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Assessing the development of Ethiopian National Spatial Data Infrastructure

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ABSTRACT

Spatial Data Infrastructure plays significant role for the development of a nation. It contributes to sustainable development of a country through facilitating spatial data sharing and utilization among all levels of stakeholders. Thus, conducting SDI assessment is essential to guide its development, to monitor and improve its quality and to provide evidence of accountability for all stakeholders. Knowledge of the development status of SDI of a country is crucial to increase the accountability and development of spatial data information. In Ethiopia, there are many governmental organizations that produce spatial data to fulfill the need of geo-information in various sectors. However, the overall development status of the SDI in Ethiopia is not well known. The objective of this study is to assess the development and milestones of Ethiopian National Spatial Data Infrastructure (ENSDI).

The assessment of the status of ENSDI is done by using the four multi-view assessment framework approaches; SDI-readiness, Modified state of play, Clearinghouse suitability index and Organizational approaches. The assessment of the milestones in the development of ENSDI is done using document analysis and interview with key stakeholders. Both assessment of status and milestones of the development of ENSDI involve questionnaire survey, interview and document analysis as data collection tool. Data analysis was done on the four assessment approach.

The result of multi-view assessment shows that, shortage of digital data, lack of open-source data, lack of SDI awareness, and unavailability of environmental dataset policy are the major weak aspects of the ENSDI. Moreover, the technology components and data quality standards of the NSDI are very low. This is mainly due to lack of awareness among stakeholders on ESDI, low technological development, human capital, SDI culture, shortage of digital data and poor coordination of various institution in data production and exchange. On the other hand, clear mission and vision, collaboration with International donors are strong aspects of the NSDI. The major milestones that initiated NSDI development in Ethiopia are the establishment of GIS education, ENRAMED database, National Clearinghouse, GIS Society of Ethiopia and Ethiopian Geospatial Metadata Clearinghouse Node.

The research identifies awareness creation for SDI, increasing ICT technology in the country, developing SDI curriculum in higher education, creation of open source data, converting analogue data to digital data, increasing cooperation of various institution in data sharing and provision, and developing data quality control procedures as the major areas of interest for NSDI secretariat to do.

Keywords*: SDI, NSDI, ENSDI, development, assessment, milestones, multi-view assessment framework.*

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LIST OF ABBREVIATIONS

AARSE	African Association of Remote Sensing of the Environment
ADB	Africa Development Bank
AEIN	Africa Environmental Information Network
ANZLIC	Australian and New Zealand Information Council
CDE	Centre for Development and Environment
CGDI	Canadian Geospatial Data Infrastructure
ECA	Economic Commissions for Africa
EMA	Ethiopian Mapping Agency
ENRAMED	Ethiopian Natural Resources and Metadata base
ENSDI	Ethiopian National Spatial Data Infrastructure
ESAPP	Eastern and Southern Africa Partnership Programme
FAO	Food and Agricultural Organization
FDRE	Federal Democratic Republic of Ethiopia
FGDC	Federal Geographic Data Committee
GDP	Gross Domestic Product
GI	Geo-Information
GIS	Geographic Information Systems
GISSE	Geographic Information System Society of Ethiopia
GMP	Global Mountain Program
GSDI	Global Spatial Data Infrastructures
ICT	Information Technology
INSA	Information Network Security Agency
LAS	Land Administration Systems
MoE	Ministry of Education
MoWR	Ministry of Water Resources
NGII	National Geo-information Infrastructure
NGO's	Non-Governmental Organizations
NSDI	National Spatial Data Infrastructure
SCRP	Soil Conservation Research Project
SDC	Swiss Agency for Development and Cooperation
SDI	Spatial Data Infrastructure
SDIs	Spatial Data Infrastructures
UCGIS	University of Consortium for Geographic Information Science
UNECA	United Nations Economic Commissions for Africa

CHAPTER 1- INTRODUCTION

This chapter explores the background of SDI, statement of the problem, research objective, research questions and organization of the thesis.

1.1 Background

Spatial Data Infrastructure (SDI) plays important role for the development of a nation. Crompovets et al., (2008) state that over the last few years' development of spatial data infrastructures have become an important subject and platform in Geo-information to facilitate and coordinate the exchange and sharing of spatial data between stakeholders in the spatial data community. It's crucial role was confirmed in supporting economy and promoting business in both private and public sectors all over the world at global, regional, national and local levels (Genovese et al., 2009). SDI facilitates the availability and access to spatial data for all levels of government, the commercial sector, the non-profit sector, academia and all citizens in general. It is also important for urban land administration, natural resource management, transportation facilities, utility services and statistical collections and decision making of any nation. All these functions are directly based on appropriate and up to date data (Qureshi, 2009).

The growing awareness of the importance of SDI for development has led to the establishment and growth of SDI in many countries across the world. Rajabifard (2003) mentioned that SDI is implemented by many countries to better manage and utilize spatial datasets. Even though many countries declare that they are involved in SDI development, these declaration need to be treated with caution (Masser, 2005 as cited in Eelderink, 2008). This means that the development status of a nation's SDI has to be determined through the use of appropriate assessment methodology. The knowledge of the development status of the National Spatial Data Infrastructure (NSDI) is crucial to increase the accountability, knowledge and development of spatial information which are the key component for the development of a nation.

Assessment of SDI is essential not only to guide its development but also to monitor and continuously improve the quality of the programs and provide evidence of accountability of all stakeholders. In the last decade different researchers have tried several SDI assessment methods. Some of them focused on the general description of the SDI (Van Orshoven 2003-2004; Delgado-Fernandezi and Crompvoets 2007), other paid more attention to the methodology for assessment (Kok and Van Loenen, 2005; and Grus, 2007). All of these authors attempts either focused on one aspect of a SDI, describe SDI development in only a few nations, or are still conceptual in nature.

Over the last few years Ethiopia has spent considerable resources on developing its NSDI. However, the Ethiopian National Spatial Data Infrastructure (ENSDI) is still not well developed due to limitation of fund for capacity building, poorly organized data and outdated data (Zeleke et al., 2007).

The Ethiopian Mapping Agency (EMA) coordinates and supervises the methodology of any fundamental geo-information dataset production activities undertaken within Ethiopia, and control the standard and quality of surveying and mapping activities in the country (EMA, 2010). It was established in 1954 within the Ministry of Education for producing various maps for school in the country. The interest for a national mapping was felt crucial soon after, and

consequently the EMA grew to the Mapping and Geography Institute of Ethiopia in 1956. Nowadays, the EMA facilitates the ENSDI through organizing workshops, awareness creation among the stakeholders and discussions on the issues of spatial data.

According to Rajabifard and Williamson (2003) SDI is an initiative which underpins the design, implementation and maintenance that facilitate the sharing, access and use of spatial data across different communities to better achieve their objectives. With this in mind, the NSDI of Ethiopia formulated strong vision recently. Their vision is to become a reliable and prime source of geo-information products and services in Ethiopia that can objectively contribute to sustainable development of the country and thereby become an agency that can be cited as a role model in the field in Africa. However, this strong vision is not realized in Ethiopia due to: shortage of computer networks and broad internet band, shortage of skilled man power in the field of GIS, lack of documentation, poor coordination of the NSDI with foreign countries, low motivation among workers because of inappropriate salaries and lack of incentives from the government, and shortage of budgetary to run software and hardware of GIS technology (EthioGIS, 2007).

Beside the national governments different International and national NGOs are struggling to develop the ENSDI. For instance, the EthioGIS Project is one of the substantial contributiors to the development of ENSDI with the major goal to reduce duplication of effort among agencies and institutions, to improve quality of the data and to make more accessible to the community. The Geospatial information System Ethiopia developed at the Centre for Development and Environment (CDE), University of Bern brings in to focus all relevant spatial data like terrain, soil, land cover and use, climate, drainage, infrastructures, population and agriculture in a Geographic Information System (GIS) as the basis for decision making and planning of resource management strategies (EthioGIS, 2007).

The United Nations Economic Commission of Africa (UNECA) has been strongly promoting the development of the ENSDI (Eelderink et al. 2008). Lance (2003) concludes that foreign donors drive the initiatives in developing countries in steady of the respective national governments. The conclusion of Lance (2003) also works in the case of Ethiopia. Foreign donors like UNECA, Swiss Agency for Development and Cooperation (SDC), the Global Spatial Data Infrastructure (GSDI), Global Mountain Program (GMP) and Eastern and Southern Africa Partnership Programme (ESAPP) are the major ones that drive NSDI initiatives in Ethiopia.

1.2 Statement of the problem

The assessment of the status of the NSDI is crucial to identify factors that may hamper its development and take action accordingly. By doing so it plays a critical role in allowing the governments, local communities, NGO's, the economic sectors and the academic community to make progress in addressing the problems facing NSDI (van Loenen et al., 2009). Assessment of SDI is important to guide its development, to monitor and improve the quality of the NSDI and provide evidence of accountability of all stakeholders.

Some studies have been done on SDI assessment by using web search in Africa, including Ethiopia. However, Makanga and Smit (2010) justify that many SDI activities in Africa are informal and not normally branded as SDI and therefore it would have been difficult to find all necessary information through web searches". Eelderink et al. (2008) try to assess the status of the Ethiopian NSDI by using online survey. The work of Eelderink et al. (2008) is not sufficient to conclude the development and status of ENSDI due to the following main factors: not detail assessment but somewhat comparing with other countries, considered limited number of indicators, used only online survey as data collection tool, no quantitative

measures of SDI development status indicators (see table 1). Assessing the status of SDI is a difficult task because of its multidimensional structure of SDI. Grus et al. (2007) prove that assessment and evaluation of SDI is difficult because of its complex, dynamic and constantly evolving in nature. As Garfield (2006) report describes assessing the performance of an SDI is very complex tasks like other infrastructures due to multifaceted and intricate structure, coupled with the qualitative and external benefits it generates. In order to overcome these problems multi-view assessment framework and face to face interview of the key stakeholders of the ENSDI was applied to fill the research gap which is not addressed by Eelderink et al. (2008). Moreover, detailed assessment is not conducted on ENSDI in the past. In general, the current status of the ENSDI is not well assessed. This problem motivates the researcher to assess the development and status of Ethiopian National Spatial Data Infrastructure.

Table 1: Status of ENSDI in comparison with Colombia and Nepal adopted from Eelderink et al. (2008)

SDI Component	Case study variables	Case study countries		
		Colombia	Nepal	Ethiopia
	Availability of digital data	Considerable	some	some
Data	Quality	Good	Acceptable	-
	Updating of new data	Yes	No	-
	Maintaining data sets	No	Yes	No
People	Willingness to share	No	Moderate	No
	Human capital	sufficient	Not sufficient	Not sufficient
	Capacity building	Yes	No	-
	Research	Yes	No	-
	SDI education	Available	Not available	-
	User involvement	No	No	No
	User satisfaction	Moderate	Not good	Not good
	SDI awareness	Moderate	Not good	Not good
Access network	Access Mechanism	Yes, not working well	Yes, not working well	No
	Reliability	Reasonable	Bad	-
	Performance	Reasonable	Bad	-
Policy	Funding	yes	yes	No
	Socio-political stability	Unstable	unstable	unstable
	Institutional arrangements	No	No	No
	Leadership	Not present	Present	present
	E-government existence	Yes	Yes	-
Standards	Adoption of standards	Yes	Yes	Yes
	Metadata (Availability)	Yes	Partly	Partly
Others	SDI Maturity	Exchange	Exchange	Stand alone
	Initiatives connected to SDI (Country's Activity)	GIS for land use planning	-	-

1.3 Research Objective and Questions

The main Objective of this research is to assess the development and current status of National Spatial Data Infrastructure of Ethiopia. To achieve this objective the following two research questions have to be answered in this research.

RQ1. What are the major milestones in the history of Ethiopian National Spatial Data Infrastructures?

RQ2. What is the current status of Ethiopian National Spatial Data Infrastructures taking the Multi-view assessment framework approaches of: SDI-Readiness, Modifies State of Play, Clearinghouse Suitability, and Organizational aspect?

1.4 Organization of the thesis

This thesis is organized in the following seven chapters:

Chapter one covers the background of the study, statement of the problem, research objective, research questions and organization of the thesis.

Chapter two covers SDI development. In this section the reviews of literature on: definition of spatial data infrastructures by different researchers and organizations, components of SDI, importance of SDI, and development of NSDI in Africa are presented.

Chapter three describes about assessment of SDI. Under this section definition and importance of SDI assessment and the multi-view assessment framework approaches: SDI-readiness, Modified state of play, Clearinghouse suitability and Organisational approaches are presented.

Chapter four describes the Ethiopian National Spatial Data Infrastructure: visions, missions and objectives of ENSDI, SDI initiatives in Ethiopia, organizational structure of ENSDI and components of the ENSDI draft policy.

Chapter five describes geographical location of Ethiopia and methodology adopted to answer the two research questions.

Chapter six presents the results and discussion on the major Ethiopian SDI milestones.

Chapter seven describes the results on the multi-view assessment framework of SDI-readiness, Modifies state of play, Clearinghouse suitability and organisational aspects of ENSDI and lastly conclusion and final recommendations.

CHAPTER 2- SDI DEVELOPMENT

This section covers literature review of SDI mainly on definition of spatial data infrastructures by various researchers and organizations, components of SDI, importance of SDI, and lastly development of NSDI in Africa are presented.

2.1 Definition of Spatial Data Infrastructures

The terms 'spatial data', 'spatial information', geographic information', and geographic data' are interchangeably used as synonyms. The term SDI has been defined and still being redefined. According to Makanga and Smit (2010) the definition and purpose of SDI varies from nation to nation. Some put emphasis on the creation of data, others on the sharing of available data and others on the use of prescribed standards. Various definition of SDI has been given by different authors and organization. Based on their interest and type of problems that they have intended to solve, the definitions given for SDI are different. As a result it is crucial to see some of the definition of SDI given by different researchers and organization (See table 2).

Table 2: Definitions of SDI at different time by various researchers and organizations

S.N	source	Definition of SDI
1	Executive Order of US President [Executive Order of the White House 1994]	"A technologies, polices, Standards, and human resources necessary to acquire, process, store, distribute, and improve utilization of geospatial data."
2	US FGDC, 1996	SDI as an umbrella of policies, standards, and procedures under which organizations and technologies interact to foster more efficient use, management, and production of geospatial data.
3	Groot 1997	"Has the potential to expand the effectiveness of Geo-Information, and to advance and increase cross-jurisdictional, transdisciplinary, multi-stakeholder, and multi-criteria decision-making"
4	The Australian and New Zealand Land Information Council (ANZLIC), 1998	"Defines SDI as comprising four core components: an institutional framework, technical standards, fundamental datasets, and clearinghouse networks"
5	Groot and McLaughin, 2000	SDI consists of the following four components: Geographic data (fundamental geospatial datasets), technology (for storing, access, distribution and use of geo-information), Standards (for describing, exchanging and linking geo-information) and policy and organization.
6	Canadian Geospatial Data Infrastructure (CGDI) , 2000	"Is the technology, standards, access systems and protocols necessary to harmonize all of Canada's geospatial data bases, and make them available on the internet"
7	Nebert, 2001	'The collection of technologies, polices and institutional arrangements that facilitate the availability of and access to geo-information to benefit of many users".

8	Chan et al., 2001	''SDI is an initiative intended to create an environment in which all stakeholders can co-operate with each other and interact with technology, to better achieve their objectives at different political/administrative levels''
9	Rajabifard Abbes, 2004	"The term SDI as the fundamentally concept about facilitation and coordination of the exchange and sharing of spatial data between stakeholders from different jurisdictional levels in the spatial data community''
10	J. Crompvoets et al., 2004	''SDI is about the facilitation and coordination of the exchange and sharing of spatial data between stakeholders in the spatial community. ''
11	Rajabifard and Williamson, 2003	SDI is an initiative which underpins the design, implementation and maintenance that facilitate the sharing, access and use of spatial data across different communities to better achieve their objectives
12	Bes Kok et al., 2004	''Spatial Data Infrastructures facilitates the collection, maintenance, dissemination, and use of spatial information''
13	Kok and Loenen, 2005	Spatial data infrastructure facilitates collection, production, dissemination, use, exchange and maintenance of spatial data
14	Kuhn , 2005	''Is a coordinated series of agreements on technology standards, institutional arrangements, and policies that enable the discovery and use of geospatial information''
15	Mulaku et al., 2006	"As the combination of technology, data, institutional arrangements and people that enables the discovery, evaluation and application of geospatial data for users from all sectors of the economy plus the general citizenry"
16	Lacasta et al., 2007	"Derived from a network infrastructure that allows the integration of different datasets from various sources based on a particular web ontology which makes access to data either directly or indirectly"
17	Rajabifard Abbes, 2007	"SDI as a dynamic, hierarchic and multi-disciplinary concept that encompasses policies, organizational remits, data, technologies, standards, delivery mechanisms and human resource dimensions".
18	Crompovoets et al., 2008	"As a dynamic, hierarchic and multi-disciplinary concepts that includes people, data, access networks, institution policy, technical standards and human resource dimensions"
19	Koerten, 2008	"Are complex phenomena combining many more elements and aspects than a mere technological perspective can unravel"
20	Nedovic- Budic et al., 2008	"A set of interacting organizational, technological, human and economic resources that are available for facilitating and coordinating geographic information access, use and sharing"
21	Yawson et al., 2010	"As a base collection of technologies, standards, laws, polices, and institutional arrangements that facilitate the availability and accessibility of spatial data"

As illustrated in table 2 the definition of SDI changes through time. At the beginning it focuses more on technology, policy and standards issues. Groot and McLaughin (2000) emphasize the sharing of spatial data and its use in the community. Recently the SDI scope increased to people, data, networks, institutional arrangements, policy, laws, technical standards and human resources particularly after 2008. Even though different definitions are given for SDI at different time by various institution and researchers its concepts and use remain similar.

2.2 Components of SDI

Like the definition of SDI, components of SDI are also different by various researchers and institutions. SDI is composed of technologies, polices, standards, data and people. The interaction and collaboration of these components are crucial for any nations to acquire process, store, distribute, and improve utilization of geo-spatial information.

The components of SDI are varying among different organization and researchers with basic similarities. For example according to the (Executive Order 12906, 1994) the SDIs should include technologies, policies, standards, and human resources. McLaughlin and Nicholas (1994); Rajabifard and Williamson (2002) identified six components of SDIs: (Framework) data sets, Institutional framework, Policies, Technology, Standards, and Human resources. According to Groot and McLaughin 2000 SDI consists of the following four components: Geographic data (fundamental geospatial datasets), technology (for storing, access, distribution and use of geo-information), Standards (for describing, exchanging and linking geo-information) and policy and organization. The components of SDI are highly interacted in providing spatial information for the users. The accessibility, retrieval and delivery of any spatial information are directly based on collaboration between all components of SDI.
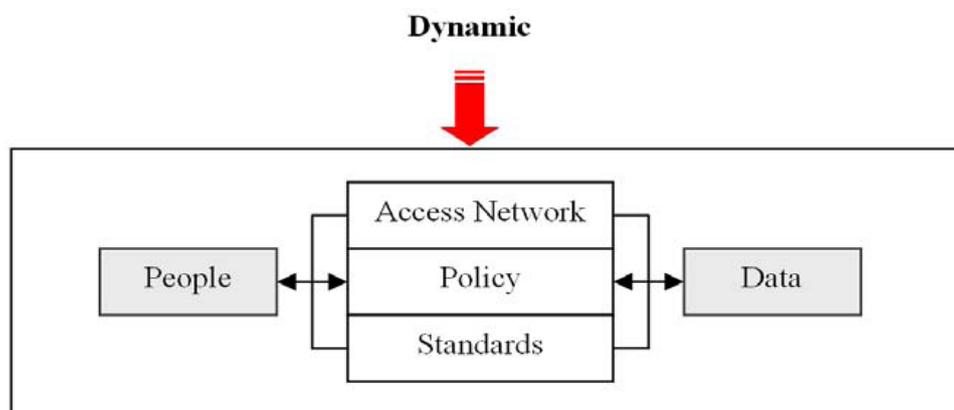
Figure 1: Nature and relations between SDI Components Rajabifard et al. (2002).

Mavima et al. (2001) also list four components as Partnerships within an institutional framework, technical standards, core datasets with their associated metadata and a clearinghouse. The institutional framework comprises different key elements like leadership, funding, custodianship (an agency having the responsibility to ensure that a fundamental dataset is collected and maintained according to standards and policies established for the national SDI), data distribution and educational training. According to Douglas (1997), the technical standards of SDI comprise the several key elements: reference system, data model, data dictionaries, data transfer, and metadata. Douglas also describes the major fundamental datasets of SDI: Core data, thematic data and associated metadata.

The Australian and New Zealand Land Information Council (ANZLI, 1998) categorized the components of NSDI in to four. Namely: an institutional framework, technical standards, fundamental datasets, and clearinghouse networks. In the same year Coleman and McLaughlin lists the components of SDI: policies, technologies, standards and human resources necessary for effective collection, management, access, delivery and use of spatial information in a global community.

The U.S. Federal Geographic Data Committee (FGDC) also lists the components of an SDI as (Nebert, 2001) in to four major categories. Namely: Technology (hardware, software, networks, databases, technical implementation plans), Policies and Institutional Arrangements (governance, privacy and security, data sharing, cost recovery), and People (training, professional development, cooperation).

Rajabifard et al. (2002) also list the major components of SDI as policy, access networks, technical standards, people (including partnerships) and data. Rajabifard (2004) encompasses the major components of SDI as the policies, technologies, standards and human resources necessary for the effective collection, management, access, delivery and utilization of geospatial data for a specific jurisdiction or community. Different scholars classified SDI components in different ways. Even though different researchers classify SDI components in different ways majority of them are similar. All of them focused on people, data, technology, standards, and policy.

2.3 Importance of NSDI

Spatial information has emerged as an important tool to improve food security and agriculture in third world countries. International organization like FAO's, IWMI's World Water Atlas, CIMMYT's Africa Maize Research Atlas, IRRI's Asian Rice Atlas and other international organization have made significant progress in the use of GIS during the last decade (Mtalo ,2003). SDI provides a basis for spatial data discovery, evaluation, and application for all users and providers with all levels of national governments, NGO's, academia and civil societies. Nwilo and Osenwuta (2004) illustrate the importance of NSDI for a nation. For instance NSDI facilitate networks of survey coordinates, waterways, transportation networks (road and railway networks), electricity supply, communication facilities, farming activities, fishing, forestry, tourism, communities to be displaced, and planning of services. It is used for handling infrastructure development, economic planning, environmental conservation and monitoring, climate change, design and deliver of public services, and a variety of other challenges facing society. It facilitates data sharing and use among different organization either with in the nation or abroad.

SDI facilitates collection, production, dissemination, use, exchange and maintenance of spatial data (Kok and Loenen, 2005). SDI provides technologies, policies and institutional arrangements that facilitate the availability of and access to spatial data (Nebert, 2004). SDI plays a remarkable role in enabling easy inclusion of spatial data in development activities. It also creates a platform in which geo-information stakeholders achieve their organizational goal in a cost-effective and cost-efficient way (Singh, 2009).

2.4 Development of NSDI in Africa

SDI development depends on cultural needs, social evolution, economic reality and national ambitions. According to (Mavima et al., 2001) SDI development requires expertise from different multidisciplinary such as social science, system design and development, information technology and other disciplinary. The development of SDIs involves a wide cross section of partners from various organizations and institutions each with various perspectives relative to how well an SDI is meeting its needs (Crompvoets et al., 2008).

Recently different countries develop the NSDI to better manage and utilize spatial datasets. In April 2005, 83 countries develop NSDI clearinghouses on the internet (Crompvoets et al., 2007). This indicates the willingness of different nations to participate and take ownership of NSDI initiatives. The increasing number of the national clearinghouse is the best indicators for the development of SDI. Different countries are launching SDI at different levels ranging from corporate, local, state, national and regional to a global level, to better manage and use spatial datasets. Crompvoets and Bregt, (2003) and Makanga and Smit (2010), prove that only two African countries (Kenya and Chad) developed the National clearinghouse in 2003. And five years later in 2008 three countries namely: Chad, Kenya and Gabon had developed NSDI clearinghouse (Crompvoets et al., 2003).

Makanga and Smit (2010), applied a methodology similar to the INSPIRE state of play and found out that the development of African NSDIs are still at infancy as it can be epitomized by only few countries with reasonable funding for NSDI, reasonable political support and legal frameworks for NSDI. According to Musinguzi et al., (2004) factors such as lack of an efficient ICT infrastructure, trained human resource, lack of coordination of various GIS activities and lack of funds are more relevant to NSDIs in developing countries like Ethiopia.

The concept and technology of ENSDI started in the year 2002. However, the status of Ethiopian SDI at that moment is low in comparison with those other African countries. According to Mulaku et al., (2006) with the exception of South Africa, the other African countries are still in the phase where the policy and legislation, institutional partnerships, databases and metadata, standards, technology and personnel are under development (see table 3).

Table 3: Status of SDI development in some African countries (Mulaku et al., 2006)

Country	Approx.GDI Initiative Date	Status
Algeria	1996	Average
Tunisia	1998	Average
Ethiopia	2002	Low
Ghana	1998	Average
Nigeria	2002	Average
Mali	2002	Average
Senegal	1996	Average
Kenya	2001	Average
Uganda	2003	Low
Tanzania	2003	Low
South Africa	1997	High
Botswana	2001	Average

CHAPTER 3-ASSESSMENT OF SDI

This chapter describes about assessment of SDI. Under this section definition and Importance of SDI assessment and the multi-view assessment framework approaches: SDI-readiness, Modified state of play, Clearinghouse suitability and Organisational approaches are presented.

3. 1 Definition and Importance of SDI assessment

Before describing SDI assessment it is better to define assessment. The word assessment is derived from the term assesses meaning to place a value on; judge the worth of something. Sometimes the word assessment and evaluation are often interchangeably used. Assessment refers to a judgment about a person or situation where as evaluation refers to a study designed and conducted to assess an objects merit and worth (Choppin, 1991; Stufflebean, 2000, Longman, 2005, cited in Grus 2010). The main reason for SDI assessment is to measure and account for the results and efficiency of public policies and programmers, or to gain explanatory insights into social and other public problems (Grus et al., 2007).

Until now assessment and evaluation of SDI have been done by different researchers as described in the introduction part of this paper. SDI assessments are conducted for different purposes, for example to measure and account for the results and efficiency of public policies and programs or to reform governments via the free flow of evaluative information (Chelimsky, 1997, citied in Grus et al., 2007).

3.2 Multi-view SDI assessment framework

The multi-view assessment strategy was based on the principles of assessing complex adaptive systems (Grus et al., 2010). SDI is defined in variety of ways by different researchers at different times. This clearly indicates the multifaceted character of SDIs (De Man, 2006). Assessing SDI remains problematic. According to (Grus et al., 2010) assessing SDI remains problematic due to nature of SDI, particularly their multifaceted and dynamic nature, complexity and vaguely defined objectives. The multi-view assessment framework treats SDI from different viewpoints. The core point of the multi-view framework is its capacity to measure the multiple facets of SDI and its complexity in terms of multiple definitions. Another strong point of this assessment framework is its capability to reduce bias in assessment results on the side of evaluator and its potential to envelop at least one of the three purposes of assessment: accountability, knowledge and development (Grus et al., 2010). In order to assess the multifaceted character of SDIs a multi-view assessment frame work is proposed to assess the SDIs (Grus et al., 2007). Some of the SDI assessments that have been done using the multi-view assessment approach include: Clearinghouses suitability assessment, Crompvoets et al. (2003); the Organizational assessment approach (Kok and Van Loenen's, 2004); the SDI Readiness assessments Index (Delgado et al. 2005); The Performance-based assessment, (Giff, 2006); The Cadastral assessment Steudler et al., (2004), and The INSPIRE state of play assessment (Vandenbrouck and Jansse, 2008). All of the multi-view assessment framework approaches covers the three purposes of assessing SDIs: Accountability, knowledge and development.
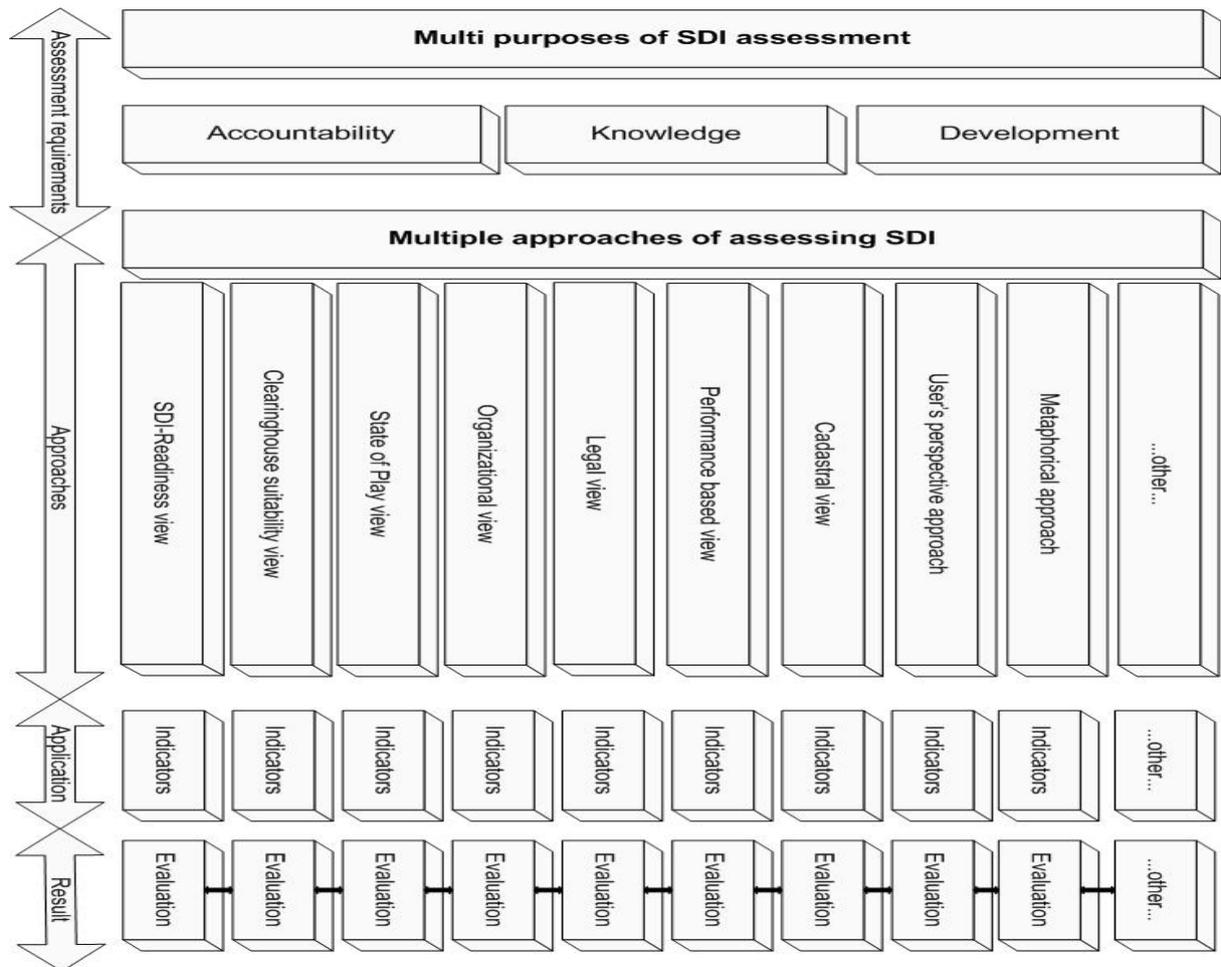
Figure 2: Multi-view SDI assessment framework adopted from Grus et al. (2007).

The multi-view framework has several assessment approaches. It is a combination of different SDI assessment approaches varying from assessing SDI organizational aspects to clearinghouse suitability. Grus et al., (2008) used four operational approaches: Clearinghouse suitability (to measure the development and impact of SDI clearinghouse worldwide), SDI-readiness (to assess the country readiness to embrace the SDI development), INSPIRE state of play (to measure status and development of SDI) and Organizational approach (to measure SDI development from institutional perspectives) which are fully operational.

Table 4: Summary of Multi-view assessment framework approaches adopted from Grus et al. (2007).

Approach	Goal Description	Method	Status	Assessment purpose class
Generational	To measure the development of SDIs worldwide	Survey, document study	Not developed	Developmental Knowledge
Programme Evaluation	To determine the worth and accomplishment of the objectives of SDIs	Case study and survey	Not developed	Developmental Knowledge Accountability
SDI-Readiness	To assess if the country is ready to embrace the SDI development	Survey	Applicable	Developmental Knowledge
Cadastral	To measure five evaluation areas of LAS	Survey	Needs improvement	Knowledge Accountability
Organisational	To measure SDI development from the institutional perspective	Case study	Applicable	Developmental
Performance-Based	To measure SDI effectiveness, efficiency and reliability	Not available	Needs improvement	Accountability
Clearinghouse Suitability	To measure the development and impact of SDI clearinghouses worldwide	Survey, key informants	Applicable	Developmental
State of Play	To measure the status and development of SDIs	Document study, survey, key informants	Applicable	Developmental Accountability

3.2.1 SDI Readiness approach

The SDI-readiness index approach integrates factors from various points of view: organisational, national legal agreements, information, access networks, people and financial resources. Each of these factors consists of different indicators that quantitatively measured (Delgado et al., 2005). Concerning the access network particularly the web connectivity and telecommunication infrastructure and from people point of view the human capacity was taken from UN Global Survey which is conducted regularly in order to determine E-Government readiness that assessed all UN member states. Delgado et al (2005) defined the E-readiness of a country as the degree to which a country is prepared to participate in the network world. According to Grus et al. (2007) the SDI readiness approach is an existing model that assesses whether a country is ready to embrace SDI development. This approach is very crucial to identify a strategy to address the basic obstacles of SDI development in any country regardless of the national development. The SDI-readiness index is calculated based on the value of the 16 indicators of SDI readiness (see Table 5).

Table 5: Factors of SDI readiness in to decision criteria adopted from (Delgado et al., 2005)

Factor	Decision Criteria
Organisational	Politician vision regarding SDI
	Institutional leadership
	Umbrella legal agreement
Information	Digital cartography
	Metadata availability
People	Human capital
	SDI culture/education
	Individual leadership
Access Network	Web connectivity
	Telecommunication infrastructure
	Own geo-information development
	Geospatial software availability
	Open source culture
Financial resources	Government central funding
	Data policy aimed to return on investment
	enterprise and private sector funding

3.2.2 Modified state of play approach

The Modified state of play approach assesses seven SDI aspects: organizational, people, policy (legal issues and funding), data and metadata, access services, standards and thematic environmental data. The State of play assessment approach is a study developed to describe, monitor and analyze activities related to NSDI in 32 European countries- 25 EU member states, 3 candidate countries and 4 EFTA countries (SADL, 2006; Nuish, 2010). This does not mean the state of play assessment approach is used only in the mentioned above countries but it can be used in regions outside Europe. The State of play approach and methods can be used in other continents like Africa to assess the status of the six building blocks of SDI-legal frameworks and funding, reference data and core thematic data, metadata, access and other services, standards along with the thematic environment (SADL, 2005). This approach used country reports, website visits and contacting key informants in the country and data collection the methods of Grus et al., (2008) used for this approach.

3.2.3 Clearinghouse suitability index

The National Clearinghouse is defined as an electronic facility for searching, viewing, transferring, ordering, advertising or disseminating spatial data from various sources via the Internet (Crompvoets and Bregt, 2003).The national clearinghouse is a web portal that facilitates data exchange among different levels of government. According to Crompvoets et al., (2004) the U.S.Federal Geographic Data Committee established the NSDI clearinghouse in 1994 in order to facilitate efficient access to the overwhelming quality of spatial data and coordinates its exchange. Different SDI assessment indicates that the clearinghouse suitability of various Africa countries is at infancy stage. In 2000 (Ezigbalike et al., 2000) it was concluded that Africa was not ready for a full on-line SDI, as evaluated from data, metadata, technology, institutional arrangements, policies and standards perspective.

Although the first SDI clearinghouse in Africa was implemented in 1996 and four were under development in 2001 (Crompvoets and Bregt, 2003), there were only 2 African countries that had established NSDI clearinghouses in 2003 (Makanga and Smit 2010). After seven years in 2010, only three out of twenty-nine case countries in Africa have a NSDI clearing house (Makanga and Smit, 2010) out of which two are operational (Kenya and Chad).

Crompvoets et al., (2004) identified 15 clearinghouse characteristics to assesses and measure the clearinghouse suitability index of a country. The main objective of this assessment approach is to measure the suitability of the national clearinghouse of a country. The 15 clearinghouse characteristics measured by this assessment approach are: the number of suppliers, monthly number of visitors, number of web references, languages used, frequency of web updates, level of metadata accessibility, number of datasets, most recently produced dataset, decentralized network architecture, availability of view services, number of mechanisms (alternatives) for searching, use of maps for searching, registration-only access, funding continuity, and metadata-standard.

3.2.4 Organizational approach

The organizational assessment approach is based on the work of Kok and van Loenen's (2004) research. This assessment approach measuring the development of the following SDI aspects: vision, leadership, communication, self-organizing ability, awareness, financial suitability and status of deliver mechanisms (Grus et al., 2010). The main core value of this assessment is its ability to improve performance mainly the outcomes and drive tangible organizational results. Most organizations view their performance in terms of effectiveness, efficiency, and financial viable in achieving their vision and mission (IUCN, 2004).

CHAPTER 4- THE ETHIOPIAN NATIONAL SPATIAL DATA INFRASTRUCTURES

This chapter explores a brief description of ENSDI: definition, vision, mission, and objectives of ENSDI, background to ENSDI initiative, organizational structure of ENSDI and lastly components of ENSDI Policy.

4.1 Definition of Ethiopian NSDI

The Ethiopian National Spatial Data Infrastructure is a framework of polices, standards, technology and institutional arrangements that promote geospatial data sharing throughout all levels of government, the academia and the private sectors (EMA, 2009).

4.2 Vision and mission of ENSDI

Recently Ethiopia develops strong vision to enable the country to have a world class infrastructure for access and use of geospatial information in decision making at all levels of government. The main mission of ENSDI is to promote coordination in the production, sharing and use of geospatial information for good governance and sustainable development (EMA, 2011). In December 2009, the Ethiopian Mapping Agency developed the following main objectives of the ENSDI namely: (1) to develop institutional frameworks and administrative arrangements that provides mechanisms for data sharing and coordination of the development of geospatial datasets; (2) to eliminate duplication of effort in the production of geospatial information; (3) to develop acceptable standards for data production and distribution and (4) to promote and coordinate national participation in International initiatives on the development of regional and global SDIs (EMA, 2009).

4.3 SDI Initiatives in Ethiopia

In recent time, Ethiopia joins the growing list of African countries that have taken initial steps in setting up NSDI initiatives. There used to be an ENSDI initiative some decade ago around 2002, but couldn't continue further because of lack of awareness from different institutions, shortage of human capital as well as financial constraints. The situation is now changed due to the initiatives of Ethiopian mapping Agency to develop and implement the NSDI. Regarding NSDI, EMA has taken the initiative by preparing draft policy that has already been dispatched to stakeholders for consideration and approval by the relevant organs of the government of the Federal Democratic Republic of Ethiopia (FDRE). It is merely at the beginning stage. EMA delegate the production and dissemination of geospatial data to facilitate spatial information that will enhance the national effort in good governance and sustainable development.

On 29 October 2002, the EMA organized a NSDI workshop in collaboration with the UN Economic Commission for Africa. Approximately 50 ministries and governmental organizations that have direct connection with geo-data discussed the importance of NSDI for the national economy and other relevant information, sharing of experiences on geo-information techniques, data sharing, and policy issues (Mtalo, 2003). Ethiopia was active in

participating different workshops on NSDI like other countries of Africa. For instance Ethiopia joins the fifth African Association of Remote Sensing of the Environment (AARSE) conference held in Nairobi, Kenya on October 17, 2004. About 80 people are participating on the conference on standards, including a good cross section of leaders in geo-spatial information from across Africa. The key standardization activities in Africa were identified and discussed. Many organizations in Africa are working towards SDI initiative, namely an SDI for Africa. Key aspects of this are: metadata, training facilities for educating people about metadata and making metadata available. The participants of the 5th African Association of Remote Sensing of the Environment conclude that Africa is getting large amounts of free (or cheap) spatial data from different countries and international organizations, and the main challenge is creating the capacity to store and available the data. International organization like UNECA has organized workshops on metadata standards especially for people working on water resource management.

4.4 Organizational Structure of Ethiopian SDI

The organizational structure of Ethiopian NSDI comprises the office of Prime Minister, National Executive Council, National Steering Committee, the ENSDI Secretariat and Working Groups (See figure 3).
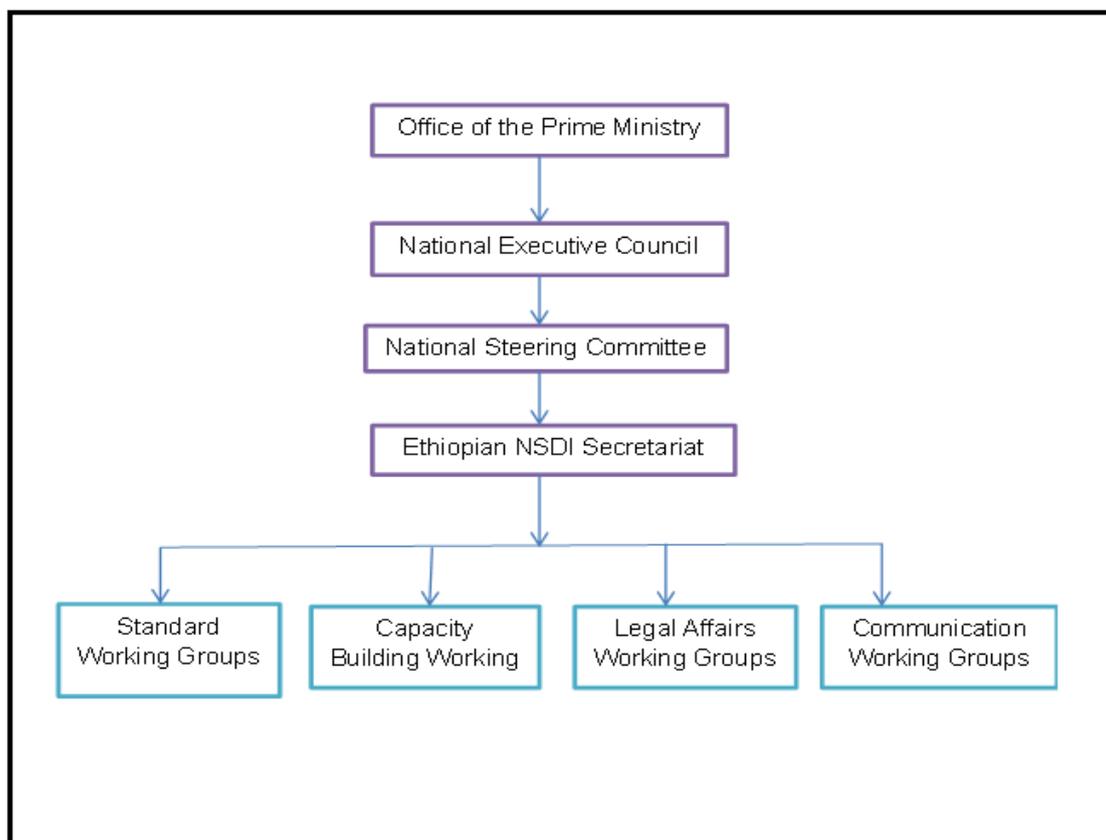
Figure 3: Organizational structure of ENSDI adopted from NSDI preliminary draft policy (EMA, 2009).

NSDI is not developed by single institution. It requires coordination and collaboration of governmental, non-governmental, civil societies, academia, NGOs and International organizations at various levels. As it depicted in figure 3 it is guided by the top high official ministerial office (office of prime ministry) followed by the National Executive Council, the Steering Committee and the NSDI Secretariat which coordinate and supervise different technical working groups at the bottom. The memberships and tasks of the different ministries and agencies that assigned to perform SDI related issues in the country are already developed and started his function. For more information (see table 6).

Table 6: ENSDI working committees adopted from preliminary draft policy (EMA, 2009).

Working Committees (Organ)	Member	Function
Office of the Prime Ministry	Prime Ministry of the Federal Democratic Republic of Ethiopia	Patron of ENSDI
National Executive Council	Ministers of main stakeholders Ministries chaired by Minister of Finance and Economic Development	Policy and funding
National Steering Committee	Director Generals (State Ministers of Partner Organizations)	Investigating problems related to geo-information and make proposals to the board for approval and execution as a project.
Ethiopian NSDI Secretariat	A group of Secretariat elected by State Ministers of Partner Organizations	Coordinating different working groups, it will serve as a liaison between the working groups and national steering Committee.
Working Groups (WG)	Different professional groups	Conducting detail study on potential problems that can affect the implementation of SDI and forward ideas for further performance.

4.5 Components of Ethiopian SDI Policy

After an initiative has been given for Ethiopian Mapping Agency (EMA) the draft policy document has already prepared and disseminated to all key stakeholders of ENSDI for comments to approve at national level in September 2011. The ENSDI is a framework of policies, standards, technology and institutional arrangements that facilitate data providers to publish and users to access and integrate and distributed heterogeneous geospatial information (EMA, 2009). The following components are included in the draft policy of ENSDI.

Metadata and Standards

The aspects of standardization that are of importance to ENSDI includes; data production, presentation, transfer, and hardware and software standards. Geospatial data producers shall provide metadata for each dataset they produce and any subsequent updates. It should conform to national and international standards and shall include at the minimum; data quality, spatial references, identification information and attribute information.

Legal Framework

Legal issues are an essential component of NSDI. These legal issues are more related to copy rights of the data. The most emerging legal issues of ENSDI include: Custodianship (Responsible for data production, storage, and management of the datasets on behalf of the producers), Ownership (Responsible for quality control and assurance, data content and formats, validation and maintenance, storage and security, maintenance and update of metadata and accessibility of the data through supply of metadata to the clearinghouse). The geospatial owner shall own copyright, the producer shall own copyright of the new data and acknowledge the source off the original data and the users shall not supply data to the third party unless this is covered by a licensing agreement between the users and the provider (EMA, 2009). To make spatial data and services more accessible, affordable, and ultimately more effective and efficient the cost sharing policy is more appropriate than cost recovery.

Data Access and Security

Access to data is made possible through the implementation of metadata catalogue and establishment of clearinghouse within a legal framework. There are two categories of data access. Namely: free access and restricted access. According to the draft policy of ENSDI only geospatial data related to national security shall be granted restricted access.

Funding

The options for funding include government, public-private-partnership, public investment, and international loans. The government will take the lead and provide the enabling mechanisms to generate finances for sustainability of ENSD development.

Training and Capacity Building

Capacity building in the form of workshop, seminars, short training and other methods are very important for all stakeholders of the ENSDI. Focus for training and capacity building for the country rests on five major pillars, namely: human resource development in GIS, curriculum development in GIS, research in GIS technology and application, user sensitization campaigns, and liaison with strategic partners.

CHAPTER 5- THE STUDY AREA AND METHODOLOGY

This chapter explores a brief description of the study area: geographical location, total land area, topography, population and the major economic activities practice in the country, and lastly the methodology adopted in this research.

5.1 Study Area- Ethiopia

The national government of Ethiopia has adopted a federalist system of governance in the constitution of 1994 (Admassie, 2002). According to this constitution Ethiopia is divided in to 9 National Regional States, 68 Zone administrations and 550 districts.

The Federal Democratic Republic of Ethiopia (FDRE) is a land-locked country in the horn of Africa and geographically located between 3^0 and 14^0 North Latitude and 33^0 and 48^0 East Longitude with in the tropics and shares common boundary with Eritrea in the north, Djibouti in the east, Kenya in the south, Somalia in the south east and Sudan in the north west and south Sudan in the west (See figure 4). It is the 10th largest country in Africa, covering a land area 1.13 million Km^2 with great elevation variation from 100 meter below sea level in Kobar sink to the high peaks of Mountain Ras Dajen (4620m) above sea levels (MoE, 2008).

Agriculture is the main economic activity of Ethiopia. It accounts for almost 50% of the GDP (Gross Domestic Product) and provides 85% of the population livelihood (ADB, 2006). Ethiopia, with a population about 85 million, is the 2nd most populated country in Africa after Nigeria (WB, 2007). The population growth of the country is still continued at an alarming rate. Recently Ethiopia stands 16th most populated country in the world with the estimated population of 88 million people (CIA World fact book, 2011).

Figure 4: Map of Ethiopia adopted from http://www.arcgis.com/home/webmap/viewr.html (2012).

5.2 Methodology

Literature review provide basis for the methodology of the research. Based on literature reviews, research objective and scopes of the study was delimited and then research questions and methodology applied to achieve the main objective of the research. On the left side of the box the first research question (major milestones) was answered through interview, literature review and own observation. The second research question (the status of ENSDI) indicated on the right side of the methodology flow chart were answered by using the four multi-view assessment approaches. The research steps can be visualized with the following flow chart in figure 5. The details shall be explained in the following sections.
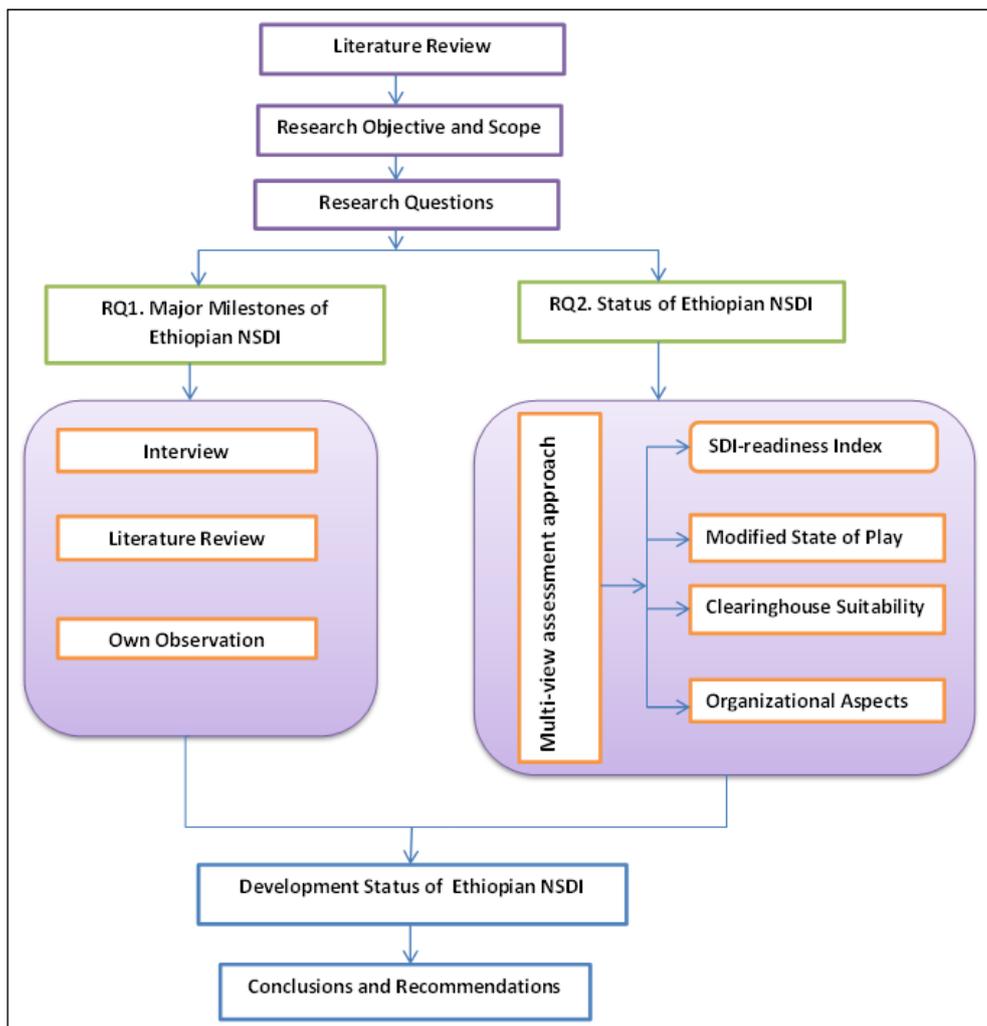
Figure 5: Methodology flowchart

The methodology flowchart in figure 5 demonstrates all procedural steps to answer the formulated questions for this thesis.

First Research Question (RQ1)

What are the major milestones in the history of Ethiopian National Spatial Data Infrastructures?

This research question was answered based on data collected through interviews, literature review, and own observation. In order to identify and describe the major milestones for the development of ENSDI the following eight procedural steps were taken during data collection:

1. Identification of major institution that involved in data production and dissemination in the country (this was done in consultation with the coordinator of ENSDI);
2. Information was gathered from the academia, civil society and public sectors about the main activities of the identified institution in step 1;
3. Selection of national, regional, international organization and NGO's for interview based on their involvement in the ENSDI;
4. Four institution were selected for interview based on their role in providing and facilitation spatial data production and dissemination for the country which directly leads to the development of NSDI. The Ethiopian Mapping Agency (EMA) and Ministry of Water Resources (MoWR) from governmental institutions, and the GIS Society of Ethiopia (GISSE) and United Nations Economic Commissions for Africa (UNECA) from non-profit geospatial organization and International organization respectively;
5. A short interview question was developed for selected institution. A total of 17 interview questions were used for interview. From these 17 questions (question 1 to 16 were used to collect general information for the development of NSDI and the last 17 question were applied for the selection of milestones (see appendix 9);
6. Introduction of the term milestone for the respondents to keep the scope of the study;
7. Selection of the major milestones for the development of Ethiopian NSDI based on the interview;
8. Lastly literature reviews were conducted particularly on the selected milestones in order to prove whether the selected milestones are really milestones or not? These were done by finding the selected milestones from the respective website and documentary reports and finally, seven major milestones were selected and described (see section 6.1).

Second Research Question (RQ2)

What is the current status of Ethiopian National Spatial Data Infrastructures taking the Multi-view assessment framework approaches of: SDI-readiness, Modifies state of play, Clearinghouse suitability, and Organizational aspect?

To answer the second research question the multi-view assessment framework by Grus et al. (2007) is adopted. Four assessment approaches were used for this research question namely: SDI-readiness, Modified state of play, Clearinghouse suitability, and Organizational aspect.

5.2.1 Data collection methods

Data was collected from various institutions (governmental, NGO's, international organizations, academia and civil society) by using the identified indicators for SDI-readiness index, state of play, organizational aspects and clearinghouse suitability index (see appendix 4, 5, 6, 7 and 8).

Based on the assessment approach indicators questionnaire survey was disseminated to the selected 15 stakeholders of the ENSDI. From the four assessment framework approach the clearinghouse suitability index characteristics were filled only by the experts of UNECA. This is due to the fact that the national clearinghouse is administered by UNECA. Furthermore, most of the stakeholders have low awareness about the national clearinghouse of Ethiopia. The other three assessment approaches were collected from various governmental, NGO's, international organizations, academia, and civil society. Besides questionnaire survey, literature review, interview and short discussion was also used for data collection methods.

For data collection a total of 15 key stakeholders were selected from governmental, academia, international organization, NGO's and civil society to assess the status of ENSDI (see table 7).

Table 7: Sampled Ethiopian NSDI stakeholders.

Stakeholders category	Number of stakeholders	Percentage
Governmental	7	47
Academia	3	20
International Organization	2	13
NGO's	2	13
Civil Society	1	7
Total	15	100

Data analysis

SDI-readiness approach has 16 indicators that measure different components of NSDI (see appendix 5). Out of 16, three indicators human capital, web connectivity and telecommunication infrastructures index are taken from the United Nations e-Governance Survey results of 2008 for this research and the remaining 13 indicators are collected from key stake holders in the form of questionnaire survey. In appendix 1 the value of 15 respondents from key stakeholders are presented. For SDI-readiness approach, the percentage for the seven alternative answers in appendix 2 are weighted as follows; extremely high (0.99 points), very high (0.8 points), high (0.65 points), medium (0.5 points), low (0.35 points), very low (0.2 points), and extremely low (0.01 points). In order to get the overall result of the SDI-readiness of Ethiopia the excel sheet format of Delgado et al. (2005) were used (see appendix 1).

The modified state of play has 36 indicators which were measured against four alternative answers; in full agreement, in partial agreement, not in agreement and no sufficient information for assessing. The 36 indicators are categorised in to six major components namely: institutional frameworks, people, access services/technology, data and metadata, policy and thematic environmental data. The average score of all indicators are calculated and converted in to percentage to assess the current status of different components of the NSDI (see appendix 2).

The organisational assessment approaches focuses on measuring the institutional development of SDI aspects like: leadership, communication, vision, self-organizing ability, awareness, and financial suitability (see appendix 8). This approach has 11 indicators that are measured against two optional answers yes or no. The organisational assessment approach results were calculated and shown in percentage (see figure 12).

The clearinghouse suitability assessment approach measures a specific set of quantitative indicators (Crompvoets et al. 2004). For this assessment approach 15 clearinghouse characteristics were used to illustrate the characteristics of Ethiopian clearinghouse Node which is already established UNECA. The 15 clearinghouse characteristics questions were sent to the expert of UNECA for more accurate and real information (see appendix 6). The collected result in table 11 is categorized in to three classes by using the work of Crompvoets et al. (2004). After assessing the 15 clearinghouse suitability characteristics, the total score is competed by adding the 15 class weights together in order to make the clearinghouse suitability index ranging between 0.00 and 1.00 (Crompvoets and Bregt, 2008). If the final summed result is 0.00 meaning the national clearinghouse is not suitable and 1.00 meaning very suitable.

CHAPTER 6- THE MAJOR SDI MILESTONES IN ETHIOPIA

This chapter describes the major SDI milestones of Ethiopia in three main sections; 6.1, describes the major milestones. 6.2, describes the general discussion on milestones and 6.3, covers the final conclusion on the milestones.

6.1 The Major SDI Milestones in Ethiopia

Based on interview, literature review and own observation the following seven major milestones were described in this section. The ''+'' sign indicates a milestones which were selected by four key organizations. Namely: Ethiopian Mapping Agency (EMA), Ministry of Water Resources (MoWR), United Nations Economic Commissions for Africa (UNECA) and GIS Society of Ethiopia (GISSE). The selected milestones were demonstrated in table 8. For detain information about Ethiopian SDI milestone see the following section.

Table 8: Major milestones for the development of ENSDI

	Major Ethiopian SDI milestones	Year of foundation	Organization interviewed for selection of major milestones			
			EMA	MoWR	UNECA	GISSE
1	Ethio-GIS project	1999	+	+	+	+
2	Opening of GIS & Remote Sensing specialization	2003	+	+	+	+
3	Establishment of ENRAMED	2003	+	+	+	+
4	Establishment of GIS Society of Ethiopia	2007	+	+	+	+
5	Construction of Ethiopian Geospatial Metadata base by INSA	2011		+	+	+
6	Contribution of various Ministerial organizations			+	+	+
7	Role of UNECA	1958	+	+	+	+

6.1.1 The establishment of Ethio-GIS Project

The establishment of Ethio-GIS in 1999 is one of the most historical events that emerged in the past decades and considered as one of the major milestones for the development of ENSDI. The project was developed at the centre for Development and Environment (CDE) university of Bern in Switzerland with well-organized spatial data released for users. Due to this technology initiative the year of 1990's are regarded as the beginning of Ethiopia national geospatial data assemblage (Krauer, 2007). The main target of the project is to reduce duplication efforts in data production and dissemination among different organization, to share resources, to consolidate information, to organize workshop and seminars on

geospatial data, to establish partnership with various governmental, NGO's, Academia, International organization and private sectors, and to contribute the technological, ecological, economic and social improvements of governmental efforts in the country.

The main output of the project at the beginning was production of digital data for Ethiopia. For instance in 1999 the project produced different digital data for Ethiopia. Namely: Administrative boundary (national, regional and districts), monthly and annual rainfall distribution, towns and villages, infrastructures (roads, railways), topography and hydrograph.

Until recently, the Ethio-GIS is actively participating in awareness creation of NSDI through organizing workshop, seminars, and short training for stakeholders in Ethiopia. For instance, on November 28, 2007 they organize the three day workshop for GIS experts and higher institutions stakeholders at Addis Ababa in order to reduce duplication efforts in spatial data production, compilation and dissemination. The contribution of Ethio-GIS is unforgettable on the side of Ethiopian governmental and other public and private sectors. Above all, the project produced various digital data that enhance the development of the NSDI because without digital data the development of SDI is too difficult.

6.1.2 The Opening of GIS and Remote Sensing Science at Addis Ababa University

The Opening of GIS and Remote Sensing Science at Addis Ababa University in 2003 at MSc level is a historical landmark for the development and evolution of GIS technology in Ethiopia. GIS and Remote Sensing specialization was began from 2003 onwards in department of Earth Sciences at 4 Kilo campus and 2 years later department of geography and environmental Studies in 6 kilo campus deliver the courses for the bachelor and MSc students. At the time of the establishment of GIS and Remote Sensing discipline different thematic data were available. Among these land use and Landover classification maps, soil types and natural resources maps, infrastructures maps (roads, electric lines, telephone towers, and etc.), spatial location of towns, localities, tourist sites and parks, drainage, topographic digital elevation model and population density.

The higher institutions are motivated to develop the curriculum on GIS and remote sensing science at different institution because of the increasing demand of GIS and remote sensing expert in various organizations in Ethiopia. This is mainly due to the awareness of the national governments on GIS as a tool for natural resources management, infrastructure planning and implementation, communication with the public (mapping) real estate management (e.g. urban land management) and other related activities to do research so as to enhance the use of spatial data for an aid to economic development.

The Institute of Geophysics Space Science and Astronomy (IGSSA) is one of the famous institutes in Addis Ababa University aimed to integrate GIS with Space Physical Geodesy Science for a better analysis and interpretation, particularly on infrastructural development activities related to railways, road and irrigation network development plans and implementation. Gradually, the curriculum of GIS and remote sensing was expanded to other university like Bahr Dar, Haromaya, Adama, Mekele, Jimma, and others. Nowadays around 20 universities deliver the course GIS and remote sensing in Ethiopia. The expansion of GIS and remote sensing science at higher institution in Ethiopia attract the attention of skilled manpower towards the GIS technology which is crucial for country development.

The graduate students of GIS and remote sensing are employed in various Ministerial and Regional organizations that involved on data production, share and dissemination. For instance, majority of the staff of Ethiopian Mapping Agency are GIS and remote sensing

professionals. The increasing number of GIS and RS experts in various organizations creates another opportunity to develop geospatial professional organization like the GIS Society of Ethiopia. Due to the above facts the key stakeholders of NSDI selected the establishment of GIS and remote sensing at Addis Ababa University as one of the most historical events that considered as a major ENSDI milestones.

6.1.3 Development of ENRAMED Soft Ware

ENRAMED originated from the environmental support project which is administered under Dutch- Ethiopian bi-lateral development cooperation with total project investment of 2.5 million USD. From 2.5 million 81% is contributed by the Netherland government MILIEV fund in the form of a grant and the remaining 19% by the Ethiopian Government (Abit, 2005).

The Ethiopian Natural Resources and Environmental Meta-Database (ENRAMED) and the National SDI are the two formal networking initiatives in Ethiopia. Both of them cover the entire nations across the country. The term ENRAMED is an Amharic term stands for the Ethiopian Natural Resources and Environmental Metadata base. The Amharic expression for "Let's walk together!" Various institutions were participated with collection, generation, storage and dissemination of information related to natural resources and environment. ENRAMED is developed based on review of international recognized metadata standards like the FGDC's, CSDGM and ANZELIC. According to Gebremeskel (2005) the ENRAMED has metadata collector, administer, explorer, and meta-database website.

Datasets of partner institutions of ENRAMED

In 2000 the preliminary data set collections assessment has been made in early in the partner Institutions. These data collections include datasets of different kinds, i.e. bibliographic, geo-spatial (maps, satellite images, aerial photographs) and others like design drawings, audio-visuals, etc. The National Meteorology Service Agency (NMSA) has the highest datasets than others during preliminary dataset collection assessment of ENRAMED in 2005 this is mainly due to their high capacity in skilled manpower as well as different station for data collection across the country.

Table 9: Preliminary dataset collection assessment of ENRAMED adopted from (Abiti, 2005).

	Governmental institutions						
	MoWR	MoA	ESTC	GSE	EPA	NMSA	EMA
Estimates of datasets	60,000	90,000	49,000	47,000	20,000	130,000	10,000
Priority datasets (10 %)	6,000	9,000	4,900	4,700	2,000	13,000	1,000
No. MD to be created per day per person	4	4	4	4	4	4	4
Estimate of annual working days	200	200	200	200	200	200	200
No. of MD to be created per year/person	800	800	800	800	800	800	800
Years needed to create MD	7.5	11.3	6.1	5.9	2.5	16.3	1.3

The number of dataset for the National Meteorology Service Agency (NMSA) is higher than other institution this is mainly due to the fact that NMSA has different station across the country on climate related datasets. In order to facilitate and exchange of their data all partners of ENRAMED are working together (MoWR, 2011). See also http://www.mowr.gov.et/index.php. The following are the partners of ENRAMED; Ministry of Water resource (host organization), Ethiopian Mapping Agency, Ministry of Agriculture, Ethiopia Science and Technology Commission, Geological Survey of Ethiopia, Environmental Protection Agency, National Meteorology Service Agency, and five Regional State (Oromia, Amhara, Gembella, Tigray and southern Nation and Nationality people of Ethiopia). The Environmental Metadata base have the following datasets which were collected by the partner institutes: socio-economic, hydrological, topographic and thematic maps, aerial photographs, satellite imagery, meteorological, agricultural, natural resources, demographic, geo-science data, passport and others. Even though different partner institutions collected data, access to information within partner institution can be challenging issue. The partner institutions are all custodians of large number of data sets, which are stored in either in hard copy or digital form. Some of the partner institutions have no well-organized environmental data management system. Up to now, about 5275 metadata have been posted on ENRAMED website and has a link to 269 meta-database sites around the world (MoWR, 2011).

The ENRAMED Metadata software has been in use starting from 2003 onwards. Because of the high importance of ENRAMED software (upgrading and providing new IT infrastructure), the Ministry of Water Resources and other international organizations like UNEP, UNECA, and UN-Water/ Africa underlined the need for upgrading of ENRAMED and to make it bug-free and ISO Standard compliant (ADB,2006). It is considered as the heart of the Ethiopian national information and knowledge management system in sharing water data and information among different national stakeholders with in the country and abroad. The major aims of the software is programming meta-database software and supporting the national government in developing an organizational framework ensuring the follow-up of the project and sustainability of the meta-database activities (ADB, 2006). Generally, the establishment ENRAMED helps the government of Ethiopia to develop various metadata for the NSDI.

6.1.4 Establishment of GIS Society of Ethiopia

Geographic Information Science Society of Ethiopia (GISSE) was established in October 2007 as non-profit professional organization composed of geospatial professionals from the public, private and academic sectors operating in the country. The GIS Society has established an ad hoc programme to organize GIS expertise from different data producing, suppliers, stakeholders and academicians so as to enhance the overall usability of GIS for socio-economic development purposes. This has ensured a standardized and consistent data availability.

GISSE is a Society of GIS and remote sensing professionals and other interested in the promotion and use of GIS and remote sensing. The main objective of GISSE is to support the setting up of national level GIS Infrastructure, standardization of the spatial data and provide professional assistance through establishing a network of GIS professionals in Ethiopia. This society also struggles to fulfil a long cherished wished to provide an opportunity for professionals, researchers and practitioners in the country to meet and keep abreast of the latest developments in the field. In addition to these, GISSE will adhere and implement its responsibility to contribute its share for the accomplishment of poverty reduction and national developments in Ethiopia. It strives to allow communities by disseminating scientific knowledge through publications, seminars and symposia (http://www.gisse.org).

The main mission of GISSE is to assist, train, coordinate and guide the implementation, development and maintenance of Geo-Information Science and other related technology in Ethiopia. The society currently performs its works in its office at Addis Ababa University (AAU), Science Faculty of Earth Sciences Department. The society organizes NSDI workshops, seminars and awareness creation among the stakeholders of the NSDI. Based on their contribution the establishment of GISSE in 2007 is considered as one of the major ENSDI milestones.

6.1.5 Establishment of Geospatial Metadata Clearinghouse Node

Ethiopian Geospatial Metadata Clearinghouse Node was established by the national government of Ethiopia under the Information Network Security Agency (INSA).The major task of INSA is "Monitoring the collection, processing and dissemination of remotely sensed data and handling of geospatial databases to ensure their compliance with the country information security standards" (Article6/5 of Ministers Regulation 2006).

INSA is one of the leading governmental organizations that exerting maximum efforts to establish geo-information standards, policy, and legislations which will lay the foundation for spatial Data Infrastructure. In 2009, INSA conducted stakeholder's survey on the status of spatial data holdings for the purpose of preparing a geo-information policy and standards. The final results of the survey identified the following situations. Firstly, no functional metadata cataloguing service is available in any governmental organization in Ethiopia. Secondly, none of the governmental institutions presently keep metadata for their spatial data holdings and thirdly there is duplication of effort in the production of the spatial data among different organizations. The duplication of data is occurred due to a loose of communication among different organization. INSA introduced an open source metadata cataloguing service for exchanging spatial information among governmental organizations. See the website (http://ethiogmcn.insa.gov.et/index.php/about-metadata.html).

The Geospatial Metadata Clearinghouse Node Project was launched on August 04,2011 in the presence of key stakeholders of Ethiopian Mapping Agency, Ethiopian Environmental Protection Authority, Geological Survey of Ethiopian, Ministry of Mines, Ethiopian Roads Authority, Ministry of Construction and Urban Development, Ministry of Water and Energy, Ethiopian Central Statistics Agency, Ministry of Agriculture and Rural Development, Ethiopian Meteorological Services Agency, Addis Ababa City Government Integrated Land Information System Implementation Project Coordination Office and the Geographic Information System Society of Ethiopia were call up on the training about the concept of metadata and purposes of creating, keeping and sharing metadata. In addition to these, practical training was also given and a discussion was held on how to work together and on what should be done to sustainably use of the metadata Clearinghouse Node (Temesgen, 2011).

The Geospatial Metadata Clearinghouse Node with the domain name http://ethiogmcn.insa.gov.et. Ethio indicates Ethiopia; and gmcn refers to Geospatial Metadata Clearinghouse Node. The Service is running on INSA's web server from the networking department. INSA organized training for the key stakeholders in order to create a common understanding on the concepts of metadata, benefits of creating and sharing metadata, and metadata standards, introducing of the website and giving short practical training on the system (INSA, 2011).

6.1.6 Role of Different Governmental Organization

In Ethiopia there are many governmental organizations that actively involved in the production, dissemination and provision of digital data at national as well as regional levels. The importance and awareness of Geo-information in all institution is increased from time to time based on the capacity of GIS technology to handle a lot of information by using various software. It is the basic tools for planning and decision making for all levels of governmental hierarchy. All governmental organization of Ethiopia is established by governmental proclamation to satisfy the need of geo-information in the country. The proclamation consists of the legal mandate and obligations of the organization like mission, power and duties, and right of ownership (Getinet, 2003). It is to difficulty to get all spatial information from one sectors or institution, as a result different governmental organization are participated in producing spatial data. The main responsibility and products of different national organization are demonstrated in Table 10.

Table 10: Organizational responsibility and main products of various Ethiopian institutions adopted from (Getinet ,2003).

Organization	Responsibility	Main products
Ethiopian Mapping Agency	Preparing foundation data	Topographic and aerial photography maps, surveying products, ortophoto products, National Atlas, RS and GIS research products
Geological Survey of Ethiopia	Producing geological and other related products	Geological, hydrological, geophysical and mineral maps ,earth sciences scientific reports
Ministry of Water Resource	Preparing master plan information for river basins and water policy	River basin master plan maps and digital maps, river basin studies report
National Urban Planning Institute	Preparing master plan and related information for urban areas	Urban areas master plan maps
Environmental Protection Authority	Monitor environmental condition and preparing environmental information	Environmental policy and assessment guide lines and strategy.
National Meteorological service Agency	Producing weather and climate information	Meteorological data (daily, monthly, seasonally weather & climate bulletins).
Population and Housing census commission office	Producing population data	Statistical information about population number, distribution etc at different administration levels in the country
Ministry of Agriculture	Preparing land use maps and policy for the country	Land use policy, land use maps
Ethiopian Science and Technology commission	Coordinating and promoting science and technology in the country	National and sectoral science and technology polices
Ethiopian-Tourism Commission	Preparing tourism information	Information on tourist areas, promoting eco-tourism

As indicated in Table 10, different governmental organizations of Ethiopia are involved in spatial data production for the users. In addition to the above mentioned organizations the Ethiopian Road Authority and from the higher institution Addis Ababa and Adama University are active in providing and using spatial data. According to the chairman of Institute of Geophysics Space Science and Astronomy (IGSSA) at Addis Ababa University, the digital map was produced in Ethiopia starting from 1991 onwards. The chairman also explains the mechanism by which different organization produced digital data. For instance, the Ethiopian Mapping Agency, Central Statistics Agency, Ministry of Water Resources, and other

institutions produced digital data by digitizing paper and analog maps, by collecting ground data using GPS, and by other methods especially by collecting satellite remote sensing imageries from international data providing institutions.

The EMA is the government organization with the responsibility for mapping, surveying and remote sensing activities in Ethiopia is the pioneer in production of thematic map and topographic maps starting from its establishment as an autonomous agency of the government of Ethiopia in 1980. The Environment Protection Agency (EPA) uses information from different governmental institutions to produce environmental reports. The EPA identified key institution that provides necessary information. EPA established Ethio-EIN is an Ethiopian Environmental Information Node in 2004 as part of the African-EIN and will contribute greatly forwarding the concepts of Land Information System and SDI Marquardt and Bekure (2009).

According to the Ethio-EIN 2009, the major institution that provide information to central environment management are Central Statistical Authority, Christian Relief Development and Aid , Disaster Prevention and Preparedness Commission , Ethiopian Mapping Authority , Geological Surveys of Ethiopia , Institute of Biodiversity Conservation ,Ministry of Agriculture and Rural Development, Ministry of Health, Ministry of Water Resources, National Meteorological Services Agency and Population and Housing Census Commissions office, Ethiopian Science and Technology Commissions, Amhara Regional State, Gambella Regional State, Oromia Regional State, Southern Nations and Nationalities Peoples Regional State , and Tigray Regional State. All these institutions have professionals in their specialty area to carry out data collection, analysis, interpretation and technical write-up.

The Ethio-EIN has their own framework structures which are actively working together in order to facilitate the development of Environmental information within the country. The framework have a national steering committee, a national coordinating unit, a forum for stakeholders, a technical support service, a national technical committee, environmental information working groups, and stakeholders' data centers. As it discussed in the preceding paragraphs most of the activities are related to organizational aspects. However, all interviewed institutions selected the contribution of various national governments in spatial data production as the major milestones.

6.1.7 The contribution of United Nations Economic Commission for Africa

International Organization like United Nations Economic Commissions for Africa (UNECA) assists the development of the ENSDI through capacity building and providing workshop and seminars in the area of SDI. UNECA has undertaken major actions to foster the development of SDI as the appropriate mechanism for the production, management, dissemination and use of spatial data and information products, both at regional and national levels in all Africa countries. In 2004, the National Clearinghouses Node with the name http://geoinfo.uneca.org/ethiopia/ was implemented on the web by UNECA. Nowadays, the number of datasets on the clearinghouse web is greater than 5000.

Several meeting was conducted by the UNECA to establish the NSDI in all African countries. In September 2001 the Committee on Development Information (CODI) sub-committee on Information and Communication Technologies and Library (CODI-ICT) had held its second meeting on Geo-information. The CODI-ICT considered various policy issues: the future Geo-information in Africa, a geographic data facility for Africa, matters related to geo-information, establishment of SDIs. The third meeting of the committee on Development Information by the ECA was conducted in May 2003 to recommend policy, infrastructure and

capacity building for all African countries. Specifically in 2003 ECA organized a workshop for Ethiopia stakeholders as a side event of the committee on development information. After that onwards successive workshop to establish the NSDI steering committee was conducted by the EMA, with ECA as a resource organization (Ezigbalike, 2009).The Economic Commissions for Africa (ECA) has undertaken major actions starting from awareness creation to implementation of NSDI through capacity building and fund grant to promote the development of SDI as the best instrument for the production, management, dissemination and use of SDI products both at regional and national levels (GISSE, 2011).

6.2 Discussion

This section describes the general discussions on the Ethiopian SDI milestones. The main obstacles and difficulties during data collection and the major findings of the paper are elaborated under this section.

Problems during data collection

The main obstacle observed during interview techniques are lack of willingness of the top officials for interview and some stakeholders nominates the communication departments of their respective institutions for interview. The other main problem was how to reach the most appropriate experts for the interview in order to get appropriate information regarding the NSDI. Above all, in few organizations it is not allowed to enter the building without direct supportive letter to the institutions either from the top federal government or from the side of the researcher's. The letter "To Whom It May Concern" which is written by Wageningen university Geo-information centre is not satisfactory in some organization.

Interview Survey

Four institutions namely: The Ethiopian mapping Agency, Ministry of Water Resources and Energy, GIS Society of Ethiopia and United Nations Economic Commissions for Africa were selected based on their involvement in the development of ENSDI. The selection of respondents from various institutions is due to the nature of NSDI development. Development of NSDI involves a wide cross section of partners from governmental institution, NGO's, industry and academia; each with various perspectives relative to how well an SDI is meeting its needs (Crompvoets et al., 2008). Before interview some basic concepts and terms of milestones were briefly explained for the interviewed. This short introduction about the concepts of milestone helps the respondent to keep the scope of the study (to focus the respondents on the major historical events of the development of NSDI).

In addition to interview and document analysis, own observation techniques were also used for the identification of SDI milestones. Accordingly, the evolution of Google Earth in 2005 as taken as one major milestones of ENSDI.This technology demonstrates a map of the earth based on satellite imagery (http://www.evolution-seo.co.uk/history-of-google.html). It is dynamic in nature, they can change the map of the place based on the information acquired from satellite and aerial photography of the data source.

Google Earth created a new opportunity for users to overlay their own spatial data infrastructure on the top of Google Earth's background imagery (Masser et al., 2009). This technology facilitates and access information freely for all countries of the world including Ethiopia. It allows accessing various geographical features of a country. For instance, it is possible to demonstrate the Ethiopian administrative borders and labels, place names, roads, buildings, terrain, water bodies, weather, gallery and etc. It has also a potential to

provide detailed information of Ethiopia local place names, parks, water bodies outlines, place categories, transportation site (Airport), traffic, Spot Image and others with the possibility of zooming in and out.

As described in the previous section the selected SDI milestones are diversified in nature. This indicates that various governmental, non-governmental and international organizations contributed for the development of ENSDI. The contribution of various governmental organizations, and UNECA are related to organizational issues where as the construction of ENRAMED and Ethio national clearinghouse node are considered as technological innovation of the national governments under the aid of foreign donors in the form of grant from the Dutch government and Global SDI. The development of GIS and remote sensing curriculum by ministry of education for higher institutions and the product of Ethio-GIS data are the main back bone for the construction and development of ENSDI (see section 6.1). From different key stakeholders we recognize that SDI milestone is not only related to the contribution and innovation of national governments but also the involvement of multi-sector both in the country and abroad.

6.3 Conclusions

This research has one major objective: to assess the development and status of Ethiopian National Spatial Data Infrastructures. In order to assess the development status of ENSDI two research questions was answered. The answer for the first research question is summarized below.

First research question (RQ1)

What are the major milestones in the history of Ethiopian National Spatial Data Infrastructures?

The first Ethiopian SDI milestones date back to the establishment of Ethio-GIS project in 1999.This project produced digital data of Ethiopia on administrative boundary, towns and villages, transportation route infrastructures, topography, and rainfall data for the users. Following the establishment of Ethio-GIS different historical events emerged that enhance the use of spatial information in Ethiopia. Four years later, in 2003 two major historical events emerged that played a great role in spatial data development in Ethiopia. Namely: establishment of GIS and remote sensing specialisation at Addis Ababa University and construction of ENRAMED metadata base at Ministry of Water resource. Thus, 2003 is a significant turning point in the history of Ethiopian SDI.

Recently, in June 2011 the Ethiopian Network security Agency established the national geospatial metadata clearinghouse node to monitor the collection, processing and dissemination of remotely sensed data in the country. Another important recent event is the development of the NSDI policy of Ethiopia which is already dispatched to all key stakeholders of the national governments for commitments and approval in the last September 2011.

The above mentioned milestones contribute a great effort to develop the NSDI of Ethiopia. Even though, different key events emerged starting from the end of 1990's still SDI is under construction in Ethiopia.

CHAPTER 7- THE STATUS OF THE ETHIOPIAN NSDI BASED THE APPLICATION RESULTS OF THE MULTI-VIEW SDI ASSESSMENT FRAMEWORK

This chapter covers the final results of the assessment of the Ethiopian National Spatial Data Infrastructures in three sections; 7.1, describes the status of Ethiopian NSDI components based on the multi-view assessment approaches of SDI-readiness, Modified state of play, Clearinghouse suitability and Organization approach and, 7.2, describes the general discussion and, 7.3, describes the final conclusions of multi-view results.

7.1 The Multi-view SDI assessment framework

In this section, the results of the questionnaire collected on the multi-view assessment framework (SDI-readiness, Modified state of play, Clearinghouse suitability and Organizational aspects) of ENSDI are presented one after another. The distributions of the sample size of the respondents are demonstrated in figure 6.
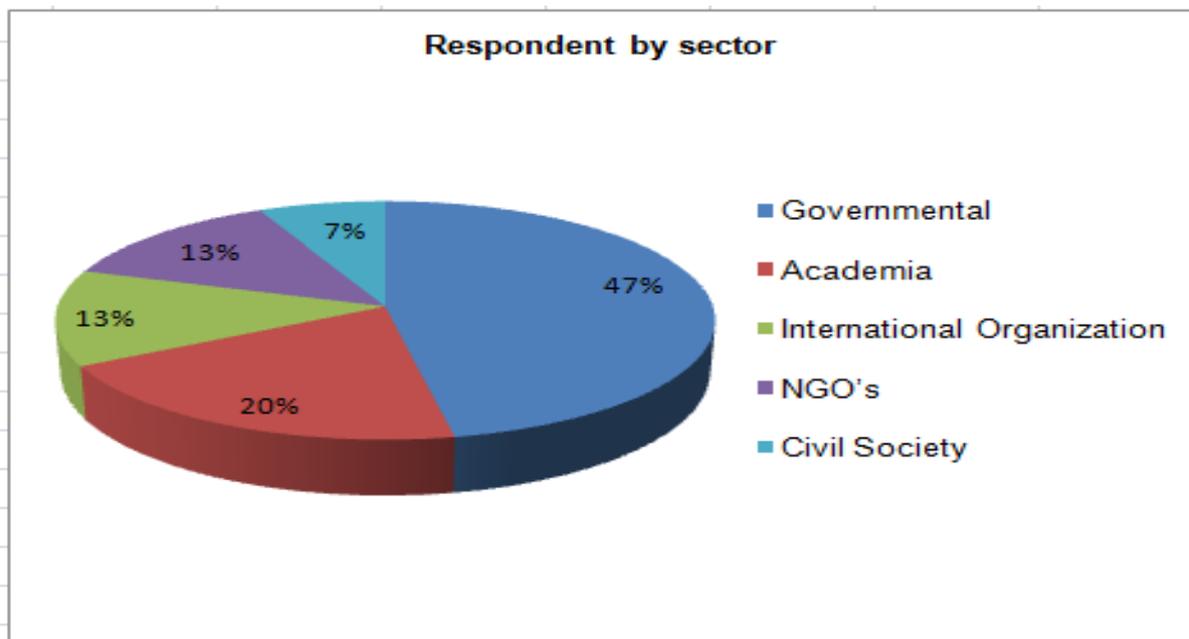
Figure 6: Respondents percentage based on sectors

Almost half of the respondents are selected from the national government 47%, 20% from academia (higher institutions), and 13 % from both International organization and NGO's and 7% from civil society.

7 .1.1 SDI-readiness index assessment results of Ethiopia
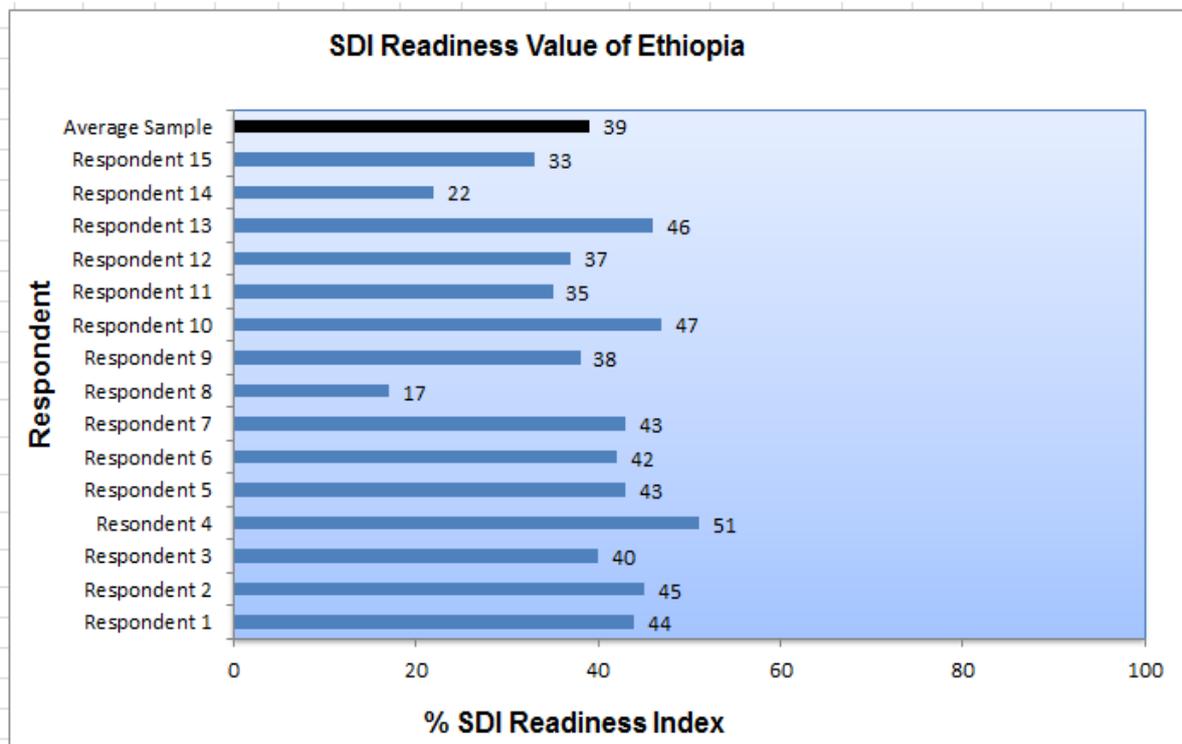
Figure 7: Ethiopian SDI-readiness index results

Figure 7 demonstrate the assessment results of 15 respondents of Ethiopian stakeholders using the SDI-readiness approach. The results show that there is great variation of results among the stakeholders. The maximum and minimum score of Ethiopia SDI-readiness is 51% and 17% respectively. The average sample of Ethiopian SDI-readiness is 39%.This suggests that the NSDI of Ethiopia is not well developed due to constraints of technological developments. On the other side this result indicates that the country is not well prepared to deliver the spatial Data Infrastructure to the users. The low score of SDI readiness (39%) is due to low level of technological developments like web connectivity and infrastructures that facilitate the development of the NSDI. In addition to low level of technological development, human capital index of the country is also extremely low 0.38 (see appendix 3). The score of 39% in range up to maximum of 100% is obviously very low. This result is very far from the findings of Grus et al. (2008) on 10 Latin American countries. Grus et al. (2008) finds the average SDI -readiness score of Ecuador 42%, Cuba and Argentina 53%, Brazil 56 %, Chile 59%, and Colombia 66%. Josephat (2011) also conduct similar study on Kenya SDI-readiness. According to the findings of Josephat (2011) the SDI-readiness of Kenya in 2010 is 39%. This score value of Ethiopia SDI-readiness is equivalent to that of Kenya SDI-readiness in the 2010.
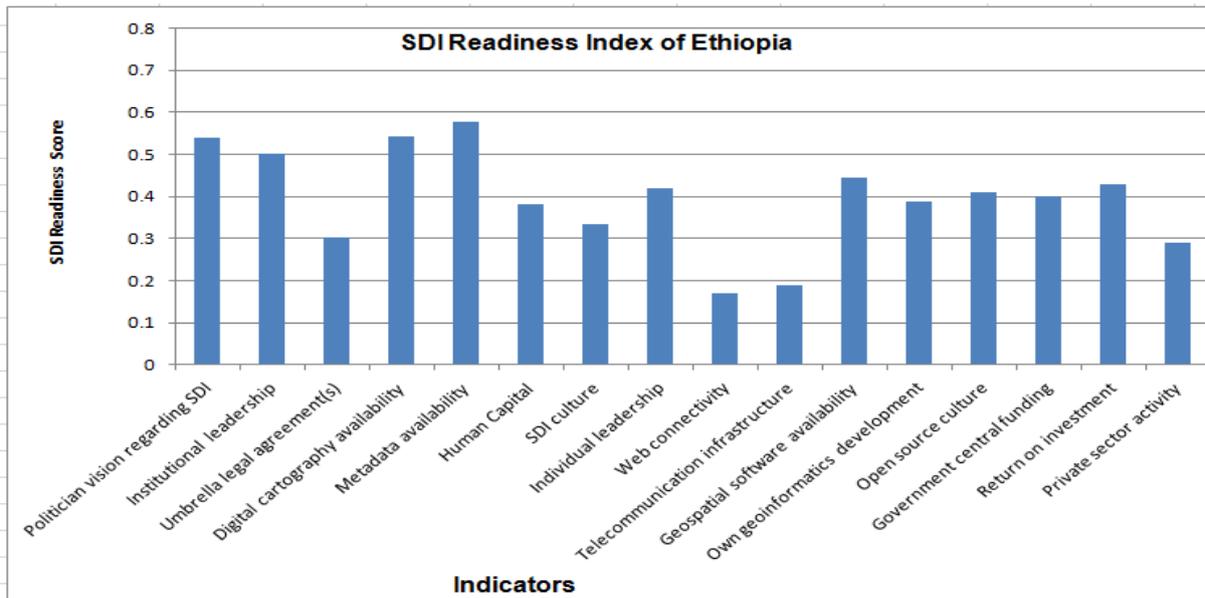
Figure 8: Summarised results of SDI-readiness index of Ethiopia against 16 indicators

7.1.2 Results on Modified state of play approach

Figure 9, 10, 11, 13, 14, 15 and appendix 2 presents the assessment results of the Ethiopian SDIs by using the Modified state of play approach. Based on this approach the people components status is relatively higher than other components when we compare with institutional, metadata, technology and policy. Greater than 50% of the respondents are in full agreement concerning people component of the ENSDI (see figure 10). For detailed information on 36 indicators (see appendix 2).

Analysis of the result of questionnaire on institutional perspectives indicates that only 33% are in full agreement and 53% in partial agreement regarding the initiatives have been taken to launch the NSDI and the same value is also scored for the existence of long term vision and mission. However, initiatives have been taken by the Ethiopian Mapping Agency starting from 2002 onwards. The possible reason for this low score (33%) is due to lack of awareness among the key stakeholders about NSDI initiatives. Regarding the territorial coverage of SDI initiatives only 20 % of the respondents are in full agreement with the statement of areal coverage of ESDI initiatives.
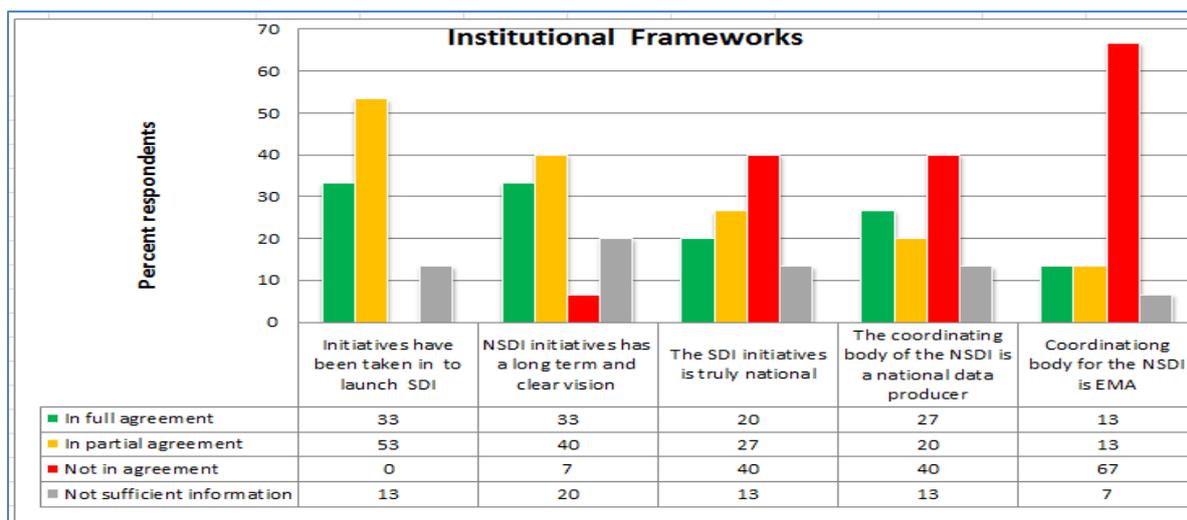
Figure 9: Institutional frameworks of NSDI results based on state of play approach

	Initiatives have been taken in to launch SDI	NSDI initiatives has a long term and clear vision	The SDI initiatives is truly national	The coordinating body of the NSDI is a national data producer	Coordinationg body for the NSDI is EMA
In full agreement	33	33	20	27	13
In partial agreement	53	40	27	20	13
Not in agreement	0	7	40	40	67
Not sufficient information	13	20	13	13	7
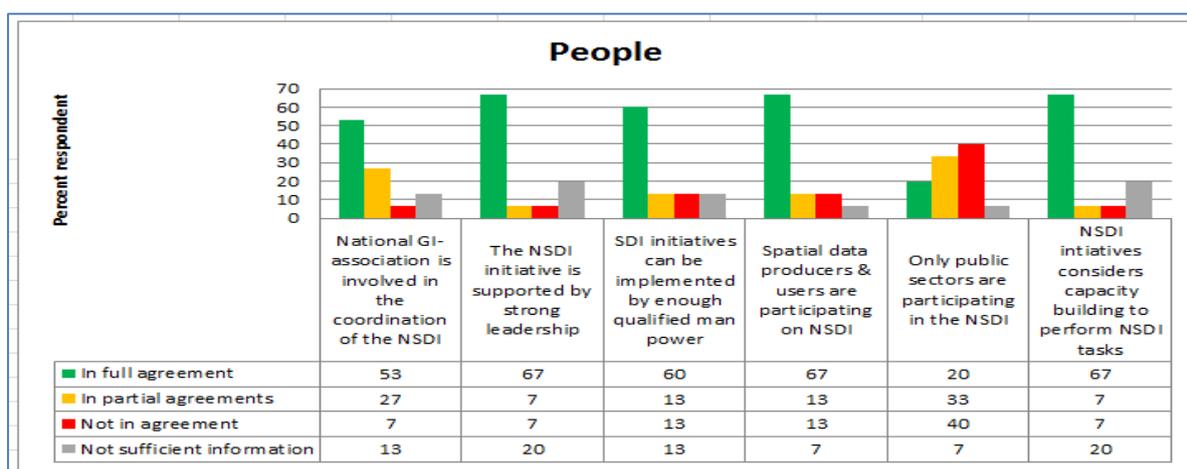
Figure 10: People components results based on state of play approach

	National GI-association is involved in the coordination of the NSDI	The NSDI initiative is supported by strong leadership	SDI initiatives can be implemented by enough qualified man power	Spatial data producers & users are participating on NSDI	Only public sectors are participating in the NSDI	NSDI intiatives considers capacity building to perform NSDI tasks
In full agreement	53	67	60	67	20	67
In partial agreements	27	7	13	13	33	7
Not in agreement	7	7	13	13	40	7
Not sufficient information	13	20	13	7	7	20

The data and metadata of ENSDI evaluation results show that there is shortage of digital data and lack of data quality control procedures in the country. Only 20% of the respondents are in full agreement with the availability of digital data in the NSDI. This result proves that most of the available data are exist in analogue form. The other big problem identified in this survey result is shortage of data quality control. As the result indicates almost 50 % of the respondent are not in agreement regarding the existence of data quality control procedures at the level of NSDI. (See figure 13 in appendix 3). Concerning the policy for the environmental data set accessibility only 13% of the respondents are in full agreement with the statement and 53 % are not information at all (see appendix 3). This result proves that the NSDI lack environmental dataset policy at the time of this research was conducted.
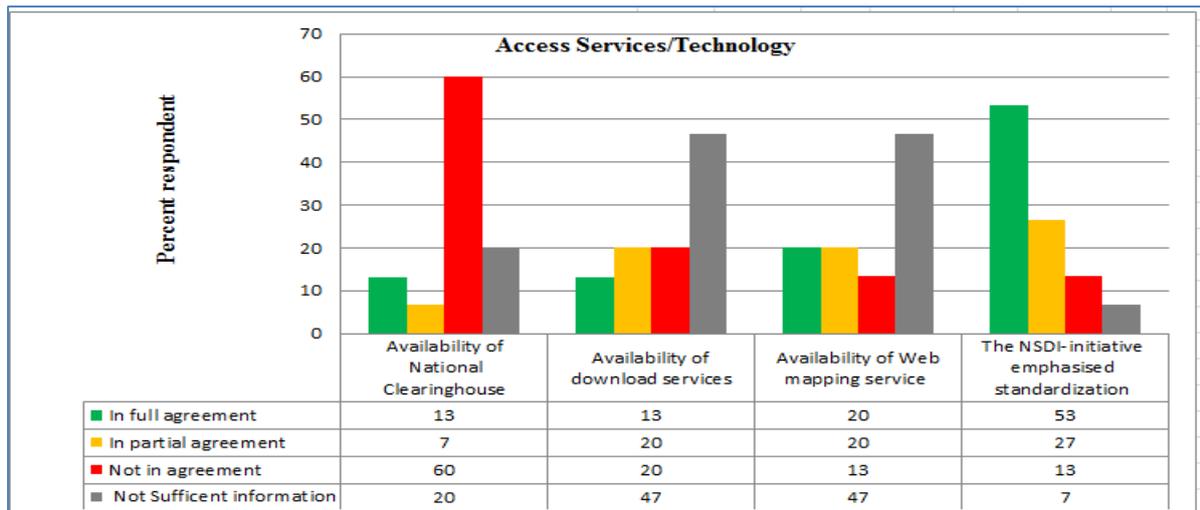
Figure 11: Access /technology services

The technology component of the ENSDI is much lower than other components. As the results show in figure 11 the availability of download and web mapping services are very low. The reason behind low score is not only related to shortage of skilled man power but also due to insufficient infrastructure of the country like telecommunication facilities. Almost 47% have not sufficient information as far as the availability of download and web mapping services is concerned. For the availability of national clearinghouse 60% are not in agreement with the existence of on-line access services for metadata. But in reality the clearinghouse is implemented on the web starting from 2004 onwards under coordination of ECA. This contrasting result occurred due to lack of awareness among some stakeholders about the existence of national clearinghouse at ECA and the term clearinghouse itself. Lack of awareness on the content of SDI and the multi-view framework assessment approach is not only the problem of Ethiopia but also for other countries like Kenya as (Josephat, 2011) conclude in its thesis report in July 2011.

7.1.3 Clearinghouse suitability index

The 15 clearinghouse Node characteristic of Ethiopia is moderately good (see table 12). This is due to the contribution of United Nations Economic Commission for Africa (UNECA) which coordinates the national clearinghouse of Ethiopia starting from 2004 onwards. The number of datasets on the web is greater than 5000 (see table 11). The overall score of the clearinghouse suitability index is 0.67. The score value of the clearinghouse suitability index of Ethiopia is better than that of SDI-readiness index (0.39).

Table 11: Clearinghouse suitability of Ethiopia detailed results (October 2011)

Clearinghouse characteristics	Description
Country	Ethiopia
Name of clearinghouse	UNECA Clearinghouse node
Name of coordination body	UNECA (United Nations Economic Commission for Africa)
Web address	http://geoinfo.uneca.org/ethiopia
Year of first implementation on the web	2004
Number of data suppliers in the national geo-portal	4
Monthly number of visitors of national geo-portal	***
Languages used	English
Frequency of web updates (days)	***
Number of datasets	>5000
Most recently produced dataset (monthly /yearly)	June 2010
(De)centralised network architecture (Yes/No)	Yes
Availability of view (web mapping)services (Yes/No)	No
Mechanism for searching (Text index, keyword, map (location or predefined boundaries)organization, date, topic category etc)	All
Use of maps for searching (Yes/No)	Yes
Availability of data downloading services (Yes/No)	Yes
Last web address change (monthly/Yearly)	2 years ago
Funding continuity (Continuous ,Piecemeal, Never)	Continuous
Metadata standard applied (ISO,FGDC,CEN,NATIONAL etc)	ISO, FGDC
Metadata records of environmental datasets (yes/No)	Yes
Number of thematic environmental datasets	***

Table 12: Clearinghouse suitability score of Ethiopia

Clearinghouse Characteristic	Class 1	Class 1 weight*	Class 2	Class 2 weight	Class 3	Class 3 weight
Number of suppliers	> 16	0.08	**2 - 16**	**0.04**	1	**0.00**
Monthly number of visitors[***]	> 4000	0.02	150 - 4000	0.01	< 150	0.00
Number of web references	**> 250**	**0.04**	20 - 250	0.02	< 20	**0.00**
Languages used	multilingual including the national language	0.06	monolingual using the national language	0.03	**monolingual using no national language**	0.00
Frequency of web updates (in days)[***]	< 4	0.10	4 - 365	0.05	**> 365**	0.00
Level of (meta) data accessibility	**data + standardised metadata**	**0.10**	standardised metadata	0.05	non-standardised metadata	**0.00**
Number of datasets	**> 1500**	**0.08**	50 - 1500	0.04	< 50	**0.00**
Most recently produced dataset (in months)	**< 2**	**0.02**	2 - 60	0.01	> 60	**0.00**
Decentralised network architect.	**yes**	**0.08**	hybrid	0.04	No	**0.00**
Availability of view services	yes	0.10	prototype	0.05	**no**	0.00
Number of mechanisms (alternatives) for searching	**> 5**	**0.18**	2 - 5	0.09	1	**0.00**
Use of maps for searching	**yes, by locating an area of interest**	**0.04**	yes, by clicking on an area with predefined boundaries	0.02	no	**0.00**
Registration-only access	no	0.02	**partly**	**0.01**	yes	**0.00**
Funding continuity	**continuously funded**	**0.01**	piecemeal funded	0.01	never funded	**0.00**
Metadata-standard applied	ISO/FGDC/CEN	0.07	**national**	**0.03**	**no standard**	**0.00**

The overall result= 0.67

***= missing data

The green value= the value of the clearinghouse characteristics

7.1.4 Results on Organizational aspects of ENSDI

The results described in this section relate with organisational aspects of ENSDI (see figure 12). The 11 indicators of organizational issues are categorized in to five major indicators. Namely: Leadership, Inclusiveness and communication, Strategic plan, Self-organizing ability and Awareness for GII. Regarding the presence of long strategic plan for the NSDI all respondents (100%) agreed to this statement. The main reason for this agreement is that the Ethiopian Mapping Agency already developed long-term strategic plan of the NSDI and dispatched their long term visions to all key stakeholders in the country. With reference to the involvement of private parties in developing long term vision of ENSDI it is very low only

27% are agreed to the statement. Concerning the awareness of the citizens on the NSDI majority of the respondents answer is no (80%). These results prove that the citizens of Ethiopia have low awareness on the NSDI Initiatives as well as the NSDI itself. The overall result on organizational issues indicates the status of leadership, strategic plan and self-organizing ability is relatively good. However the results obtained on communication channels and awareness of the citizen is very poor.
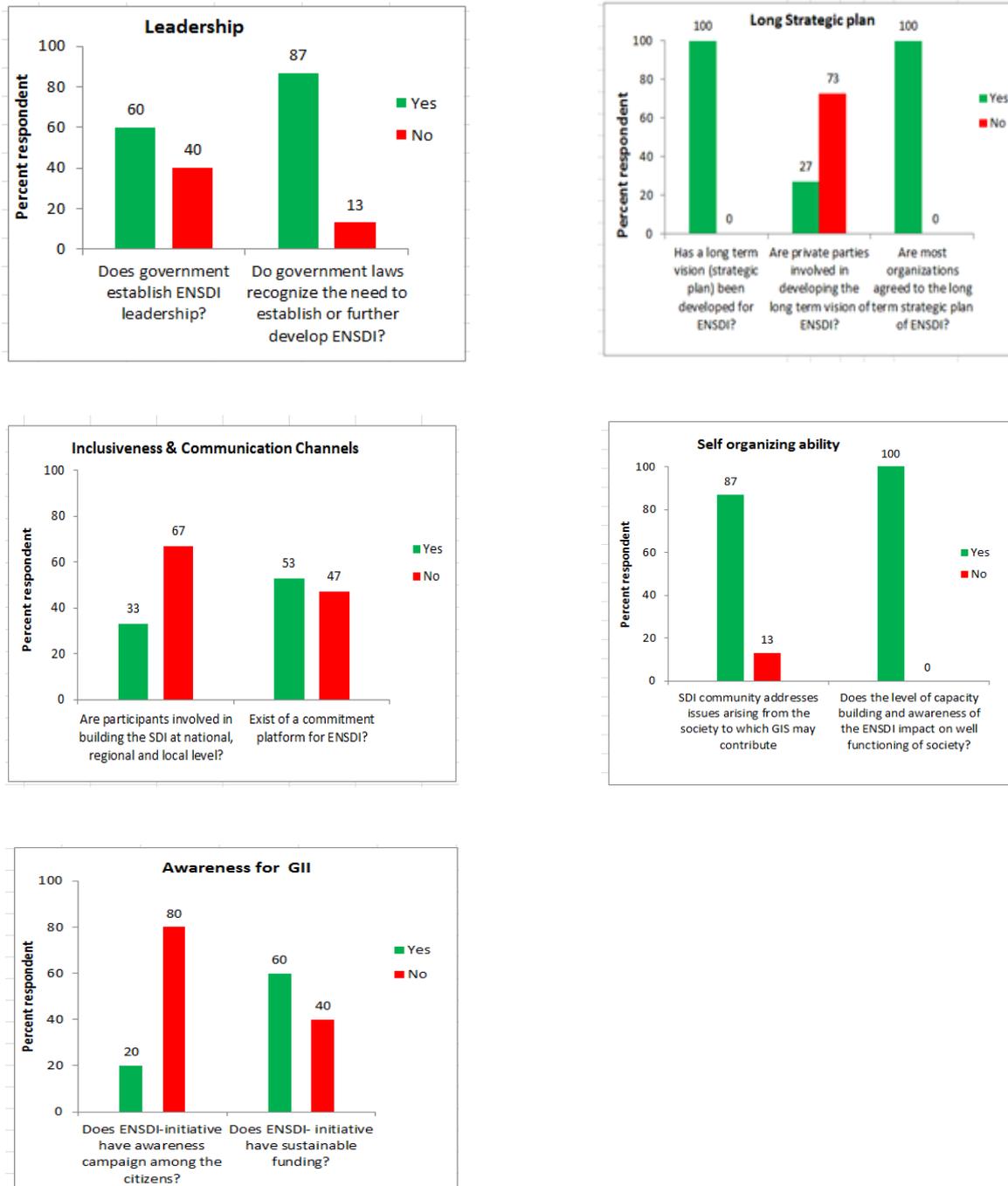
Figure 12: Results on Organizational aspects of ENSDI

7.2 Discussion

This section explores general discussion on data collection methods, problems and findings on multi-view SDI assessment frameworks. To answer the second research question different methodology were applied.

RQ2, What is the current status of Ethiopian National Spatial Data Infrastructures taking the Multi-view assessment framework approaches of: SDI-readiness, Modifies state of play, Clearinghouse suitability, and Organizational aspect?

Data Collection

Data was collected from September 5 to December 17, 2011 from 15 key stakeholders from various institutions namely: Seven from governmental organization, three academia, two international organizations, two NGO's and one civil society based on their role in the development of ENSDI (see table 7). Two International organizations included in the survey based on their role. International organizations played a big role in the development of ENSDI. Lance (2003) concludes that foreign donors drive the initiatives in developing countries in steady of the respective national governments. This statement does not mean the national government is always passive in SDI activities. The Ethiopian mapping Agency with other governmental organization are producing different digital datasets for the NSDI (see table 10). Because of this fact questionnaire survey was conducted in various institutions: Governmental, NGO's and International Organisations. The response time of the respondents varies from 7 to 45 days. From governmental institutions the Ministry of Water resource fill the questionnaire with in short couple of days while the Ethiopian Mapping Agency and Central Statics Agency takes 14 days to respond the questionnaire survey. The questionnaire on the clearinghouse suitability is collected within two days. The experts of UNECA fill the main indicators of clearinghouse suitability and send the result on the next day. One respondent from the academia takes 45 days to return the questionnaire is the longest time recorded by the researcher.

The main problems observed during the data collection process are as follows: lack of willingness of the top officials to respond and fill the questionnaire survey, the key stakeholders of some institutions nominates other junior officers to fill the questionnaire. Other serious challenge after data collection is the situation of Ethiopia in respect of SDI development. SDI development is at infancy stage as a result there is lack of published paper on ENSDI. Only conference proceedings and workshops papers are exist on ENSDI. These all situation hinder the researcher to compare the relative development of ENSDI by analysing the findings of other in the past.

Most of the ENSDI stakeholders were not familiar with the multi-view assessment framework approach indicators. This lack of knowledge on the indicators affects the results of the research. For instance some respondents give random answers. To solve the knowledge gap the interviewer provide necessary information for the stakeholders about the concepts as well as the contents of the four multi-view assessment framework indicators.

Problems in data analysis on multi-view assessment approaches

The collected data through questionnaire survey was analysed per each assessment indicators for all the assessment approach used in this research. The major problem on the multi-view assessment is completeness of data or missing data particularly on national clearinghouse. There are 2 missing data namely: the number of monthly visitors and

frequency of web updates in days (see table 11 and 12). The main problem for the missing data is simple due to lack of information. In order to overcome the problem the simplest approach-listwise deletion method was used. Different researchers give different name for this method. Namely: listwise deletion and complete case analysis. Listwise deletion is the most common approach in dealing with the data missing in questionnaire survey if the missing data is too small (Howell, 2009). This method simply omits those indicators with missing data and to run analyses on what remains. Consequently, the Clearinghouse suitability index is computed only by 13 indicators.

Result analysis on the four assessment approaches

The result of SDI-readiness assessment show that only organizational factors (political vision and leadership) and information factors (availability of digital cartography and metadata) score above average. The score value of people, access network and financial resources are extremely low (see figure 8). Based on the value obtained from the respondent the average score value of the national SDI-readiness value of Ethiopia is 39% (see figure 7). Accordingly, it is possible to say the SDI-readiness of the country is very low. This result helps the country to increase insight into mechanisms and forces steering the evaluated SDI and to investigate what kind of changes should be recommendable for improvement (Grus et al., 2008). The low score of this SDI-readiness is due to low status of different components of SDI and lack of finance for the NSDI. Lance (2003) concludes that the low score of SDI readiness is due to lack budgetary and strong leadership of a nation. Even though different situations are changed after the study of Lance the problem of political influence, budgetary and lack of strong leadership are still the main difficulties exist in the country. Based on the value of SDI readiness index it is possible to conclude that Ethiopia is not well prepared to deliver their spatial data for the users in online bases. The SDI-readiness index helps to identify a strategy to address the primary obstacles of SDI development (Delgado et al., 2005). In 2000 (Ezigbalike et al., 2000) it was summarised that Africa was not ready for a full on-line SDI, as evaluated from data, metadata, technology, institutional arrangements, policies and standards perspective.

More detailed results were obtained by modified state of play approach since it has 36 indicators (see appendix 2). The result obtained on people related components of ENSDI is relatively good in this assessment approach. Greater than 50% of the respondents are agreed regarding the availability of people components (see figure 10). The surprising thing is the score value of the people component obtained by SDI readiness index is reverse. In the case of SDI-readiness the people component: human capital, SDI culture and individual leadership score value is very low (see figure 8). This is only for the sake of understanding the disparity because comparing the result of different assessment approach is not the objectives of this research.

The result on the institutional frameworks indicates that majority of the respondents are not agreed concerning the existence of clear vision and mission as well as the SDI initiatives. Only 33% are full agreed as far as the initiatives have been taken (see figure 9). This result shows the awareness of stakeholders on the NSDI Initiatives is very low. Elderink et al. (2008) also conclude in the same way on the awareness of the people on the NSDI. However, Ethiopia already took initiatives under the mandate of Ethiopian Mapping Agency to develop and implement the NSDI. As it described in chapter four Ethiopia already developed strong vision and mission for the NSDI (see section 4.2).

Concerning the availability and status of data and metadata it is not satisfactory. As it indicated in figure 13 of appendix 3 only 20% of the respondents are in full agreement regarding the availability of digital data. With reference to data quality control almost 50% of

the respondents are not in agreement on the availability of data quality control system. This result find out most of the available data are exist in analogue form.

The result on the technology component is poor. The level of information technology infrastructure to store, analyse and disseminate data and information, and lack of skilled professional man power are the major problems encountering Ethiopia according to the report of Africa Development Bank (ADB, 2006). With reference to the availability of download and web mapping services 47% of the respondents have not sufficient information (see figure 11). Concerning the availability of national clearinghouse 60% are not in agreement with the existence of on-line access services for metadata. Conversely, the national clearinghouse (http://geoinfo.uneca.org/ethiopia) is developed and implemented under ECA with having greater than 5700 datasets on the geo-portals (see table 11).

7.3 Conclusion

This section describes the conclusion on the status of ENSDI by using the results obtained from the four multi-view assessment frameworks.

Second research question (RQ2)

What is the current status of Ethiopian National Spatial Data Infrastructures taking the Multi-view assessment framework approaches of: SDI-readiness, Modifies state of play, Clearinghouse suitability, and Organizational aspect?

The NSDI-readiness result indicates that Ethiopia is not well prepared to deliver their spatial information for the users in on-line bases. This is due to low level of web connectivity and IT infrastructures, and human capital index. Even though Ethiopia develop strong vision and mission to develop the NSDI the following challenges affect its implementation namely: lack of fund, shortage of skilled man power in GIS, low technological development, lack of awareness among the community on SDI and poor coordination among different federal and regional institution in data sharing and provision services delayed the development of ENSDI.

Modified state of play approach results show that the people component score is relatively higher than institutional, data, technology and policy. The technology component of the NSDI is very poor. The other problems identified in this approach were shortage of digital data, lack of quality control procedures and lack of environmental datasets policy.

The national clearinghouse (http://geoinfo.uneca.org/ethiopia/) which was operational under the administration of United Nations Economic Commissions for Africa is moderately good with having greater than 5700 datasets on the portals and this geo-portals use International metadata standards like ISO and FGDC.

The organisational aspects of the NSDI results indicate that the status of leadership, strategic plan and self-organizing ability is relatively good. This is because of the fact that Ethiopia already developed a long term strategic plan of the NSDI under the mandate of Ethiopian Mapping Agency and recently Ethiopian Mapping Agency disseminate the long-strategic plan of the NSDI in line with the draft policy to all key stakeholders in the country. However, majority of the Ethiopian population have no awareness on the existence the NSDI strategic plan as well as the NSDI itself.

The above all statement leads to the conclusion that the development status of ENSDI is low with high opportunity to improve in the near future.

7.4. Recommendations

Based on the assessment result and limitation of the study, the following recommendations are suggested for the development of ENSDI:

- The government of Ethiopia should assign sufficient fund for SDI implementation by increasing annual budgetary allocation, international donor, cost sharing and private sector funding mechanisms;
- The national parliamentary of Ethiopia should approved the draft policy of the ENSDI within a short period of time to focus on standardisation, cost, openness and copy right of the original source;
- The ENSDI secretariat should develop the awareness of all stakeholders about the importance and benefits of SDI for sustainable development of the country through workshop, seminars mass media and other mechanisms; the higher institution in the country should develop SDI curriculum in the near future to develop the awareness of the skilled man power in the area of SDI;
- The ENSDI coordinator should develop documented database (journals, articles, conference proceedings and other NSDI related documents) for general information to facilitate research in the future;
- All partner institution of the ENSDI should focus on the improvement of technology services like web mapping services and connectivity as the same time it is also crucial to increase the availability and production of digital data on all thematic and environmental data;
- For identification of Ethiopian SDI milestones the information should be collected in the form of interview and structural developed questionnaire from various institution in order to get more historical events in the past and to predict the future developments;
- To avoid duplication of similar ideas the assessment framework approaches should be not greater than two at one moment;
- Similar research should be carried out on ENSDI assessment to better capture and understand the progress in its development. SDI assessment should be conducted regularly at least on annual bases to take immediate solution for future development. The multi-view assessment framework approach is more appropriate methods to understand and evaluate the development status of ENSDI. So, in the future the multi-view assessment framework approaches are recommendable to assess the development status of ENSDI.

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APPENDICES

Appendix 1: Results of SDI-readiness index of ENSDI per 15 respondents

C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
Decision Criteria	Rs1	Rs2	Rs3	Rs4	Rs5	Rs6	Rs7	Rs8	Rs9	Rs10	Rs11	Rs12	Rs13	Rs14	Rs15
Politician vision regarding SDI (Ov)	0.65	0.65	0.65	0.65	0.2	0.5	0.2	0.35	0.5	0.65	0.5	0.65	0.8	0.35	0.8
Institutional leadership (Ol)	0.99	0.35	0.35	0.5	0.5	0.35	0.35	0.35	0.35	0.99	0.65	0.2	0.99	0.35	0.2
Umbrella legal agreement(s) (Oa)	0.2	0.5	0.65	0.8	0.8	0.2	0.2	0.2	0.2	0.2	0.2	0.01	0.2	0.01	0.2
Digital cartography availability (Ic)	0.65	0.5	0.5	0.5	0.5	0.65	0.8	0.35	0.5	0.99	0.8	0.35	0.35	0.35	0.35
Metadata availability (Ia)	0.65	0.5	0.35	0.65	0.99	0.99	0.65	0.5	0.5	0.5	0.2	0.8	0.5	0.2	0.65
Human Capital (Pc)	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38
SDI culture (Ps)	0.35	0.35	0.35	0.35	0.35	0.5	0.5	0.01	0.35	0.35	0.2	0.5	0.5	0.01	0.35
Individual leadership (Pl)	0.35	0.5	0.35	0.5	0.35	0.2	0.8	0.35	0.35	0.5	0.2	0.65	0.65	0.35	0.2
Web connectivity (Aw)	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
Telecommunication infrastructure (At)	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
Geospatial software availability (As)	0.65	0.65	0.35	0.2	0.65	0.99	0.5	0.2	0.2	0.2	0.35	0.5	0.35	0.5	0.35
Own geoinformatics development (Ad)	0.2	0.35	0.35	0.65	0.35	0.99	0.65	0.2	0.5	0.5	0.35	0.01	0.5	0.2	0.01
Open source culture (Ao)	0.65	0.5	0.5	0.5	0.5	0.01	0.65	0.35	0.5	0.5	0.35	0.65	0.5	0.01	0.01
Government central funding (Fg)	0.2	0.5	0.35	0.65	0.35	0.35	0.65	0.2	0.2	0.65	0.2	0.8	0.2	0.5	0.2
Return on investment (Fr)	0.35	0.35	0.35	0.65	0.35	0.35	0.65	0.2	0.35	0.5	0.35	0.5	0.65	0.35	0.5
Private sector activity (Fp)	0.35	0.35	0.01	0.35	0.35	0.65	0.5	0.2	0.2	0.2	0.2	0.65	0.35	0.01	0.01
Index of Organization (O) component	0.5049	0.48	0.53	0.638	0.431	0.327	0.24	0.29	0.327	0.50	0.40	0.11	0.54	0.11	0.32
Index of Information (I) component	0.57	0.46	0.42	0.49	0.54	0.63	0.62	0.36	0.46	0.47	0.46	0.41	0.36	0.29	0.39
Index of People (P) component	0.3597	0.41	0.36	0.41	0.36	0.44	0.50	0.43	0.43	0.41	0.25	0.50	0.50	0.11	0.30
Index of Access network (A) component	0.5091	0.505	0.485	0.50	0.51	0.38	0.38	0.14	0.35	0.49	0.47	0.49	0.49	0.45	0.41
Index of Financial resources (F) component	0.30	0.40	0.25	0.57	0.35	0.36	0.52	0.02	0.33	0.48	0.25	0.67	0.43	0.31	0.27
Overall Index value of 15 respondents	0.437	0.45	0.40	0.51	0.43	0.42	0.43	0.17	0.38	0.47	0.35	0.37	0.46	0.22	0.33
Where:															
Rs= Respondents															
0.99= Extremely high															
0.8= Very high															
0.65= High															
0.5= Medium															
0.35= Low															
0.35= Very low															
0.01= Extremely low															

The index of Organizational (O), Information (I), People (P), Access network (A), Financial resources (F) and the overall SDI-readiness index of ENSDI is calculated by applying the compensatory logic of (Delgado et al., 2005).The above index is calculated as demonstrated below:

Organizational (O) index= Power (Ov*Ol*Oa, 1/3)

Information (I) index= Power (Ic*power((1-Ic)*Power(Ia,2),1/2),1/2),1/2),1/2)

People (P) index= Power (Pc*Ps*Pi, 1/3)

Access Network (A) index= Power (At*Aw*(1-Power ((1-As)*(1-Ad)*(1-Ao), 1/3)), 1/3, 1/2)

Index of Financial (F) resources= 1-Powe ((1-Fg)*(1-Fr)*(1-Fp), 1/3)

Overall SDI-readiness index=Power (Organizational index*Information index*People index*Access network index*Financial index, 1/5)

Appendix 2: Detailed results of Ethiopia Modified state of play based on questionnaires survey

Indicators	In full agreement		In partial agreement		Not in agreement		Not sufficient information	
Organizational issues	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Initiatives have been taken in Ethiopia to launch the development of SDI	5	33	8	53	0	0	2	14
National SDI initiatives has a long term and clear vision about NSDI	5	33	6	40	1	7	3	20
The SDI initiatives is truly national	3	20	4	27	6	40	2	13
The coordinating body of the national SDI is a national data producer	4	27	3	20	6	40	2	13
The de facto coordinating body for the NSDI is an organization controlled by data users	2	13	2	13	10	67	1	7
National GI-association is involved in the coordination of the NSDI	8	53	4	27	1	7	2	13
The national SDI initiative is supported by someone with strong leadership	10	67	1	6	1	7	3	20
The SDI initiatives can be implemented by enough qualified man power	9	60	2	13	2	13	2	14
Spatial data producers & users are participating on NSDI	10	67	2	13	2	14	1	7
Only public sectors are participating in the NSDI	3	20	5	33	6	40	1	7
NSDI initiatives considers capacity building to perform tasks for ENSDI	10	67	1	7	1	6	3	20
Policy (Legal issues and funding)								
There is a legal instrument determining the SDI strategy	10	67	1	6	0	0	4	27
There are true PPP'S b/n public & private sector bodies with respect to the development & operation of the NSDI related projects	9	60	2	13	3	20	1	7
There is a freedom of information act which contains legislation for GI-sector	7	47	2	13	5	33	1	7
Geo-Information can specifically protected by copyright	3	20	3	20	8	53	1	7
Privacy laws are actively being taken into account by the holders of geo-information	9	60	0	0	5	33	1	7
NSDI initiatives considers capacity building to perform tasks for ENSDI	7	47	4	27	3	20	1	6
There is a legal instrument determining the SDI strategy	9	60	1	7	2	13	3	20
There are true PPP'S b/n public & private sector bodies with respect to the development & operation of the NSDI related projects	8	53	1	7	4	27	2	13
There is a pricing policy for GIS data	7	47	3	20	2	13	3	20
Data and Metadata								
Most spatial datasets are available in digital format	3	20	9	60	2	13	1	7
The geodetic reference system and projection system are standardised, documented interconvert able	10	66	4	27	0	0	1	7
There is documented data quality control procedures applied at the level of the NSDI	3	20	3	20	7	47	2	13
Concern for interoperability goes beyond conversion between different data formats	4	27	0	0	8	53	3	20
The national language is the operational language of SDI	3	20	1	7	10	66	1	7
English is used as secondary language	5	33	2	13	7	47	1	7
Metadata are produced for a significant fraction of geo-datasets of reference data & core thematic data	6	40	0	0	8	53	1	7
Access services and other services for data and metadata								
one or more standardized metadata catalogues are available covering more than one data producing agency	4	27	6	40	2	13	3	20
There is coordinating authority for metadata implementation at the level of the NSDI	3	20	3	20	7	47	2	13
One national on-line access services for metadata (Clearinghouse) is available providing metadata of more than one data producing agency	2	13	1	7	9	60	3	20
There are one or more on-line services to download core spatial datasets	2	13	3	20	3	20	7	47
There are one or more web mapping service available for core spatial data	3	20	3	20	2	13	7	47
The national SDI-initiative is devoting significant attention to standardization issues	8	53	4	27	2	13	1	7
Thematic environmental data are covered by the described SDI initiative or there is an independent thematic environmental data	3	20	2	13	2	13	8	54
There is an independent thematic environmental SDI	2	13	2	13	8	54	3	20
There is a policy focusing on the access of thematic environmental data	2	13	3	20	2	13	8	54

Data and metadata

	Most spatial datasets are available in digital format	The geodetic reference system & projection system are standardised	Data quality control procedures at the level of the NSDI	Data interoperabi lity standards	The national language is the operational language of SDI	English is used as secondary language	Metadata produced for geodatasets of reference & core thematic data	one or more standardized metadata catalogues are available	There is acoordinating authority for metadata implementat ion at NSDI
In full agreement	20	67	20	27	20	33	40	27	20
In partial agreement	60	27	20	0	7	13	0	40	20
Not in agreement	13	0	47	53	67	47	53	13	47
Not Sufficent information	7	7	13	20	7	7	7	20	13

Figure 13: results of data and metadata components of ENSDI

Policy

	There is a legal instrument determining the SDI strategy	Strong PPP'S b/n public & private sectors	There is FOI act containing legislation for GI-sector	GIS can specifically protected by copyright	Privacy laws considered by GIS data producers GIS	There is an nstitutional policy for sharing GIS b/n public institution	There are simplified & standardized licenses for personal use	The long-term financial security of the NSDI initiative is secured	There is a pricing policy for GIS data
In full agreement	67	60	47	20	60	47	60	53	47
In partial agreement	7	13	13	20	0	27	7	7	20
Not in agreement	0	20	33	53	33	20	13	27	13
Not Sufficent information	27	7	7	7	7	7	20	13	20

Figure 14:Results on policy issues of ENSDI

Thematic Environmental Data

	Enviromental data are covered by the SDI intiative	There is an independent thematic environmental SDI	Policy for environmental data sets access availabile
In full agreement	20	13	13
In partial agreement	13	13	20
Not in agreement	13	53	13
Not Sufficent information	53	20	53
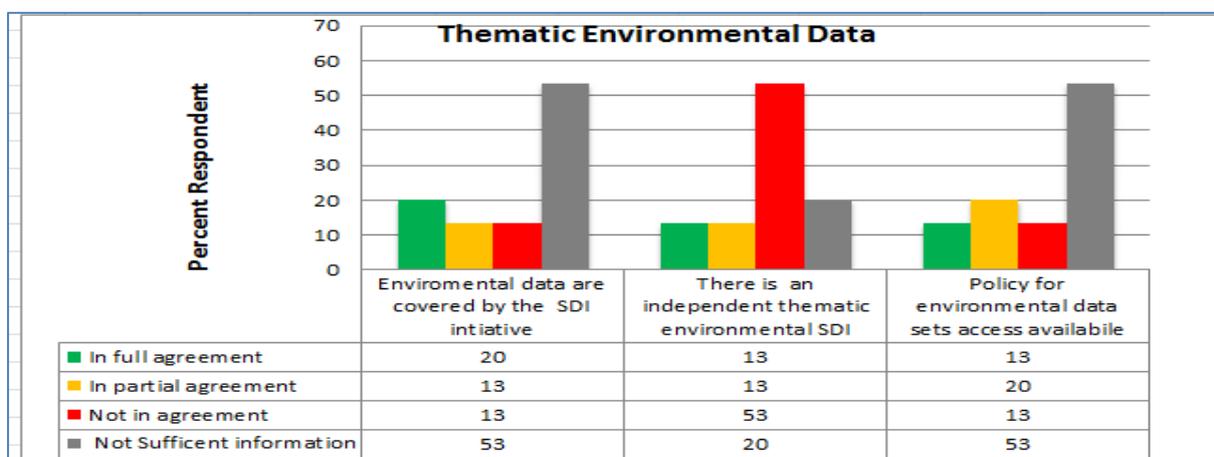
Figure 15: Results on thematic environmental data of ENSDI

Appendix 4: Detailed results of Organizational aspects of ENSDI

| Indicators	Number of response and percentages			
	Yes		No	
Leadership/ Authority	N	%	N	%
Does government establish Ethiopia national SDI leadership?	9	60	6	40
Do formal orders or government laws recognize the need to establish or further develop Ethiopia NSDI?	13	87	2	13
Inclusiveness & Communication Channels				
Are participants involved in building the SDI at national, regional and local level?	5	33	10	67
There exist a commitment fora or platform for Ethiopia NSDI?	8	53	7	47
Long term vision or strategic plan				
Existence of long term vision statement or strategic plan for Ethiopian NSDI development is acceptable to all parties?	15	100	0	0
Are private parties involved in developing the long term vision of Ethiopian NSDI?	4	27	11	73
Are most organizations agreed to the long term vision or strategic plan of Ethiopia NSDI?	15	100	0	0
Self-Organizing Ability				
SDI community addresses issues arising from the society to which geographic information may contribute. Does ENSDI do the same?	13	87	2	13
Does the level of capacity building and awareness of the ENSDI impact on well-functioning of society including business, public and academia?	15	100	0	0
Awareness for GII				
Does ENSDI-initiative have awareness campaign among the citizens?	3	20	12	80
Does ENSDI- initiative have sustainable funding?	9	60	6	40

Appendix 5: SDI-readiness approach assessment indicators adopted from Delgado et al. (2005).

SDI Readiness Aspect		Indicator
Organisational (O)	1	Politician vision regarding SDI (Ov)
	2	Institutional leadership (Ol)
	3	Umbrella legal agreement (Oa)
Information/data availability (I)	4	Digital cartography (Ic)
	5	Metadata availability (Im)
People (P)	6	Human capital (Pc)
	7	SDI culture/education (Ps)
	8	Individual leadership (Pl)
Access network (A)	9	Web connectivity (Aw)
	10	Telecommunication infrastructure (At)
	11	Own geo-information development (Ad)
	12	Geospatial software availability (As)
	13	Open source culture (Ao)
Financial resources (F)	14	Government central funding (Fg)
	15	Data policy aimed to return on investment (Fr)
	16	Enterprise and private sector funding (Fp)

Appendix 6: Indicators of Clearinghouse suitability view adopted from (Crompvoets et al., 2004)

Clearinghouse characteristics	Description
Name of clearinghouse	
Name of coordination body	
Web address	
Year of first implementation on the web	
Number of data suppliers in the national Clearinghouse	
Monthly number of visitors of national Clearinghouse	
Languages used	
Frequency of web updates (days)	
Number of datasets	
Most recently produced dataset (monthly /yearly)	
(De)centralised network architecture (Yes/No)	
Availability of view (web mapping)services (Yes/No)	
Mechanism for searching (Text index, keyword, map (location or predefined boundaries) organization, date, topic category etc.)	
Use of maps for searching (Yes/No)	
Availability of data downloading services (Yes/No)	
Last web address change (monthly/Yearly)	
Funding continuity (Continuous ,Piecemeal, Never)	
Metadata standard applied (ISO, FGDC, CEN, NATIONAL etc.)	
Metadata records of environmental datasets (yes/No)	
Number of thematic environmental datasets	

Appendix 7: Modified state of play assessment indicators adopted from Vandenbroucke et al. (2008)

Indicators	In full agreement	In partial agreement	Not in agreement	Not sufficient information
Organizational issues				
Initiatives have been taken in Ethiopia to launch the development of SDI				
National SDI initiatives has a long term and clear vision about NSDI				
The SDI initiatives is truly national				
The coordinating body of the national SDI is a national data producer				
The de facto coordinating body for the NSDI is an organization controlled by data users				
National GI-association is involved in the coordination of the NSDI				
The national SDI initiative is supported by someone with strong leadership				
The SDI initiatives can be implemented by enough qualified man power				
Spatial data producers & users are participating on NSDI				
Only public sectors are participating in the NSDI				
NSDI initiatives considers capacity building to perform appropriate tasks for ENSDI				
Policy (Legal issues and funding)				
There is a legal instrument determining the SDI strategy				
There are true PPP'S b/n public & private sector bodies with respect to the development & operation of the NSDI related projects				
There is a freedom of information act which contains legislation for GI-sector				
Geo-Information can specifically protected by copyright				
Privacy laws are actively being taken into account by the holders of geo-information				
NSDI initiatives considers capacity building to perform tasks for ENSDI				
There is a legal instrument determining the SDI strategy				
There are true PPP'S b/n public & private sector bodies with respect to the development & operation of the NSDI related projects				

There is a pricing policy for GIS data				
Data and Metadata				
Most spatial datasets are available in digital format				
The geodetic reference system and projection system are standardised, documented interconvert able				
There is documented data quality control procedures applied at the level of the NSDI				
Concern for interoperability goes beyond conversion between different data formats				
The national language is the operational language of SDI				
English is used as secondary language				
Metadata are produced for a significant fraction of geo-datasets of reference data & core thematic data				
Access services and other services for data and metadata				
one or more standardized metadata catalogues are available covering more than one data producing agency				
There is coordinating authority for metadata implementation at the level of the SDI				
One national on-line access services for metadata (Clearinghouse) is available providing metadata of more than one data producing agency				
There are one or more on-line services to download core spatial datasets				
There are one or more web mapping service available for core spatial data				
The national SDI-initiative is devoting significant attention to standardization issues				
Thematic environmental data are covered by the described SDI initiative or there is an independent thematic environmental data				
There is an independent thematic environmental SDI				
There is a policy focusing on the access of thematic environmental data				

Appendix 8: Organizational approach assessment indicators adopted from Kok and Van Loenen (2005)

Organizational Aspects		Indicator
Leadership/authority	1	Does government establish Ethiopia NSDI leadership?
	2	Do formal orders or government laws recognize the need to establish or further develop ENSDI?
Inclusiveness and communication channels	3	Are participants involved in building Ethiopia NSDI at National, regional and international
	4	There exists a commitment platform for Ethiopia NSDI?
Long-time vision (strategic plan)	5	Existence of long-term vision (strategic plan) for ENSDI development is acceptable to all parties?
	6	Are private parties involved in developing the long term vision or strategic plan of ENSDI?
	7	Are most organizations agreed to the long term vision of ENSDI or strategic plan?
Self-organising ability	8	SDI community addresses issues arising from society to which geographic information may contribute. Does ENSDI do the same?
	9	Does the Level of capacity building and awareness of the ENSDI impact on well-functioning of society including business, public and academia?
Awareness for GII	10	Does ENSDI-initiative have awareness campaign among the citizenry?
Financial sustainability	11	Does ENSDI-initiative have sustainable funding?

Appendix 9: Interview questions for SDI milestones

Interview questions for identification of Ethiopian SDI milestones.

Introduction

The interview was designed to collect views from the key stakeholders of relevant organization of ENSDI to whom you are a member and I therefore kindly ask you to provide information on the major milestones which contribute for the development of ENSDI. A milestone is an important event in the history of a nation, or the advancement of knowledge in a field. It is an important event that emerged at a critical time with high opportunity to deliver some tasks in an institution either at local or global scale. Thus, this interview is aimed to collect information on major SDI milestones of Ethiopia from key geo-information provider and users in the country.

Your contribution will greatly increase the value of this research aimed at assessing the development of ENSDI activities in our country. All information provided will be treated in the strictest confidence and only used in the thesis but upon request it will be availed.

Questionnaire for interview

1. Do you know when the concept of SDI was introduced and applied in Ethiopia for the first time?
2. When the first time digital data was produced in Ethiopia?
   ☐ Before 1980   ☐ 1980-1990   ☐ 1990-2000   ☐ After 2000   ☐ I don't know

3. Which national university trained the first GIS experts in Ethiopia and in which year?
   University name _____ Year _____
4. What is the role of the GIS Graduates in the development of GIS sector in Ethiopia?
5. Is there some sort of GIS society or association of GIS stakeholders in Ethiopia?
6. If your answer to Q5 is 'Yes', list the names of this society and/or associations and when they were established.
   Name _____ Year_____
   Name _____ Year_____
7. How significantly do you think this/these society contributed to the development of NSDI in Ethiopia?
8. In which area of spatial data infrastructure do the society or associations contributed?
   ☐ Data production
   ☐ Data exchange and access facilitation
   ☐ Data exchange and access policy formulation
   ☐ Data standard formulation and/or adoption
   If others, specify_____
9. Is there a national platform or web portals from which one can get GIS data?
10. If your answer to Q9 is 'Yes', when was this web portal launched and by whom?
    By _____ Year_____
11. Who administer the geo-portal of Ethiopia?
12. Does Ethiopia have metadata base? If yes who is the coordinator?
13. Which institutions in the country actively participate in the production of digital data for GIS activities?
14. Which organization aids the development of Ethiopia NSDI?
15. Which countries highly support Ethiopia on the area of GIS technology?
16. Based on your experience what are the major historical events for the development of the NSDI of Ethiopia?
17. Do you mention some of the major SDI Milestones of Ethiopia?