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National Spatial Data Infrastructure Building Blocks: The Status Quo in Ethiopia*

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Abstract

In Ethiopia, geospatial data silos are common due to the absence of a proactive and collaborative geospatial sharing platform. A national sharing platform, Ethiopian National Spatial Data Infrastructure (ENSDI), is in its pre-implementation phase. It is now of crucial concern to identify and prioritize areas of investment. However, we lack information on what is already available and where, and what is still required to deliver ENSDI building blocks. The purpose of this work is to assess status quo of these building blocks. 110 organizations were addressed based on a sampling procedure that is free of personal bias. Data was collected through semi-structured interviews, on-site inspections, and a review of secondary sources. The analysis revealed that many national geospatial information and other enabling policies, laws and strategies are already available. Although they do incorporate the value of sharing and accessing information, it appears that they lack details regarding interoperability, inclusiveness, and implementation. This work reveals complex institutional challenges that require better definitions of roles and responsibilities in order to overcome existing overlaps of mandates; and improved coordination of efforts with the geospatial industry. Furthermore, most legacy data sets are available in digital form, but they are neither ready to be shared on the Web nor accessible for the wider Geographic Information Systems (GIS) community. This is largely due to the absence of standardization, negligence of metadata, extended use of proprietary software, absence of clear data models and definitions, and poor (file based) data organization. The absence of Internet connectivity or low band width remains a fundamental obstacle for any web-based sharing of geospatial data. We also identify a lack of expertise in spatial data management, processing and programming. GIS and Remote Sensing specialist

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remain hard to find. Last but not least, this study recommends further study on data quality and data management issues.

Key words: SDI, building blocks, status quo, Ethiopia

1. INTRODUCTION

Geospatial data is valuable to safeguard the environment, enhance stewardship for natural resources, and activate the economy through business process improvement (OSDM, 2002). It was estimated that more than 80 % of governmental data has therefore a locational base (Lemmens, 2001). Geospatial information – a derivative from geospatial data – influences our daily lives with unique capabilities in establishing interaction and inter-linkage between bio-physical and socio-economic elements over time and space[1]. Facilitating the access to and exchange of geospatial information across disciplines and organizations at all levels of the government, non-profit and private sectors, and the academia supports the decision making process, and balances the socio-economic and environmental forces (Ting and Williamson,1999) to bring sustainable development. However, it demands organized and collaborative effort at national level.

For the last two decades, proactive and collaborative approaches helped to establish National Spatial Data Infrastructure (NSDI) as well accepted platforms in many countries around the globe. Many regional and national geospatial data infrastructure thus developed to promote access to and sharing of geospatial information among organization (Longley et al., 2001; Moeller, 2001; Feeney et al, 2001). The development process of this platform dated back to 1994 since the American National Spatial Data Infrastructure (SDI), an executive order 12906 passed by Bill Clinton, established followed by the Australia New Zealand Land Information Council (ANZLIC) since 1996, and the European SDI (INSPIRE) since 2007. In understanding of this, Global Spatial Data Infrastructure (GSDI) had been initiated since 1998 to encourage international cooperation that stimulates the implementation and development of national, regional and local spatial data infrastructures[2].

Though it is relatively late, some African countries are at the stage of either implementing or advancing NSDI strategies; to support natural resource management and land information systems (Mozambique), for national census

[1] https://www.directionsmag.com/article/4035
[2] http://gsdiassociation.org

(Lesotho and Tanzania), for environmental data and information systems (Lesotho), and environmental decision support (Zambia) (SADC 2004a), and for National Land Information System (South Africa) (Clarke, 2011).

Formally, the concept of SDI in Ethiopia dated 20 years back, introduced by the former Ethiopian Mapping Agency (Mulaku et al., 2006). From 2013 up to mid-2018, it was under the remit of Information Network security Agency of Ethiopia by proclamation number 808/2013 with the definition modified from Douglas (1997). Following the recent mission re-orientation and changes of competencies between EMA and INSA, the geospatial sector of INSA and the entire EMA has been merged in order to establish the Ethiopian Geospatial Information Institute by regulation number 440/2018 (FNG, 2018). The ENSDI development and administration is now under the remit of this newly created institute. At the national level, SDI in Ethiopia is now treated as a framework of policies, institutional arrangements, standards, technologies and metadata that promotes the sharing and accessibility of geospatial data at all levels of the government, the private and non-profit sectors, and the academic community.

At the same time, voluminous geospatial data about environment, infrastructure, and cultural phenomena have been collected by various stakeholders for more than 18 years, in order to effectively manage and assess natural resource. This created valuable public goods but unfortunately those are organized in silos, and the associated waste of resources and duplication of efforts are still common. There remains a strong need to unlock the entire potential of geospatial information to support the national Growth and Transformation Plan (GTPII), and the Sustainable Development Goals (SDGs) through a well-established national sharing platform.

Gelagay (2017) tried to identify, through literature review, the major barriers for geospatial data sharing at national level and for the development and implementation of ENSDI. As major obstructions which hinder ENSDI from being effective for the last 20 years, the author identified poor government buy-in and weak culture of data sharing among institutions associated with inexistence of strong governance mechanisms, policies and legal frame works, low level of technological readiness and data incompatibility. However, in his earlier work, Gelagay did not complement his findings with dedicated field research, and little was stated on the actual quo status of the ENSDI building blocks. In addition, the ENSDI still misses well communicated reference data (base line information) on what is available and where, and what is still required to be available for the sake of the successful establishment and execution of E(NSDI). The program planners and leaders at Ethiopian Geospatial Information Institute are challenged to identify and prioritize areas of investment, and to set different strategic directions for the implementation of the ENSDI. Due to the aforementioned rationale, the in-depth research on the status and readiness of ENSDI frameworks presented in this article complements the work of Gelagay (2017) by clearly showing the areas for urgent and long-term investment, and by recommending a general direction for the future development. This includes a detailed assessment of the status of ENSDI building blocks before any intervention is made.

2. RESEARCH METHODS

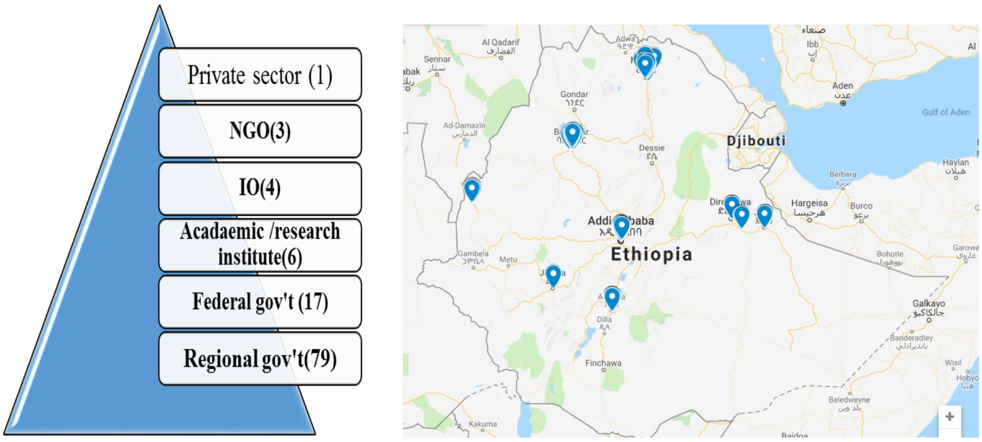
2.1 Sampling and Data Collection Methods

2.1.1 Sampling Method

This work targets organizations that are engaged directly or indirectly in the geospatial and ICT industry, which are likely to have the required information to achieve the assessment objective. Purposive sampling was applied, using the definition of a sample based on judgments. A total of 110 organizations, which represents the overall landscape of the relevant organizations across the country, situated in nine ethno-linguistically regions, and two city administrations were interviewed and inspected (see also Figure 1). The selection was based on the following sampling questions to be free of personal bias:

1) Does the organization focus on geospatial data production, management, archiving, and dissemination as part of its core business?
2) Does the organization focus on the provision and development of technology as part of its core business?
3) Does the organization provide financial or technical support to others for data production, archiving, and dissemination?
4) Is the organization invovled in the regulation of the geospatial and ICT industry?
5) Does the organization focus on research and development as part of its core business, and does it highly demand on geospatial data and technology?
6) Does the organization focus on value addition, and brokering in the geospatial and ICT industry as part of its core business?
7) Is the organization in need of and use geospatial data in order to accomplish its mission?

Figure 1. Purposively sampled organizational category& their geographical distribution



Two experts (GIS and IT) at each 110 sampled organization's GIS and related directorates were team up to respond to the semi-structured interview administered for them by the data collector team (experts from ENSDI center and ENSDI Working group) ,and to facilitate the on-site inspection process.

2.1.2 Data Collection methods

Primary data was collected through semi-structured face-to-face interviews, and on-site inspections. A questioner was developed to guide the semi-structured interviews. It covered the status of technology, people, standards, institutional arrangements, and metadata, as well as, legal and policy aspects. On-site inspections were carried out in addition, in order to reveal the available documentation (geospatial data and technology standards; guidelines, Memorandum of Understanding (MOU), supportive laws, and policies), and to examine the technological facilities.

ENSDI working group (formed from different stakeholders and is not now functional due to the reorientation of different federal organization following the reform made by the government) together with experts at ENSDI center administered the semi structured interview, onsite inspection, and on the desk unpublished document collection.

GIS and IT experts at each sampled organization which are selected based on the sampling question (section2.1.1) were team up to respond to the semi-structured interview administered for them and to facilitate the on-site inspection process. Some of the interviewee GIS and IT experts were from GIS unit of each sampled organization for those with GIS units, and others were assigned by each sampled organization's higher officials from units or directorates who engaged on geospatial and related works.

Furthermore, secondary data was collected by a review of published and unpublished sectorial policies, program reports and other documents related to geographic information, geographic information system (GIS), and SDI development - both locally and globally.

2.2 Data Analysis Method

The evolving and complex nature of SDI has shown by different scholars and nations depending on the scientific and technical background of the involved scholars, and governmental context as well. Due to this reason, the first generation SDI such as ANZLIC and the U.S. NSDI considers the hard infrastructure such as data, database, and deployed systems for the accessing and sharing of geospatial data. Later on, the second generation SDI like INSPIRE come up with certain level of advancement by focusing not only on the data management part but also on the soft infrastructure (people and communication) (Williamson et al. 2003).The conceptualization of SDI is still the key area of research for many scholars due to its evolving and complex nature (Williamson et al., 2003). It is considered as a complex and adaptive networks (Grus et al, 2010), spatial Information Infrastructures (Ran and Nedovic-Budic 2016; Crompvoets et al. 2018; Gourmelon et al., 2019), information infrastructure (Aanestad et al. 2017). De Man (2011) depicts the socio-economic nature of SDIs.

However, the current ENSDI definition is a modification form Douglas (1997), and considers people, data, metadata, technology, standards, institutional arrangements, and policies as the main building blocks. This research paper therefore bases these elements as unit of analysis for the assessment of the current status of ENSDI. The researcher analyzes and discusses the status quo of each ENSDI building block in separate section, each dedicated to one of these aspects.

The primary data about the identified building blocks were sorted and analyzed using descriptive statistics (frequency) using the software package SPSS 2.0. The information from on-site inspections was sorted too. Relevant information from the many reviewed document was extracted, sorted and interpreted by the researcher. The results are presented graphically, in diagrams, and in tabular form below.

3. RESULT AND DISCUSSION

The results are presented and discussed following the separation of the different ENSDI components: policy, data, metadata, technology, standards, people, and institutional arrangement.

3.1 Legal and Policy Component

This section focuses on the policy issues that were obtained from the literature review and the semi-structured interviews. The policy review addressed the following questions:

1) Do geospatial information and other related policies, strategies or laws exist?
2) Are these policies/laws are functional?
3) Have they an enabling or impeding impact on the geospatial industry in general, and on the access to and sharing of geospatial information in particular?
4) What are their major gaps as far as the geospatial industry is concerned?
5) Are they interoperable and free of conflict of interest?
6) What are the existing geospatial data access grant types and how is pricing condition?

3.1.1 Landscape of existing policies

On the bases of national geospatial policies (such as open data, space/earth observation and Global Navigation Satellite System - GNSS) and enabling policy frameworks (such as science and technology, or information and communication) Ethiopia ranks 49th out of 50 selected countries (Geo-Buiz, 2018). The Countries Geographical Readiness Index (CGRI) report mentions Ethiopia under aspirer countries, which do not have policies in areas such as national geospatial, surveying and mapping, GNSS, earth observation, and remote sensing and innovation, but acknowledges the existence of policies for information communication and technology (ICT), open data, unmanned aerial vehicles (UAV), and science and technology. However, some of the facts that were collected as part of our study contradict these statements of the CGRI-2018 report.

Policies such as Spatial Information and Technology (SIT), Space Science and Technology, Information Communication and Technology (ICT), Science, Technology and Innovation, and Open Data are available, with the limitations in their functionality. A UAV policy is indeed still in draft and not yet endorsed. Allied policies which could influence or could be influenced by the establishment of the

ENSDI (such as environment, water, and urban land management) also exist and are implemented. All of the aforementioned national and sectorial policies directly or indirectly demand the establishment and smooth implementation of the ENSDI. For example, the ICT policy 2009 incorporates almost all of the relevant components of an SDI, which is quite important for the development of ENSDI.

The Water policy endorsed in 2001 acknowledges the development of a data base and an information management system, which accelerate the access to and dissemination of water resource related information; and the significance of quality information as an input for the planning of water management.

The Urban Land Management policy, endorsed in 2003, pinpoints the necessity of assigning a mandated institution for the coordination of all geospatial information management activities. Meaning, it indirectly recommends the establishment of ENSDI. This policy also explicitly and widely acknowledges the value of geospatial information for urban land management, and it addresses some core SDI components such as standards and physical systems (Land Information System) for the access to and sharing of information related to the location, size, previous tender price, and transaction of land.

The National Science and Technology policy, endorsed in 2010, guarantees the significance of standards to ensure the harmonious management and operation of information resources, services and systems, as well as, the access to technological information. The creation of national information systems is recommended by firmly stressing the challenges caused by fragmented information handling, and the absence of easy access to information.

Ownership, security, awareness, human resource development, research and development, legal framework, coordination and cooperation, and access to geospatial information and technology are the core strategic focus of the National Spatial Information and Technology (NSIT) policy. It even recommends the establishment of a national spatial data infrastructure as part of its implementation strategy. However, as far as geospatial industry is concerned, the NSIT policy statement lacks a clear direction for the development of a geospatial information and technology governance model. Such a statement would be required to translate the elements of national geospatial policy initiatives into practices. The policy also fails to properly address the data policy and/or licensing issues that geospatial industry could follow i.e. whether open or restrictive data policy; and the constitutional content of security issue (privacy issue). As a consequence, the NSIT policy lacks the alignment with other related policy. The policy statement also lacks any monitoring and evaluation framework. Furthermore, following the policy title (National Spatial Information and Technology), the term geospatial is not defined well-enough, as it suggests an all-inclusive notion that spatial is a location which refers anything on the Earth, Moon, Mars, etc. (OGC,2010). For these reasons, the researcher sees an urgent need to update and clarify the definition in this particular policy.

The second priority is the Open Data policy. The rationale of the Open Data policy in Ethiopia follows a general need to facilitate the sharing and use of the large amounts of data generated and held by the government, as far as, evidence-based planning in concerned to steer socio-economic development. However, the Open Data policy applies only to all those government data that are in line with principles of open-by-default and published at the most granular level. Exceptions are accepted. In such cases, data may be classified as either “restricted data” or as “sensitive data”. Due to the absence of nationally agreed and publically disclosed data classification standards, it remains challenging to categorize and clearly label the existing geospatial data as open, sensitive, and restricted. Since its aim has close similarities to that of an NSDI – to facilitate access to and sharing of data so as to reduce duplication of effort and to increase the value of governmentally owned data - the Open Data policy could directly support ENSDI if it would be slightly modified and adopted.

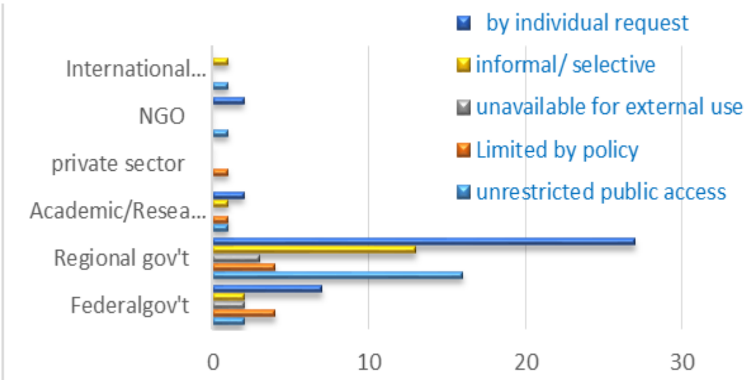
From this perspective, it is also important to consider the provision of the supreme law, the Federal Democratic Republic of Ethiopia (FDRE) constitution. Article 29 of the FDRE constitution guaranteed the right to obtain information about the activities of state organs and organs of local administration, meaning that access to information is guaranteed by the constitution. At the same time, the constitution protects privacy of persons, their home and correspondences, which is informed by the privacy provisions of the Universal Declaration of Human Rights (UDHR) and the International Covenant on Civil Political Rights (ICCPR) to which Ethiopia is a state party. Although the constitution acknowledges the protection of individual privacy, there is no clarity in privacy protection in a case when information is collected in digital format and can easily be copied and exchanged. We also miss any clear and explicit statement about the geospatial aspects of privacy.

The Government of the Federal Democratic Republic of Ethiopia has also put in place laws and legislation which are emanated from FDRE constitution to promote access to online data and information. These include Freedom of the Mass Media and Access to Information (Proclamation No. 590/2008); the National Data Protection Law, E-commerce Law, Computer Misuses and Cybercrime Law and the E-signature Law. The enactment of these laws provides for the availability of data in open formats while safeguarding the privacy and security of institutions and individuals.

3.1.2 Existing geospatial data access grant type and pricing conditions: a link to policy implementation

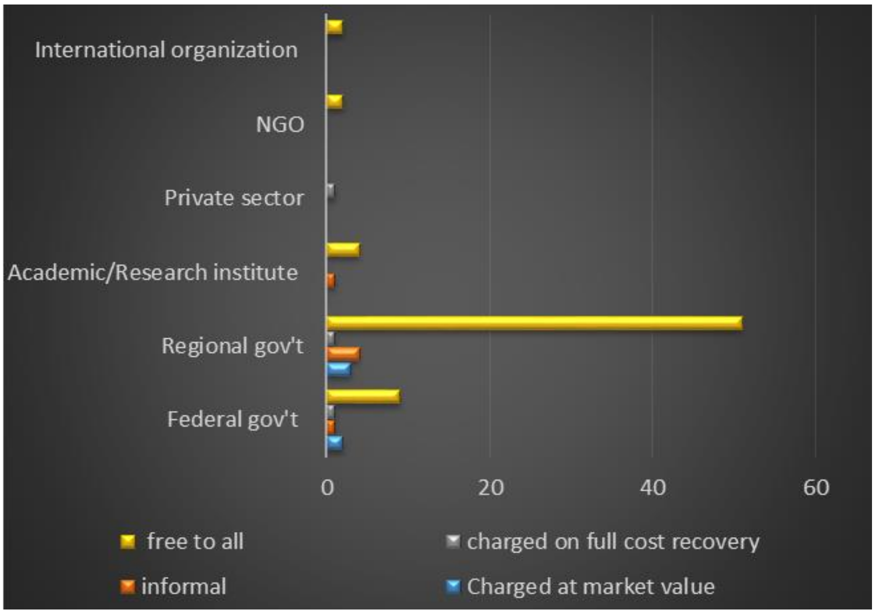
Some other policy issues obtained from the analysis result of the data captured by semi-structured interview includes geospatial data access grant type (Figure 2), and pricing issues (Figure 3).

Figure 2. Geospatial data access grant type



In Ethiopia, geospatial data access and/or sharing is granted in various ways. 42% of the examined organizations shared their geospatial data holdings whenever there is an individual request by official letter. 23% of the organizations release their geospatial data holdings for the public without any kind of restriction and promote the open data policy. And 18.6% of the organizations make their geospatial data holdings accessible informally and/or selectively (18.6%). On the other side, 5.5 % of respondent organizations do not make their data available for external use. The remaining 11% of organizations shared their data in accordance with their institutional directives and organizational operational policies, which address topics, related to the lifecycle of geospatial data and help to facilitate access to and use of geospatial information (e.g., guidelines and manuals dealing with data collection, management, or dissemination and use). Organization such as Abay Basin (working on draft data and information sharing protocols), Agricultural Transformation Agency (working on data sharing guide lines, on progress), Amhara Rural Land Administration bureau, and Meteorological Agency (working on service charge policy) do take considerable efforts, but it still needs teaming up and agreement in order to streamline this into a single common national activity.

Figure 3. Existing pricing mechanism



Following what was described in the Open Data policy review section, the leverage of the easy discovery and accessibility of geospatial data is neglected and unknown, and access is often granted with lots of administrative or bureaucratic overhead. Hence, there is little (almost no) geospatial data in a machine-readable format that is publicly available under an open license, which would ensure that the data can be freely used, reused and redistributed by anyone for any legal purpose.

As far as pricing issues are concerned, 83% of the participating organizations shared their geospatial data holdings on free to all bases (unrestricted provision of geospatial data holdings for all without fee) while few organizations shared their data by charging on full cost recovery bases (4%). Here, sharing of geospatial data holdings is realized if and only if the cost incurred for geospatial data production and processing is fully covered by those organizations that are in demand of it. And some other does not have formal pricing policy; they just share their holdings informally (7%). Around 6% of sampled organization shared their holdings by charging at market value (see also Figure 3). In this respect, the absence of formal pricing policy hinders both the seller/providers and the users/consumers. There is a danger that this could seriously lower the value of the available geospatial data in particular and the role of the geospatial industryin the country's gross domestic product (GDP) in general.

3.2 Institutional Arrangement

Institutional arrangement is the mechanism created to enable key stakeholders to collaborate and engage actively in the planning and implementation of NSDI. It includes the governance and business model, and an operational architecture created to facilitate the sharing and accessibility of geospatial information. Institutional arrangement - though it is not an easy deal as it includes policy, financial and political issues (Woldai, 2002) - provides an instrument that governments can used to facilitate institutionalization. Institutionalization refers to formal and informal structures that aim to enhance, frame or regulate the voluntary or forced alignment of tasks and efforts of organization in the pursuit of geospatial information management. Institutionalization would be thus realized through structural instrument such as (1) establishment of coordinating function or entities; (2) reshuffling competencies; (3) establishment of entities for collective decision making; (4) establishment of systems for information exchange; (5) creating regulated market; (6) establishment of legal frame works; and (7) partnership. These instruments are used to create greater coherency and to reduce redundancy, lacunae and contradictions with and between policies, implementation and management (Bouckaert and Verhoest, 2010 - cited in UNGGIM, 2017).

This section therefore focused on demonstrating the status of structured based institutionalization at first, and then communicating grounded facts on fragmentation of tasks and the subsequent effort duplication with the emphasis on geospatial information management due to the absence of coherent effort coordination mechanisms.

3.2.1 Status of Geospatial Information Management Institutionalization

Most institutionalization structural instruments specified by Bouckaert and Verhoest (2010) have been observed in the geospatial industry in Ethiopia in unorganized manner. These efforts are discussed separately in the following sequential paragraphs.

Establishment of Partnership*:* Partnership created on the bases of mutual inter-dependence such as Environmental and Natural Metadata Data base (ENRAMED), E-EIN (Ethiopian Environmental Information Network), the former Ethiopian National Spatial Data Infrastructure (ENSDI) under Ethiopian Mapping

Agency were some of unsuccessful partnership based efforts to make geospatial information management tasks aligned (Gelagay, 2017).What is more here is only government to government (G2G) partnership efforts were exercised irrespective of the private and other business sectors.

Establishment of Coordinating Entities: ENSDI coordination center established under Information Network Security Agency (INSA) based on the role given by proclamation no 808/2013 is under progress to bring together efforts of all stakeholders in the geospatial industry. However, the role given to INSA to coordinate the establishment of ENSDI – geospatial information management activities – in an inter-organizational system is now challenged by the hierarchical authority and power imbalance between coordinator (INSA) and coordinated organization. The coordination center is now therefore deprived off from getting the full support of the government in general and from concerned organization in particular. Although this problem is manifested in many ways, the absence of budget allocated for coordination and/or establishing ENSDI is a central point.

Establishment of entities for collective decision making: The national spatial information and technology policy (endorsed in 2016) statement clearly indicates the necessities of establishing councils consisting of senior officials of different organizations belonging to the policy domain of geospatial information management in order to collectively set out strategy, and control its implementation. Following the policy statement, the need of establishing council is clearly indicated in the draft organizational structure. However, entities for collective decision making in the geospatial industry is not yet established.

Establishment of legal frame works*:* As stated by (idem), coordination of geospatial information management activities could be brought through the preparation of legal frame works. However, in Ethiopia, little efforts have been invested on the adoption of some ISO-TC2011 geo-informatics standards and endorsement of the National Spatial Information and Technology Policy (NSITP) though there is a limitation to make them workable. Hence, it is now impossible to ensure that data are produced once in accordance with standards as per the policy stated and used many times, and wastage of resources is the common interface of Ethiopian geospatial industry.

Creating regulated market*:* The institutional arrangement of tasks and activities associated with geospatial information system by different organizations could also be done through mechanisms of creating regulated market, offer and demand. In this regard due to the embryonic stage of the industry, there is no clearly stated market created by government so as to facilitate coordination of efforts.

Reshuffling competencies: The other issue is alignment of geospatial related tasks through creating new or changing the existing institutional forms either by merging organization with similar tasks or completely separating them from other with different tasks. In this regard, most socio-economic developmental problems in developing country Ethiopia are institutional in nature, and this problem is also going to the absence of effort coordination in the geospatial industry alike. However, as Getinet (2003) organizations in Ethiopia are established by proclamation, and providing reliable and timely geospatial information are challenged by mandate and right inscribed in the proclamation (mission). Coordination among organization to formulate geospatial information policy, and exchange information does not exist; and different organizations collect / create data, in isolation and/or ad hoc manner. And because of lack of good communication among organization, and mandate and role overlap is common.

The mandate conflict between INSA and the former EMA for sharing and administering geospatial information at national level was the good manifestation. Due to this mandate overlap, ENDSI has long been suffered from being realized. In understanding of the aforementioned mandate overlap, mission re-orientation and /or reshuffling competencies between EMA and INSA has been done as part of the reform done by Ethiopian government and the geospatial wing from INSA and EMA has been merged and now established as Ethiopian Geo-Spatial Information Institute by regulation number,440/2018 (FNG,2018).

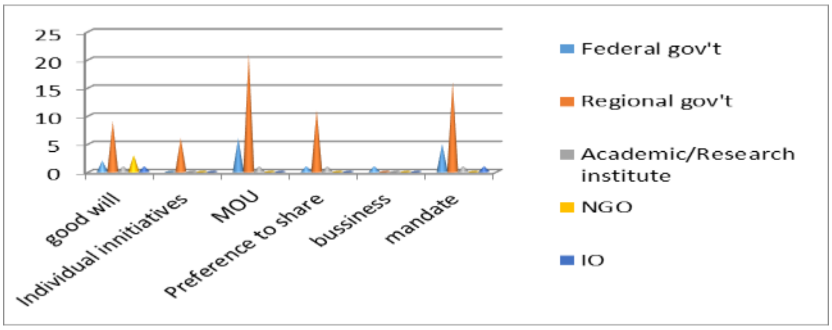
The absence of membership based organization/association representing the local geospatial industry, institution, and professionals across industry segments to advocate and represent their interest; and very few international membership networks are also assured by the Geo-Buize (2018) report.

Establishment of information flow and exchange system*:* The last but not least structural national institutional instrument observed was an attempt done to coordinate information flow and exchange through national information system. In this respect, deployment of national geo-portal in some selected organization such as Biodiversity institute of Ethiopia was done with the focus on the ICT system while the case demands equal attention on the information content of the information system.

Rajabafared and Williamson (2001) define governance - as part of cooperation - includes agreements and geospatial resources (what) in addition to people situated within organizations (who), linked together through governance mechanisms (how). It is thus worthy to address geospatial data sharing rational, governance mechanism, and culture across organization as far as institutionalization and /or governance is apprehensive.

Geospatial data sharing in most of the regional and federal government is because of memorandum of understanding (MOU) (32.2%), followed by mandate (26%) and preference to share (14.5%). Good will (18.4%) is the basic geospatial data sharing rational at all sampled organizational category. Organizations who understand geospatial data as public asset that needs to be shared for people, share their data holding by their good will without any enforcing rules or affiliation (Figure 4).

Figure 4. Geospatial data sharing rational across organization



3.2.2 Observed fragmentation of tasks and the subsequent effort duplication with the emphasis on geospatial information management

Due to the absence of governance model, business model, and operational architecture, and poor institutional arrangements, bringing satisfactory collaboration in the course of planning and developing ENSDI is still challenging. Information silos and effort duplication are therefore common (Getinet,2002; and Gelagay, 2017). Similarly, the finding of this study assured that geospatial information is being generated by various organizations in a fragmented and uncoordinated manner (Table1, and Figure 5).

As shown in Table1, around 85 organizations are engaged in primary geospatial data collection, analysis and processing. It means that many actors are engaged in data production, and many organizations attempt to develop their own datasets (see also Figure 5) beyond their expertise. The main issues are that: 1) these actors do not know the available data sets that could be appropriate for their application; and 2) the existing geospatial data are simply not accessible.

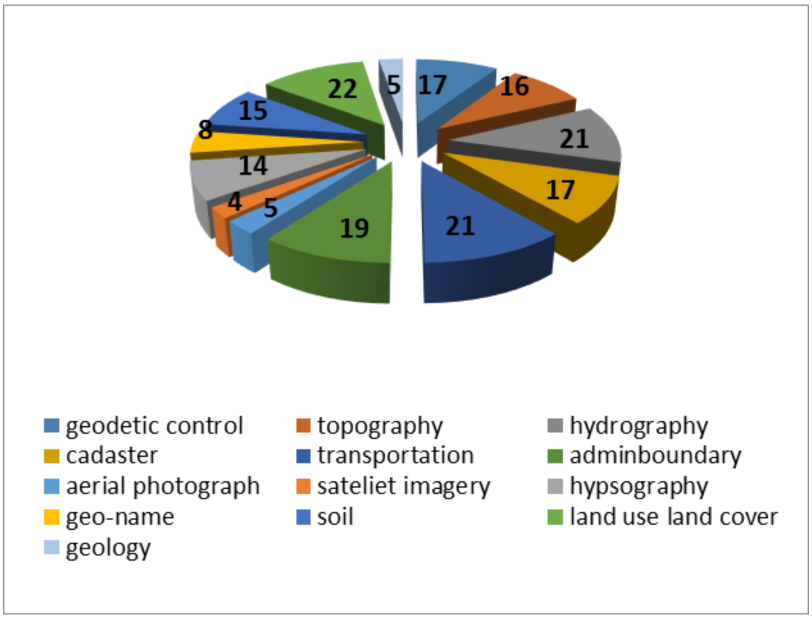
Table 1. Duplication of organizations effort in Geospatial – Information Management activities

		Responses	
		N	*%*
Management activities [a]	*Primary data collection*	*85*	*24.6*
	Secondary data collection	*72*	*20.8*
	Data analysis and processing	*84*	*24.3*
	data storage	*44*	*12.7*
	dissemination	*61*	*17.6*
Total		*346*	*100.0*

The toughest thing here is the difficulty to have single reliable version of each data set. For examples, 22 organizations tried to collect land use land cover data, which is very hard to identify the right data with its right custody.

The absence of governance so that lack of clear role and responsibility among organization in the geospatial industry is the underline causes for the difficulties to know the right distributor, the right data, and the body that is responsible for the misleading information. The case for land use and land cover, hydrography, soil, road network, hypsography, and topography data is the clear manifestation, and there is no responsible body for the production, management, and dissemination of such data sets. Hoping that this issue will be answered by the future ENSDI governance model, effort coordination in the geospatial industry at regional level is in demand so as to reduce the duplication of efforts across organization, to exploit the available efforts on data management, and to strengthen the ENSDI network. This in turn requests the clarity of hierarchical development of ENSDI. Because ENSDI should not be advocated only at the national level (strategic level) rather it should also focus at regional and local level (operational level).

Figure 5. Number of organization engaged in geospatial data management vs data set types: redundancy of efforts



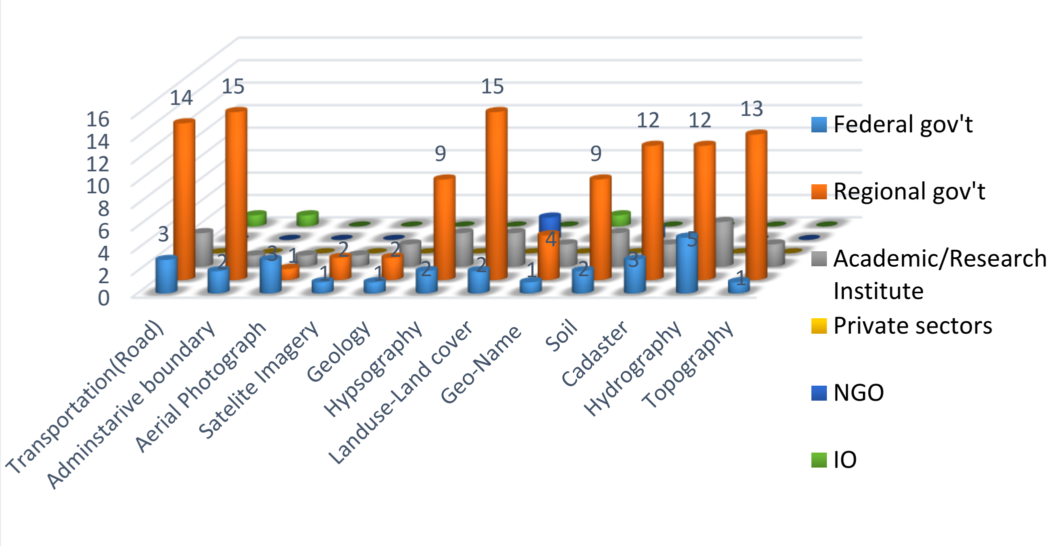
3.3 Geospatial Data, Metadata

This part attempted to answer question such as:

1) What is available and what is not?
2) Are the available data accessible?
3) Is there sufficient documentation (metadata)?
4) In what way geospatial data are stored and what is a grounded problem in this regard?
5) How is the development and updating trend of our legacy data sets? and
6) How is the usability of the available geospatial data sets?

Data availability: Census, meteorological, road network, administrative boundary, aerial photograph, satellite imagery, geology, hypsography, land use land cover, soil, cadaster, hydrography, and topography data are available in digital form. As shown in Figure 6 below, more data are available at regional organization level followed by federal organization. It means that regional organizations are more operational than the other and could serve fundamentally through the provision of spatial data needed by ENSDI.

Figure 6. The available geospatial data sets, and where they are available



What is important here is answering what is not available while it is highly demanded by the vast majority of the GIS community. In this regard, geographic name and utility data sets are not available. Besides these two data sets, high resolution imagery, dispute free authoritative administrative boundary, high resolution meteorological datasets are highly demanded to be avail for users due to the fact that the existing version of these data sets are vetted by the users and labeled as unfit for use.

Accessibility of the available data sets: The readiness of data for sharing (digital in form, quality, existence of metadata, well stored in an organized manner); and the availability of agreeable sharing platform/ mechanism and regulatory frame works potentially expedite the data available to be accessible. Though most of the geospatial data sets are available in their digital form (33% GIS coverage and shape file, 22% in imagery form, and 13 % are in an organized data base), this study confirmed that data available are not accessible and are not used beyond their first intended purpose due to the absence of data sharing policy, legal frame works, and good sharing mechanism.

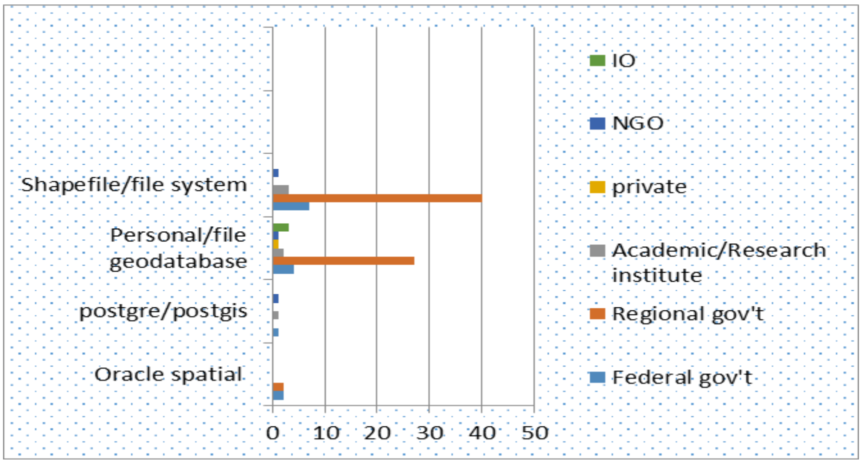
Satellite imagery for census purpose at the Central Statistical Agency, Aerial photograph (1.8 terabyte) and hypsography (DEM, DTM) data at the Geospatial Spatial Information Institute for cadaster purpose, and soil data at the Agricultural Transformation Agency (ATA) are some of the available but not accessible data sets due to the aforementioned issues. All of these datasets do have the potential to be used by researchers and businesses for new applications that go beyond the original intent. For example, they could be used for applications in the environmental sector, utilities, emergency response, homeland security and many others.

Geospatial data storage mechanism across organizations: Web-based accessibility of the available data sets depends on the storage structure (Shekharand Chawla, 2003). Spatial Database Management Systems (SDBMS) provide storage structures and basic operations for spatial data manipulation. However, this study found that most of the geospatial data at regional and federal governments stored in folder in local disk as a shape file followed by ESRI Arc GIS file and personal geospatial database (Figure 7). Very little efforts were observed by few sampled organizations to store geospatial data holdings by spatially enabled relational data base. It meant that, it is impossible to fully exploit the spatially enabling data base (Postgre/Postgis, Oracle Spatial) provision of well-organized data structure such as better integration of disparate data; new spatially enabled analysis; reduced decision cycle time and improved decision. The predominance of file based geospatial data storage - which is often even restricted to an individual personal computer - made it impossible to know the amount and size of the data sets housed by each sampled organization.

Furthermore, the reliance of most organization on proprietary data model using commercial soft wares produced by the high tech giant, and poor culture of using standards, Open Geospatial Consortium (OGC) and International Standardization Organization (ISO), defies the organization and storage of geospatial data in an interoperable manner.

In general, storing spatial data centrally in a structured manner is uncommon in all most all of the sampled organization. This is due to (1) poor technical capability; (2) poor attention especially for spatial data base management system, and (3) absence of high performing storage facilities.

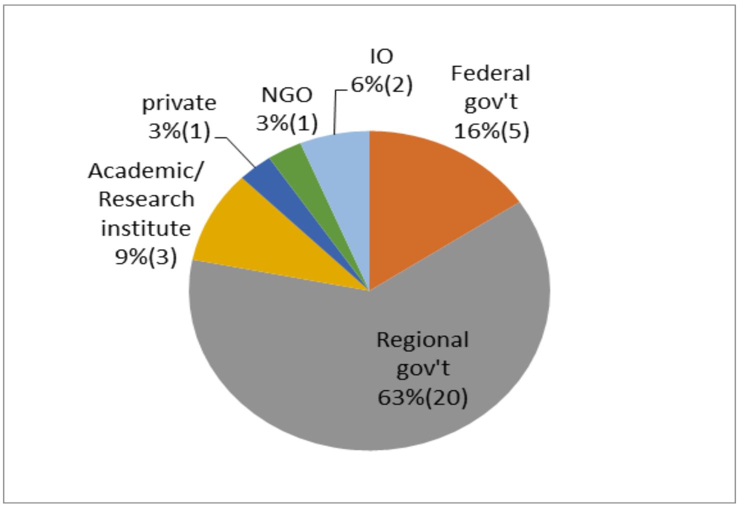
Figure 7. Geospatial data storage mechanisms



Geospatial data development and updating trend: Updating of legacy data sets was not observed. This lack of practice might be due to the absence of governance and/or legal frameworks to either punish or reward organization's geospatial related activities, as well as the lack of clearly defined mandated organization. Absence of updating is especially disastrous for administrative boundary for the reason that: (1) It is one of the core data, widely used for any business, and serve as a reference; (2) ever increasing number of new districts being created, and lower level units such as woreda and kebele been steadily increasing; and (3) even the legacy one still has no clearly defined boundary and needs political saying. It is now therefore a sensitive and hot issue for every GIS community due to the fact that information generated through overlay analysis of multiple data sets taking administrative data as a base is totally misleading and irrelevant. Absence of regular updating would also be dangerous for soil data produced by Agricultural Transformation Agency (ATA) which is approaching to be wasted due to the fact that the biological and chemical properties of soil are ever changing so that soil data require regular updating. This data covering the national geospatial coverage collected for the last 4 years is still withhold by ATA, Bear in mind that such data sets are purchased or produced by exploiting the country's limited dollar account and are public goods which needs to be shared and serve the public. This problem should therefore be well communicated by the concerned body so as to get the government attention.

Metadata documentation status: The sufficient documentation (metadata) of geospatial data sets is an uncompromised requirement for any SDI. Every SDI includes a catalog holding a metadata record about each the available geospatial data set and services**.** These records entail an index and make use of dedicated vocabularies against which intelligent geospatial search can be performed. By creating metadata records and sharing them with others, information about existing geospatial data set becomes readily available to anyone seeking it, makes data discovery easier, and reduces data duplication (ESRI, 2002). Still, so many efforts invested here and there to produce various kinds of geospatial data at various sectors of Ethiopia are neglecting the significance of standards and metadata describing the content of the data. Organizations (20 regionals, and 5 federal governments) who responded as if they do have a metadata for their data holding is just a trial and is not much more descriptive. There are no well-organized catalogs that describe and reference geographic information set about the scale, source, accuracy, projection, resolution, and its reliability with regard to some standards.

Figure 8. Number of organization with metadata for their data holding

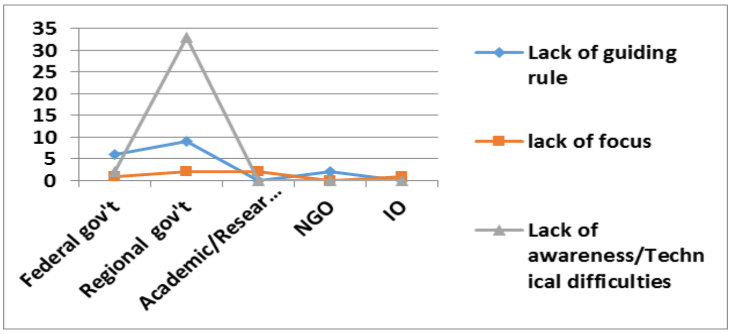


Lack of awareness and/ or technical difficulties (60%), lack of guiding rule or standards (33%of respondents), and lack of focus (7%) (Figure 9) are the primary reasons for the absence of metadata about the available data. Similar to the finding of this study, CGRI_2018 report characterized Ethiopia's geospatial data infrastructure by:

1) low quality scale of the available thematic layer usually ranges from 1:40,000 to 1: 250,000 or above;
2) poor and/or zero data updating frequency;

3) conservative and restricted geospatial data sharing, and inter and intra-data linkages are not encouraged, and data dissemination is still limited to traditional methods (CD/DVD, FTP); and
4) negligence of the importance of realizing standard.

Figure 9. Basic rationale for the absence of metadata documentation



3.4 Standards

Standard is a documented agreement between providers and consumers established by consensus, that provides rules, guidelines, or characteristics ensuring materials, products, and services are fit for purpose (UNGGIM, 2015). Without standards, SDI is unthinkable (Geospatial World, 2010). This part therefore focused on geospatial standards, which encompasses geospatial data development, production, management, discovery, access, sharing, visualization, and analysis[3] and in sum can be generalized as information (content) and technology (service) standards, and in this study more attention is given for information and /or content standard the so called information/data modeling so as to assess the readiness of legacy geospatial data set for seamless sharing, exchanging and usage.

In this regard, though some ISO-TC2011 geo-informatics standards have been adopted by Ethiopian standardization agency: the production, development and management of geospatial data in 63% of respondent organization (mostly federal and regional government) did not comply with these standards, and only 13% and 5% of sampled organization's geospatial data sets conformed with ISO and FGDC standards respectively (Figure10). The Amhara Design and Supervision work Agency (soil data), and the Land Administration Domain Model (LADM) by the Ministry of Urban and Housing Development should be mentioned for developing

[3] http://www.nrcan.gc.ca/earth-sciences/geomatics/canadas-spatial-data-infrastructure/8902

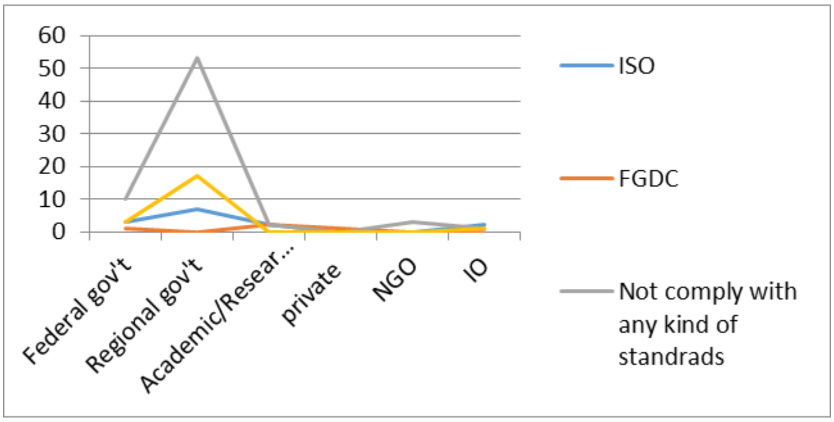
their data in accordance with ISO –TC211 geo-informatics standards - although with limitation. The remaining 19 % of organizations such as the Abay basin Authority, the Agricultural Transformation Agency, and the Meteorological Agency, did attempt to developed their geospatial data holdings in accordance with some specific standards such as IHO, FAO, WMO standards, but did not take geospatial informatics standards into account (for location and other spatial aspects).

(Open) Geospatial standards are rarely used due to a lack of understanding of the significance of a standard-based approach and a lack of knowledge and experience in information modeling and standards implementation. Accordingly many organizations still rely on proprietary geospatial information and technology, and continue to create silos of information users. And absence of open culture associated with the infancy-ness of the geospatial industry is the underline causes.

As a result, for a single thematic data, it is uncommon to find standardized geospatial data definition (geometry and the associated characteristics (attribute)) and is quite different across organization. Storing different attributes and calls them by different names, and different numbers of attribute (some have just a few attributes, others have long lists) for single geospatial data by different organization is common. It implies that such data sets are not discoverable, accessible, interoperable, and in total are not ready for exchange and sharing. Their fitness for use is thus in question, and is very difficult to find the truth data fitted for the purpose.

Noting the importance of standard to create, reproduce, update, and maintain geospatial data and services in a consistent and interoperable manner; and to promote sharing of geospatial data that may include guidance on expected structure, definition, repeatability and condition of elements, huge investment on standardization is highly in demand for the success full development and implementation of ENSDI.

Figure 10. Compliance of organization's legacy geospatial data to standards



3.5 Technology

The technological component of SDI includes hardware, software, physical communication networks, databases, technical implementation plans/procedure, architectures and standards (Douglas, 1997). This technological infrastructure provides a platform for collecting, storing, accessing, sharing, analyzing and usage of geospatial data. All components of SDI are influenced by technology with all the geospatial technologies having an influence in one way or another on SDI development. It has also important influencing factors on the evolving SDI concepts. Nedovic et al. (2006) argue that ICT and information infrastructure potentially enables GIS and SDI by providing generic technological bases; on the other side GIS and SDI offer important content to ICT and Information Infrastructure.

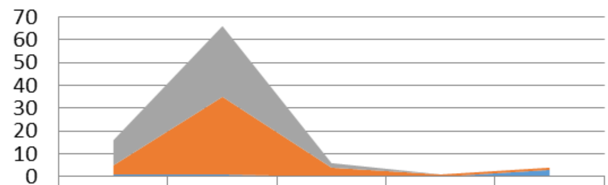
This part of the analysis therefore assessed the status of the available information infrastructure (delivery platforms and interconnected systems, internet and wireless application, and Data Base Management Systems, and Sservers), and GIS (Geospatial Information System, spatial analytics capabilities, GIS technologies).

A country's capacity and capability in Information Communication Technology (ICT) is the basic determinants for the development and effectiveness of SDI, and the Internet is the most influential category of ICT, making significant economic and social impact (Wheeler et al., 2000). The possibilities to query, retrieve, process, and analyze information obtained via the internet have galvanized the interest of both data users and producers. SDI is meant to interconnect users GIS nodes across the internet (in many cases over secured networks),and as

(Williamson et al.,2003) internet is the revolutionizing methods of maintaining, disseminating, and accessing spatial data base. The availability and bandwidth of internet is therefore the key technological component of SDI to promote the access and sharing spatial data holdings.

In this regard, this assessment tried to address the status quo of internet bandwidth. 54 % of organizations do have a cable, and the rest 46% do have a wireless connection. The overall working condition of internet across the country is too poor (Figure 11) with a mean of 33Mbs, and is unimaginable to realize easy and quick access of voluminous geospatial data. Because, geospatial data especially imagery demands long downloading time unless there is good internet speed. This is due to the fact that geospatial data are unique by their structure and volumes; they are also interrelated and often very large.

Figure 11. Internet working condition across organization



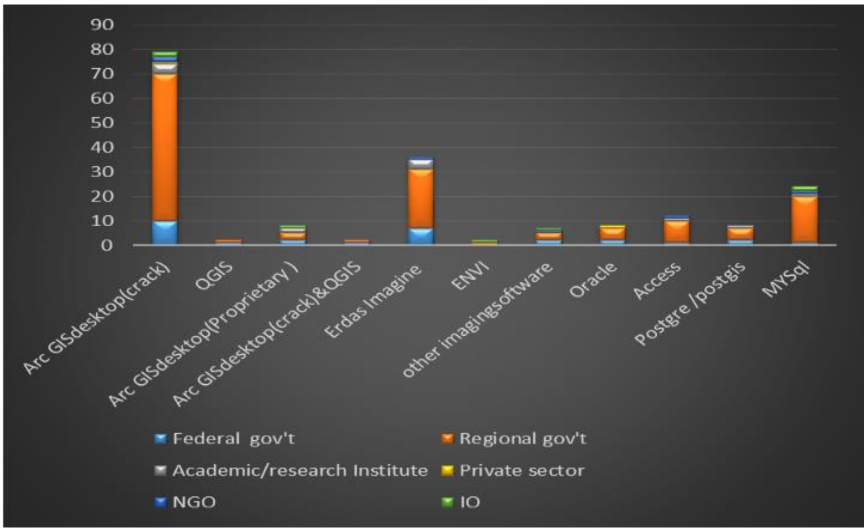
	Federal gov't	Regional gov't	Academic /Research institute	private	NGO
Poor	11	31	2	0	0
Good	4	34	4	1	1
Excellent	1	1	0	0	3

Georgiadou et al (2005) argue that SDI requires strong GIS installed base. In this respect, the researcher tried to assess the GIS technology such as GNSS and positioning, GIS and spatial analytics, Earth Observation and 3D scanning (Lidar, RADAR, and LaserJet), and the spatial analytics separately.

GIS technology: Ethiopia is a novice in geospatial technology such as Earth observation (under development), and 3D scanning technologies, and we do not have our own GNSS and position system and relies on the USA's positioning system. This study confirms that, positioning instruments such as hand held (widely used) and differential global positioning system are available and widely used in many of interviewed organization to collect location information.

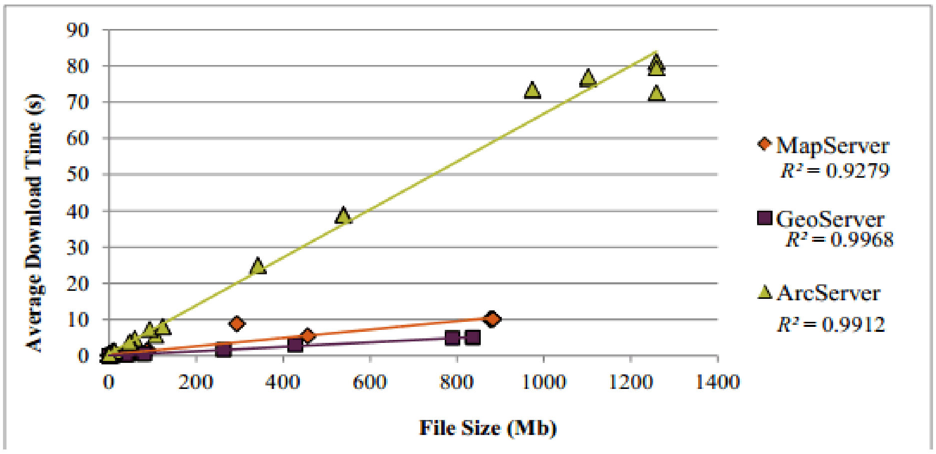
Geospatial Information System/spatial analytics capabilities: this segment can be avail to users as software's in the form of desktop which runs in the personal computer, web/cloud GIS which allows the user to use the software on cloud; and mobile GIS which enables users to use GIS on smart phone and tablets. Arc GIS desktop (crack), ERDAS Imagine and My SQL are the most widely used desktop GIS and DBMS software's used across organization at different level (Figure 12).

Figure 12. GIS and DBMS software across organization



Available Open Source software's are compliant to open standards such as the OGC and ISO 1900 series, and it is not limited to specific data models. In this way it can be used to promote data integration and interoperability - more than proprietary software. It was also proven that open solutions perform relatively good in terms of the average download times for geospatial data, for example, for the OGC Web Feature Service - WFS (Bauer, 2012). Bauer (2012) also compared three web mapping application and GIS desktop clients: Map Server and Geo-Server (open source category), and ArcGIS for server (proprietary) to demonstrate the feasible one in terms of down loading time. He found that open source web mapping servers are efficient and less time consuming than proprietary one to download the physical geospatial data (Figure 13). The download time for web feature service request created by ArcGIS server is larger than those created by Map server and Geo-server. On the reverse, the average download time for Geo-server WFS request is too much less compared to ARC GIS server.

Figure 13. A comparison of average downloading time for WFS request to open source and proprietary web applications (adopted from Bauer, 2012)



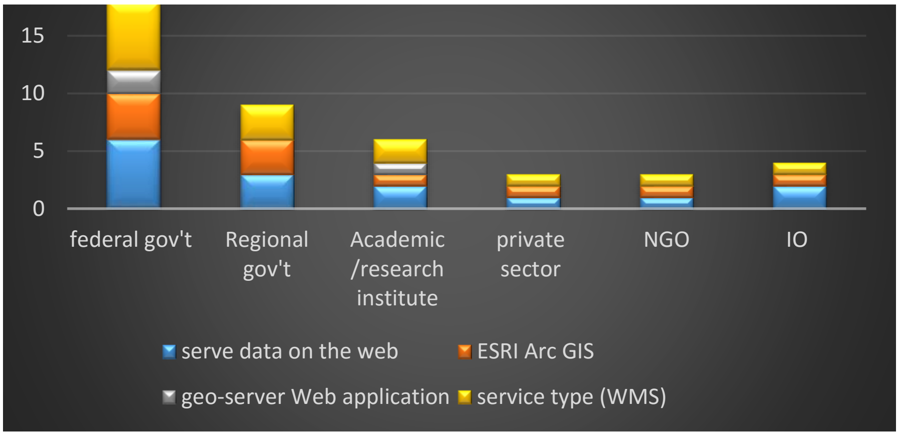
However, this study assured that the trend of using open software in Ethiopia is limited. All most all of our legacy data sets are produced using proprietary software's (Arc GIS) and the data models used are also limited to this proprietary software (e.g. ESRI Arc GIS data models of shape file, TIN, coverage, recently geospatial data) so that are not ready for sharing in an interoperable manner.

The other technological issue considered in this part includes (1) interconnected systems, and (2) delivery platform. As far as delivery platform is concerned, a beta version of the Ethiopian National Open Data Portal[4] has been developed. Individual government departments, ministries and agencies are publishing data on their respective websites although predominantly in an ad hoc manner. Meaning, there is an attempt to serve geospatial data on the web using different web mapping application across organization ranging from simple FTP site to web mapping services to real time data provision. For example, organizations such as International Livestock Research Institute (ILRI), data are stored in the cloud. Organizations such as Water and Land Resource Center (Ethio-GIS data); and Economic Commission of Africa do have their own geo-portal and are providing both value added geospatial products and physical geospatial data. And some others organization such as the Ministry of Forest Environment and Climate Change, Geo-mark (internal use only), Oromia Forest and Wild Life Bureau, and Agricultural Transformation Agency (soil data) are attempted to serve and/ or advert their product on their official web using simple FTP data transfer protocols.

[4] http://www.data.gov.et

Whereas Abay basin/Tana basin provides hydrologic real time data (such as stream flow, water surface elevation, and water quality concentration) using CUAHSI-HIS software for storing, analyzing and editing and internet based sharing of hydrological time-series data.

Figure 14.Organizations with trial to serve data on the web, and the web application and service type they used



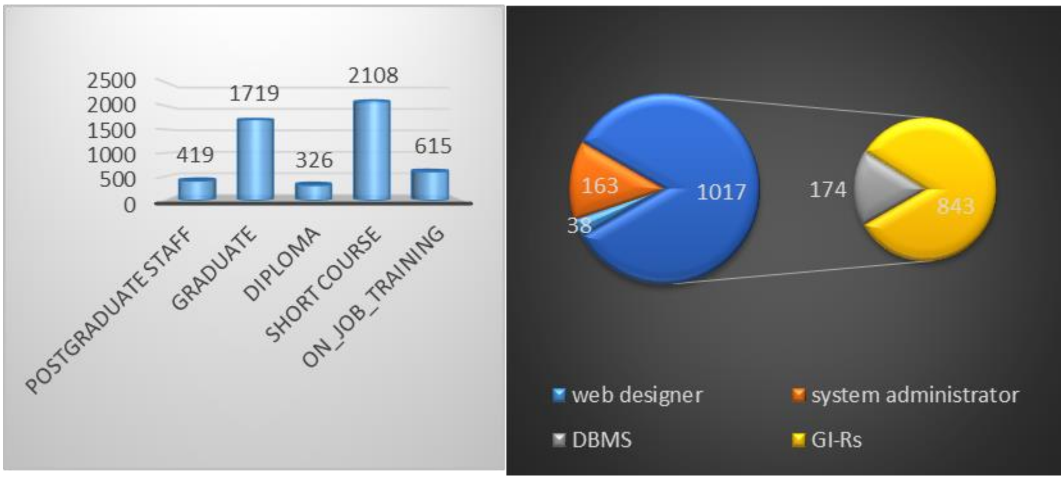
3.6 People

People in this aspect are considered as stakeholders that either affect the NSDI or are affected by it (adapted from Interoperability Clearinghouse 2006). People play different roles in NSDI development, with implications on the required spatial information and technology skills, awareness, capacity, and professional development (Georgiadou, 2009; Douglas, 1997). Geospatial data management and digital geospatial data sharing depends not only on technology but also on people as SDI dynamism is driven by the dynamic shift in people's attitude (Williamson et al., 2003). The focus of this part was thus focused on the assessment of the organizations employee, professional development and capacity building both in GIS and remote sensing, and in ICT across the country, and the roles of actors in the general geospatial industry alike.

Often forgotten but extremely important stakeholder groups are the employees in one's organization ("The SDI handbook for Africa. Chapter Three: Geospatial Data Needs Assessment," n.d.). Thus this section tried to assess the status of GIS, Remote Sensing (RS) and ICT employee of sampled organization.

Most GIS and Remote Sensing (RS) positions are occupied by geographers, land administration, and environmental experts who take GIS and RS courses in short-term (2108) and in the form of on –job training (615) (Figure 15). Though few GIS and RS positions are occupied by specialized staffs, we confirmed that GIS and RS specialist are not working on GIS and remote sensing tasks (as advertised in their job description). They rather serve as forester, land use planner, and soil experts and so forth. This shows how infant the application of GIS and RS is, and how far the GIS and RS profession is biased.

Figure 15. Number of staffs by qualification level(left), and by qualification type (right)



As far as professional development is concerned, only four universities such as Mekele (geo-information science and earth observation, MSC); Adama (Geodesy, MSc, and Geomatics engineering, BSc); Bahir Dar (Geo-Information System, MSc); Addis Ababa university (GIS and RS, MSc) provides geospatial information system related courses both at graduate (BSc) and postgraduate (MSc) level. However, these programs in most of the aforementioned universities are either under the domain of department of geography and environmental studies or geology, so that Spatial Data Base Management System and essential programing language courses are given as elective course (weak attention on geo-informatics) plus graduate students in this program are good enough in theory and bad enough in practice (are not thus good practitioners). Furthermore, Spatial Data Infrastructure is not provided as a course in any of the aforementioned universities. In the GIS courses in all of the above universities, little is said about metadata. In total, the geospatial applications are still not considered far beyond mapping exercises.

The assessment revealed three issues concerning employee and professional development in ICT. First professional development in this sector was found to be limited that only first degree (1719) and diploma (326) graduate were observed, and no specialization beyond first degree were observed in this sector. Second, the job title in most of sampled organization is generalized as ICT and most experts at the ICT position serve as simply as a maintenance expert sometimes as a clerk. Hence, very few web designer (38), system administrator (163) and DBMS (174) experts were observed. Third, some of them who are at ICT position are specialized in management and assigned as information experts- the profession is biased here as a case for GIS and RS profession.

Noting the developments in ICT and location based initiatives in general and immediate demand from ENSDI development, skill gaps in the ICT and geo-informatics specifically on the area of web GIS, data modeling, spatial data base management system, image processing, and programing were assessed (Table 2). Human resource development is therefore, a challenge that needs to be addressed as a matter of urgency.

Table 2. Observed skill gaps both in ICT a and GIS

		Responses	
		N	***Percent***
Skill gaps	***Web GIS***	***61***	***31.1%***
	Data modeling	***33***	***16.8%***
	programing	***51***	***26.0%***
	Image processing	***51***	***26.0%***
Total		***196***	***100.0%***

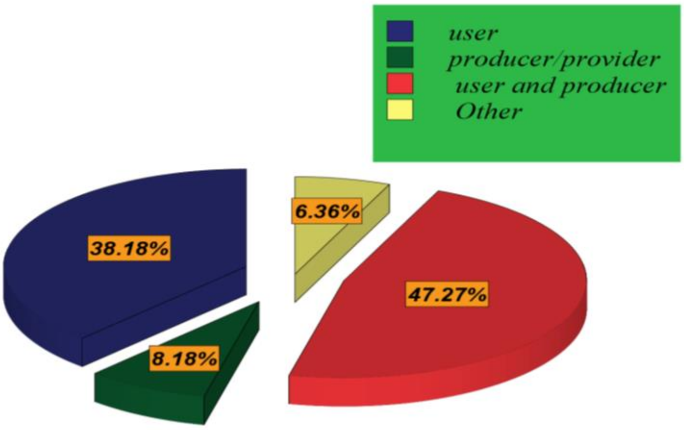
As Box and Rajabifard (2005) it is important to know the roles of people (stakeholders) they could play in the development of NSDI so as to identify their mandate, and potential influence that stake holders are likely to have. Hence, an attempt was made to note what roles each sampled organization play in the current geospatial industry.

Hence, organizations based on their role in the geospatial industry in general and in the development ENSDI in particular, a draft on ENSDI policy, are categorized in to end user[5], provider/supplier[6], regulator/enabler[7], marketer/value adder[8] (modified from Geo Connections, 2007a). A majority of the surveyed organization (47) are under producer and users segment. On the other side, 38 % respondent organizations are end user. 8 % of organization do have a provider role in the industry and are providing their data for the end user, and are thus the key actors in the development of ENSDI (Figure 16). The remaining 6% of organizations play a broker or marketer (add value, sell or promote application and information), and enabler / regulator (facilitation, coordination, and financial support) role in the industry. Most of the private sectors are now engaged in the industry as value adder, and as broker for the provision of commercial product (data, and software's), and still they do not have their own product, and their role is still ill defined as a result they are passive in activity.

What we have to bear in mind here is that, the roles and responsibilities of organization in the geospatial industry are not clearly identified and seated; the types of data they care (custody) and/or produce are not well identified and regulated. Role and responsibility overlap is thus common, efforts are duplicated, and resources are wasted here and there in the country.

[5] Use geospatial data in decision-making or in business operations and rely on applications to produce usable outputs.
[6] Provide geospatial data and Web services to the SDI. They are at the core of the SDI, providing the building blocks necessary to develop geospatial applications.
[7] Actors who can support the ENSDI establishment and building through providing program facilitation, financial support, coordination, or facilitate the use of geospatial information by a larger group.
[8] Add value to the geospatial information and Sell or otherwise promote geospatial applications and information to end users.

Figure 16. Roles of stakeholder in the geospatial industry



4. CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

Knowing the pre-intervention status of the ENSDI framework is valuable to clearly identify the potential, constraints, threats, and strengths in respect of each building block. The result of this study clearly shows the areas of urgent investment, and gives a general direction for the design of new and modification of the existing development strategies and policies, and to design development approach and models. The impact specifically goes for those who are on the chair to lead the program, and coordinating and bringing together efforts of stakeholders. It also clearly shows stakeholders effort and operational capacity specific to each building blocks of the platform (SDI) so that they can evaluate themselves whether they can be a node or not; can they value their data holding by sharing reliable , quality, and timely geospatial data using the platform or not.

Available geospatial and related enabling national policies, laws and strategies would be supportive for ENSDI establishment with an effort to make them communicable and inclusive. However, the trend of poor policy enforcement could be a continued challenge.

It is assured that there is no a strong mechanism created enabling the stakeholders to actively engage in the planning and development of ENSDI. The role of each actor in the geospatial industry is not clearly defined so that mandate conflict is the critical bad-behaves that hinders cooperation among organization at all levels.

Though most legacy data sets are available in digital form, due to the absence of standardization, lack of metadata documentation, prevalence of project and proprietary software based data modeling, absence of proper data definition, poor data organization (file based), they lack readiness for web based sharing and are not accessible for the wider GIS community across the country.

Technologically, the long lasted internet connection problem in the whole country's territory would be a tough challenge for the realization of ENSDI. The dependence on proprietary based desktop and web application would questions the interoperability aspect of jurisdiction wide geospatial data sharing unless otherwise open culture is developed immediately.

The very poor professional development approach and curriculum along with very little attention of the government for capacity building in the industry, absence of qualified practitioners in the sectors would be the continuing challenges for the ongoing ENSDI development.

However, it has to be acknowledged that the limitation of this work includes the reluctance of some sampled organizations to freely respond to the semi-structure interview and to provide relevant sectorial documents.

4.2 Recommendations

The work presented in this article leads to the following recommendations to advance the development of the ENSDI:

- There should be geospatial data management and development revolution – standardization.
- The issues of internet-the high way of information – should be resolved firmly.
- A shift from commercial web and desk top spatial analytic software's to open source.
- There should be great national focus on ; capacity building, outreach and awareness creation, and curriculum and professional development.
- Attention has to be given for institutionalization of geospatial activities across the country's territory.
- Development of ENSDI policy, amendment of the available national geospatial information and technology policy, and making them communicable and interoperable with other related and enabling national and sectorial policy has to be done.

- Finally, this study recommends further detailed research focusing on each building blocks of ENSDI.

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REFERENCES

Aanestad, Margunn, Miria Grisot, Ole Hanseth, and Polyxeni Vassilakopoulou. (2017). 'Information infrastructures and the challenge of the installed base.' in, *Information Infrastructures within European Health Care* (Springer, Cham).

Bauer.J.R.(2012). Assessing the robustness of web feature services necessary to satisfy the requirements costal management application. Master thesis. The College of Earth, Ocean, and Atmospheric Sciences, Oregon State University.

Bouckaert, G, B.G. Peters & K. Verhoest (2010). The coordination of public sector organizations – Shifting patterns of public management. Palgrave Macmillan

Box, P., & Rajabifard, A. (2009). SDI governance bridging the gap between people and geospatial resources. In GSDI 11 World Conference, Rotterdam, The Netherlands, http://hdl.handle.net/11343/26692Clarke.

Clarke,D. (2011). Initiatives and challenges of SDI in South Africa. Position –It, Nov/Dec,2011. http://www.ee.co.za/wp-content/uploads/legacy/posit11/PositionIT_nov-dec11-Pro_33-35.pdf, accessed 9/28/2018.

Crompvoets, Joep, G Vancauwenberghe, Serene Ho, Ian Masser, and Walter Timo de Vries. (2018).'Governance of national spatial data infrastructures in Europe', *International Journal of Spatial Data Infrastructures Research*, 13

De Man, Erik. (2011). 'Spatial Data Infrastructuring: praxis between dilemmas', *International Journal of Spatial Data Infrastructures Research*, 6: 261-89.

Douglas,D.N. (1997). The US National Spatial Data Infrastructure: http://buccaneer.geo.orst.edu/myst/nsdi_ppt/sld001.htm accessed 3 September 2018

ESRI White Paper (October 2002), “Metadata and GIS” - 4. Vermeij, Bert, “implementing European Metadata Using ArcCatalog”, ESRI Arc User, July - September.

Federal Negarit Gazette – FNG (2014). A Proclamation to Re-Establish the Information Network Security Agency. Proclamation No.808/2013, 20thyear No. 6, Addis Ababa

Federal Negarit Gazette – FNG (2018). Council of minister regulation to provide the definition of powers, duties and organization of the Geo-spatial Information Institute.Regulation No.404/2018,25 year No.12,Adiss Ababa,December 2018.

Feeney. M-E, Rajabifard.A, Williamson.I.P.(2001). Spatial Data Infrastructure Frameworks to Support Decision Making for Sustainable Development.

Gelagay, H. S. (2017). Geospatial Data Sharing Barriers across Organisations and the Possible Solution for Ethiopia. International Journal of Spatial Data Infrastructures Research, 23.

Geo-Buiz.(2018).Global Geospatial outlook and Readiness index.

GeoConnections. (2007a). Understanding Users‘ Needs and User-Centred Design.Ottawa:GeoConnections, Natural Resources Canada. Retrieved June 18, 2013,fromNaturalResourcesCanadaGEOSCAN:http://geoscan.ess.nrcan.gc.ca/cgibin/starfinder/0?path=geoscan.fl&id=fastlink&pass=&format=FLFULL&search=R=292113

Georgiadou, Y.,, S. Puri, S. Sahay (2005). Towards a potential research agenda to guide the implementation of Spatial Data Infrastructures - A case study from India, International Journal of Geographical Information Science,19(10): 1113-1130.

Geospatialworld.(2010).OGCstandardsplayakeyroleinSDIdevelopment. https://www.geospatialworld.net/article/ogc. Accessed on 09 September 2018

Getinet.B.(2003). Developing guidelines for the institutional arrangement of federal gov’tal geo- information provider organization in Ethiopia.

Gourmelon, Françoise, Matthieu Noucher, Jade Georis-Creuseveau, Xavier Amelot, Pierre Gautreau,Grégoire Le Campion, Adeline Maulpoix, Julie Pierson, Olivier Pissoat, and Mathias Rouan.(2019). 'An integrated conceptual framework for SDI research: experiences from French case studies', *International Journal of Spatial Data Infrastructures Research*, 14: 54-82.

Grus, Lukasz, Joep Crompvoets, and AK Bregt. (2010). 'Spatial data infrastructures as complex adaptivesystems', *International Journal of Geographical Information Science*, 24: 439-63

Information Communication and Technology policy(ICTP).(2009). Federal Democratic Republic of Ethiopia. Information Communication and Technology policy, Addis, Ababa, Ethiopia

Lemmens, M.J.P.M., (2001).An European Perspectives on Geo-Information Infrastructure (GII)Issues. GIS development .net.1

Longley,P.A., M.F.Good child, D.J. Maguier, and D.W. Rhind. (2001). Geographic Information Systems and Science: New Yorke.

Moeller,J. (2001). Spatial Data Infrastructures: A Local to Global View. http://gsdi.org/PPT/unrcc01.ppt, accessed 25 December 2018

Mulaku, G. C., Kiema, J. B. K., andD.N. Siriba (2006). Assessment of Kenya’sReadiness for Geospatial Data Infrastructure Take Off. University ofNairobi, Department of Surveying, Nairobi, Kenya.

National Spatial Information and Technology policy(NSITP).(2016). Federal Democratic Republic of Ethiopia. National Spatial Information and Technology policy, Addis, Ababa, Ethiopia

Nedovic, Z. (2006). 1Technological and Institutional Interdependences and SDI – The Bermuda Square? International Journal of Spatial Data Infrastructures Research, 1, 15.

Open Geospatial Consortium(OGC). (2010). OGC web services common standrads.OGC06-121r9

OSDM.(2002).OfficeofSpatialDataManagementGlossary. http://www.OSDM.gov.au/osdm/glossary.html, accessed 9/218/2018

Ran, Jing, and Zorica Nedovic-Budic. (2016). 'Integrating spatial planning and flood risk management: Anew conceptual framework for the spatially integrated policy infrastructure', *Computers,Environment and Urban Systems*, 57: 68-79.

Rajabifard,A.and Williamson,I.P.(2001).Spatial Infrastructures :Concepts,SDI Hierarchy and Future directions,in proceedings, of GEOMATICS'80 Conference ,Tehran, Iran

SDI handbook for Africa. Chapter Three: Geospatial Data Needs Assessment. (n.d.), 21.

Shekhar, S. and Chawla, S(2003). Spatial databases: a tour. Prentice Hall

South Africa Development Community.(2004a).Protocol on trade.Gaborone,Botswana:SADC Secretariat.

Ting, L., Williamson, I.P., Grant, D., Parker, J.R., (1999).Understanding the evolution of land administration systems in some common law countries. The Survey Review 35 (272),83102.

United Nation Global Geospatial Information Management (UN_GGIM). (2017). National Institutional Arrangements: Instruments, principles and Guidelines. www.esri.com/library/whitepapers/pdfs/metadata-and-gis.pdf

United Nation Global Geospatial Information Management (UN- GGIM). (2015). A Guide to the Role of Standards in Geospatial Information Management Held from 3-7 August 2015 at the United Nations Headquarters in New York.

Water policy.(2001). Federal Democratic Republic of Ethiopia, National water policy, Addis, Ababa, Ethiopia

Williamson, I., Rajabifard, A. and Feeny, M.-E. (Eds.) (2003) Developing Spatial Data Infrastructures: From Concept to Reality, Taylor and Francis Ltd, London

Wheeler,J.O.,Aoyama,Y.,and Warf(eds).(2000).Cities in the telecommunication age :the Fracturing of Geographies.New York:Routledge.

Woldai,T.,2002. Geospatial Data Infrastructure : The problem of Developing Metadata for Geo-information in Africa.,ITC, ENSchede, The Netherlands.