), whose aim is the realization of instruments of analysis and monitoring of territorial organisations of the European Union for the benefit of the Community regional policy. This program has been carried out a spatial database that has different geographical scales, source of several books and atlases of the Union.

Spatial data infrastructures mentioned above are some of the most successful initiatives worldwide.

III. THE COMPONENTS OF SDI

Implementation of an SDI is largely determined by the effective collaboration of organizations, providers of data, including government agencies and local administrative authorities, as well as representatives of the private sector. The objective is to improve the availability of data to make them easier to find access and use them online. This, in turn, will be more accessible to the general public geospatial data, increase the profits of their implementation. However, the main producer of geoscience data is usually institutions geological, geophysical, geographical and environmental. Knowing that these data were often limited to a specific project, where they are established, which makes access and reuse of the information distributed somewhat complex due to the absence of an effective system of management of spatial data. This means will have to be common

conventions and technical agreements between the various stakeholders for the implementation of an SDI and which must be based on the following components:

- **Information resources -** are defined as the data and information used by an organization, including spatial reference data and metadata.
  - **Spatial data** - are data that have a spatial component, which means that the data are related to a place on Earth (Rupali B. Surve and Kathane 2014).
  - **Metadata (information about data) -** is the term used to describe the summary information or characteristics of a data set. It provides a formal structure to identify the structure of the knowledge of a given discipline, and linking this structure to information of the discipline through the creation of an information system that will help identification, discovery and the use of information in this discipline (ALCTS 2000).
- **Standards -** are one of the key elements of the SDI. They define the rules of the language and the interaction of the participants, providing the interoperability of data and services. According to international experience, standards should include the International Organization for Standardization (ISO) standards and specifications of Open Geospatial Consortium (OGC). Indeed, the primary mission of the standards is to define a set of structured standards concerning objects or phenomena directly or indirectly associated with a location in space (KOUSSA 2011).
- **Technologies -** are the means implies for the effective use of spatial data. In fact, They allow to collect, manage, interpret, integrate, display, manipulate, analyze and use dataset concentrating on the geographic, temporal and spatial reference.(RAI and NATHAWAT 2013), whether these technologies for storage (DBMS Database Management System) or research and the exchange of geospatial information resources through Geoportal.
- **Organizational structure -** These are the authorities, commissions and agencies that must be responsible for the creation, development and maintenance of an SDI.
- **Legislative and Regulatory Framework -** It is a set of rules are intended for the creation, use and the development of SDI, in addition to protect copyright and freedom of information.

These above mentioned components represent the basic fundamentals for the establishment of an SDI (Fig.1)

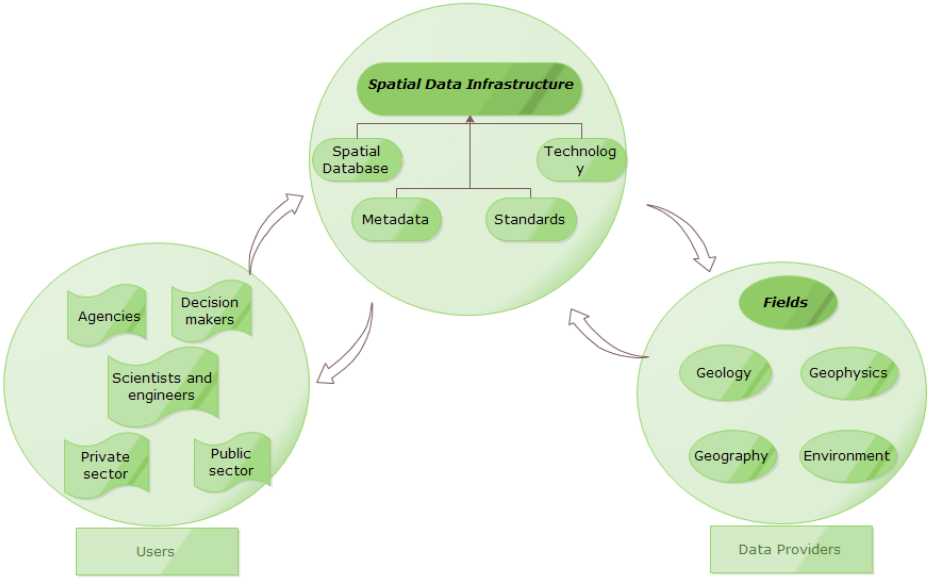

Fig.1: Architecture of a spatial data infrastructure

Generally, an SDI consists of interconnected SDIs to one another, as shown below (Fig.2). Rajabifard and al (Rajabifard, Binns et al. 2006), state that the SDI hierarchy allows decision makers to access and share geographic information from any other level in the hierarchy between stakeholders. The themes, scales and coverage of the data depend on the level of the spatial data hierarchy the data is accessed from. Figure 2 also shows that the GSDI can be developed top-down or bottom up.

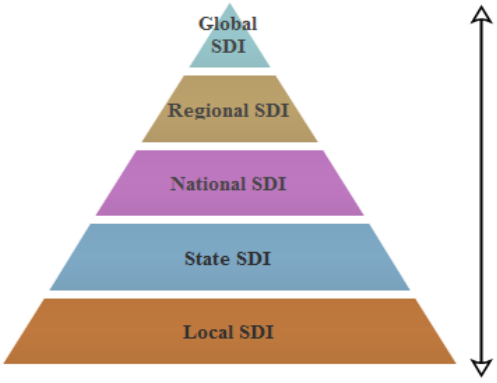

Fig.2: SDI hierarchy (Rajabifard, Binns et al. 2006)

IV. BENEFITS FROM A SDI

The establishment of a spatial data infrastructure is to create conditions to ensure free access of public authorities, local authorities, organizations and citizens to spatial data. So the achievement of this objective will automatically have certain benefits according to some studies (Borzacchiello and Craglia 2013, Committee 2013, Xu, Yan et al. 2014, Yalcin 2014).

Table 1: SDI benefits

Financial benefits	**Strategic benefits**	**Social benefits**	**Customers benefits**
Reduction in costs of data sharing	A better market understanding	Facilitates data usage	Improves customer responsive ness
Decreased costs of geospatial data	Improved working relationships between stakeholders and administrations	Increases the sharing of information between organizations	
Reduction in cost of maintenance operations		Geospatial stakeholders	Improves services to researchers , engineers, ...
Duplicate data costs avoidance	Improved data privacy	Gives better understanding of the benefits of data sharing	
Reduction in the time of integration of data and interoperability	Improved rigor and transparency about data collection, processing and updating	Gives better documentation of information sources	
Reduces the risks and the costs of development of new applications	Improved partnerships	Increases understanding of Geospatial Data	
	Efficient Data Sharing Agreements	Improves access to relevant data in emergency situations, disasters and conflicts	
		Improves access to data	

V. CONCLUSIONS

SDIs are becoming a major resource for data access and various geospatial services. Partnerships between public and private sectors are paying off with higher returns on investment and environmental monitoring. In addition, this implementation will rely heavily on the opportunities offered by the social-political stability, economic and also the legal context of a country and other major institutional structures that could become instrumental during the installation of a dynamic process of creation and information exchange, providing the benefits of the long-term preservation of the national and international geoscience information, and limit the cost driven by the integration of information from various sources such as eliminating the need for parallel and costly development of tools to discover, exchange and use of spatial data.

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