

# A Review of the status of Spatial Data Infrastructure Implementation in Africa

Prestige Makanga<sup>1</sup>, Dr. Julian Smit<sup>2</sup>

<sup>1</sup>Geomatics Department, University of Cape Town, South Africa, [ptmakanga@gmail.com](mailto:ptmakanga@gmail.com)

<sup>2</sup>Geomatics Department, University of Cape Town, South Africa, [Julian.Smit@uct.ac.za](mailto:Julian.Smit@uct.ac.za)

## Abstract

*Spatial data is a key resource for the development of a nation. There is a lot of economic potential that is locked away in spatial data collections and this potential is realised by making the data widely available. Spatial Data Infrastructures (SDI) provide a platform for spatial data users, producers and those that manage it, to distribute the data more efficiently. Governments all over the world are realising the value of National Spatial Data Infrastructures (NSDI) and therefore making major investments to establish them. However, in Africa, Implementation of formal NSDI is being done at a seemingly slow pace. This paper presents an assessment of the status of NSDI activity in Africa. 29 countries are selected for the survey and assessment was done per region (Southern Africa Development Community (SADC), West, East, North and Central Africa). The results show that formal NSDI activity is generally still in its infancy in most African countries. The paper also gives recommendations of possible measures that can be taken to foster SDI implementation on the continent. It also highlights possible areas of further SDI research.*

## 1. Introduction

Spatial Data Infrastructures (SDI) are a key component for the development of a Nation. There is a lot of economic potential that is locked away in Spatial Data holdings and this potential is realised by making the data widely available through an SDI (UNECA, 2001). In April 2005, 83 countries had established National Spatial Data Infrastructure (NSDI) Clearinghouses on the internet (Crompvoets et al, 2007). This development indicates the large extent to which Nations are prioritizing and formalising NSDI initiatives. In Africa, SDI are being implemented, although in some instances they are done so using a different name (Lance, 2003). There is an obviously evident lagging behind of formal NSDI activity in Africa although there is a lot of informal activity that will contribute to the formal NSDI once governments are fully willing to participate in and take ownership of NSDI initiatives. Examples of a project and organisation that informally contribute to NSDI development are FAOSwalim (Somalia) (Von Hagen, 2006) and SADC Regional Remote Sensing Unit (Nebert, 2004), respectively.

Although the above project and organisation are making critical contributions to SDI development, they don't have the legal mandate to officially sanction SDI activity and brand them with a formal national character. This is mainly because of the fact that these projects are done by Non Governmental Organisations (NGO's) and have defined timelines to completion. There is therefore a high risk that once the projects have been terminated all the effort will go to waste because of failure to have well defined strategies to takeover and maintain the data. Von Hagen (2006) wrote;

*“while some SDI components appear to be in development, ultimately it is the handing over that is the critical aspect”.*

For nations to derive full benefit from the effort of such projects, there is need for a solid handover strategy. There should be structures in government that take an active part in the SDI initiative. This calls for formalising SDI initiatives and realising them as part of the national agenda.

The main purpose of this paper is to assess the status of formal NSDI development in Africa. The paper also serves as a platform to establish other areas of pending SDI research in Africa. A thorough review of informal Thematic SDI activity on the continent is beyond the scope of this paper

## **2. A Review of SDI Assessments**

Since the late 1970's, many National Survey and Mapping organisations begun to recognize the need to justify the large public investments they had received by improving access to and encouraging wider use of the spatial information in their custody (Groot, 1997). The framework that was desired to achieve this is similar to what we call SDI today. NSDIs are mainly established by government bodies and resourced by public funds hence the need to assess their progress (Grus et al, 2007). The definition and purpose of an 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. There is no prescriptive order in which the different components that make up an SDI can be implemented. Some implementing agencies choose to start with the clearinghouse so as to present the concept to potential stakeholders in an attempt to sell the SDI concept. This portrays a seemingly advanced SDI status, but this can be an inaccurate assessment considering that there are other viewpoints (described in the following section) that should be considered when assessing SDIs. Due to their complex, dynamic and evolutionary nature SDI assessments are difficult (Grus et al, 2007).

Hjelmager, et al (2005) proposed to use the Reference Model for Open Distributed Processing (RM-ODP) for the design of an SDI. This model looks at the design process from 5 different viewpoints namely; Enterprise, Information, Computational, Engineering and Technology viewpoints. The premise behind this approach is that SDI are complex systems and their design requires a multiple viewpoint approach. In an article on design science research in Information

Systems, Herver (2004) shows that the business environment establishes the requirements upon which the evaluation of an artefact is based. In other words, if multiple viewpoints are considered to conceptualise thorough and relevant SDI, then a multi-view assessment framework needs to be adopted to review the status of SDI development. SDI have similar characteristics with Complex Adaptive Systems (CAS) in that they are open systems in which different elements interact dynamically to exchange information and where the system as a whole has emergent properties that cannot be understood by reference to the component parts (Marian et al, 2003). Some of the SDI assessments that have been done using the multiview approach include:

- a) Assessing an SDI Readiness Index (Delgado et al, 2005)
- b) World Status of NSDI Clearinghouses (Cromptvoets et al, 2003)
- c) INSPIRE State of play: Generic approach to assess the status of NSDIs (Vandenbroucke & Jansse, 2008)

### **3. Adopted Methodology**

For this study, a multi-view SDI assessment framework was adopted. Four viewpoints were established and these are Organisational, Funding, Legal and Technical. A set of 14 more specific indicators were formulated which are described in table 1 below. A questionnaire was created based on the final list of indicators. Many of the SDI activities in Africa are informal (Lance, 2003) and not normally branded as SDI and therefore it would have been difficult to find all the useful information through searching the web. The questionnaire was sent to 269 people in 47 countries. The people were chosen from various SDI coordinating agencies, National Mapping Agencies, NGOs, Universities and other relevant people in Africa. Through the questionnaire we managed to get input to this study which was not available on the internet. A document survey was also done to assess different NSDI activities. In instances where there was inadequate information from the questionnaire, documents and web visits, personal emails were sent to the relevant people to get the required information.

Table 1. SDI Assessment viewpoints and indicators

INDICATOR CLASS		INDICATOR
Organisational	1A	There is a National SDI Coordinating body (Government, Voluntary)
	1B	There is maximum stakeholder participation (Government, Private Sector)
	1C	There is an SDI Champion at the Highest Political Level
Funding	2A	There is a reasonable budget to fund SDI activities
	2B	The SDI initiative is self-sustaining
Legal	3A	There is a legal framework governing spatial data pricing
	3B	There is a legal framework governing spatial data use
	3C	There is a legal framework governing spatial data creation
Technical (Data)	4A1	There is a reasonable level of interagency coordination of spatial data creation efforts
	4A2	The data creation process is formally standardised for all data creators
	4A3	There is ready access to electronic spatial data through a Geo-portal, CDs and other forms
(Metadata)	4B1	Metadata is captured for most of the spatial data that is created
	4B2	Data creators create metadata according to a prescribed standard
	4B3	There is a clearinghouse(s) that communicates most of the available data resources

The Information was compiled to establish scores against the indicators. For all the indicators there were five possible responses namely; Absolutely True, Fairly True, Slightly False, Absolutely False and Not Sure. For the purposes of ranking, Not Sure =0, Absolutely False = 1, Slightly False = 2, Fairly True = 3 and Absolutely True = 4.

A total of 29 African Countries were used in the study. Table 2 gives a summary of these countries and Figure 1 presents a map showing the spatial distribution of the countries polled. There were 3 central African countries, 5 East African, 5 North African, 9 Southern African Development community (SADC) and 7 West African countries that were used in the study (Figure 1). Resources, language barriers and time constraints did not permit for the study to be done for all the African countries. The researchers are however confident that the countries that were sampled give a meaningful representation of SDI activity in the different regions of the continent.

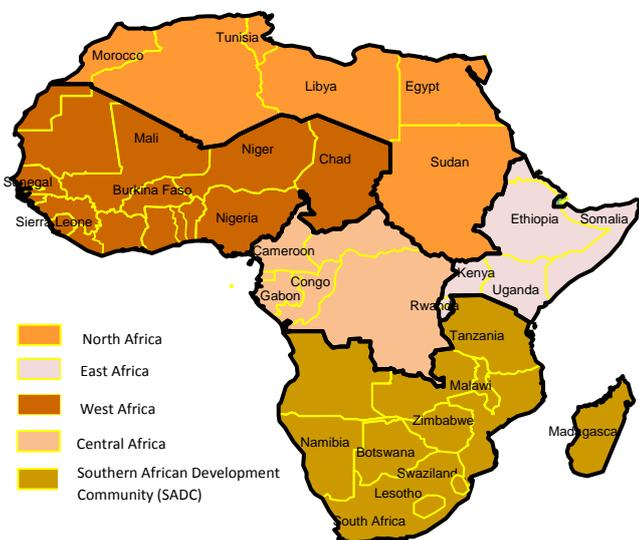


Figure 1: Countries included in the Survey

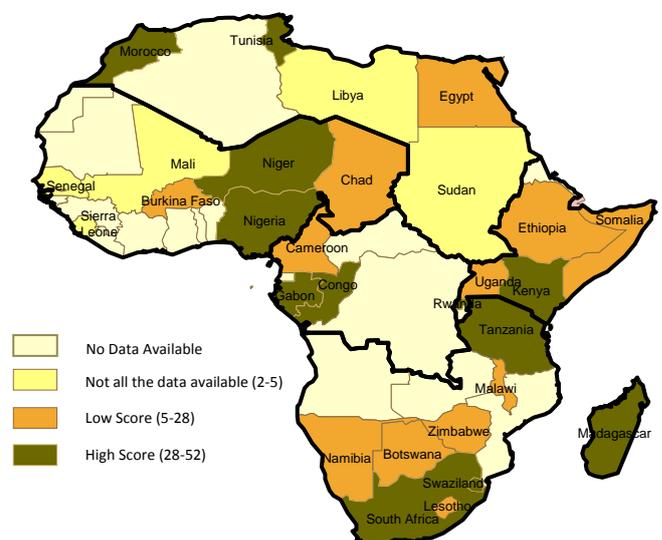


Figure 2: SDI Scores of the countries under study

## 4. Results

The results of the survey were tabulated in the form of an assessment matrix of the indicators and the respective scores of each country in table 2.

Table 2: Assessment Matrix

Region	Country	1A	1B	1C	2A	2B	3A	3B	3C	4A1	4A2	4A3	4B1	4B2	4B3	SDI Score
South	Botswana	4	3	2	3	1	1	1	1	2	2	2	2	2	1	27
West	Burkina Faso	2	2	1	2	3	1	1	1	2	3	3	1	1	1	24
Central	Cameroon	1	2	1	1	1	1	1	1	3	3	2	3	1	1	22
West	Chad	3	1	3	1	2	1	1	1	1	1	3	2	1	4	25
West	Congo	1	3	3	2	1	2	1	2	3	3	3	3	3	1	31
North	Egypt	2	3	2	2	1	1	1	1	2	1	2	1	2	2	23
East	Ethiopia	4	4	1	1	1	1	2	2	2	2	2	2	2	2	28
Central	Gabon	4	4	4	4	4	1	4	4	4	3	4	4	4	4	52
East	Kenya	4	3	3	1	1	3	3	2	1	2	2	2	2	4	33
South	Lesotho	3	4	1	1	1	1	1	1	1	1	1	1	1	1	19
North	Libya	4	0	0	0	0	0	0	0	0	0	0	0	0	0	4
South	Madagascar	2	3	1	2	3	3	3	3	1	2	3	3	3	2	34
South	Malawi	4	3	1	1	2	1	1	1	3	1	3	2	1	1	25
West	Mali	4	0	0	0	0	0	0	0	0	0	0	0	0	0	4
North	Morocco	4	4	1	1	1	4	4	4	4	3	1	2	1	1	35
South	Namibia	2	2	1	2	1	1	2	1	1	1	3	3	2	1	23
West	Niger	4	3	4	2	3	4	3	4	3	4	4	4	3	3	48
West	Nigeria	4	4	4	4	3	4	4	4	2	2	1	2	2	2	42
East	Rwanda	2	4	4	4	1	2	2	2	4	3	4	4	4	3	43
West	Senegal	3	0	0	0	0	0	0	0	1	0	0	0	0	1	5
West	Sierra Leone	4	0	0	0	0	0	0	0	0	0	0	0	0	0	4
East	Somalia	1	1	1	3	1	1	1	1	2	2	3	3	2	1	23
South	South Africa	4	3	3	2	2	3	4	2	1	3	2	1	2	1	33
North	Sudan	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2
South	Swaziland	4	3	3	3	2	2	2	2	3	2	1	2	2	1	32
South	Tanzania	4	2	3	3	2	3	3	2	3	2	2	2	3	2	36
North	Tunisia	4	3	3	2	2	3	4	2	1	3	2	1	2	1	33
East	Uganda	3	3	3	1	1	2	1	1	3	1	3	2	1	1	26
South	Zimbabwe	3	1	1	1	1	1	2	2	2	1	2	1	2	1	21

The SDI score is a sum of the individual indicator scores for each country under study. In this study, it is assumed that all the indicators have equal weight and therefore a summation of the scores would give an indication of the relative status of SDI Implementation with regards to the given Indicators. The scores were divided into three classes, one with low values due to missing data (2-5) and two other equal classes (5-28 and 28-53) and this is shown in Figure 2.

From Table 2, 20 out of the 29 countries at least have a body that is coordinating the attempts to come up with a formal SDI. There is generally minimal political support for NSDI initiatives. However Rwanda and Uganda are among the countries that have a very high level of political support directly from the President's office. For Rwanda this has been a major milestone and they have managed to get adequate funding for their NSDI initiative. Only three other countries have expressed adequacy of funding for their NSDI initiative (Gabon, Swaziland and Nigeria).

The participation of stakeholders in NSDI initiatives is generally not satisfactory. Only six out of the 29 countries expressed satisfaction in the participation of different stakeholders in the NSDI initiatives. From the questionnaire there is a general lack of appreciation of the benefits of a NSDI to those that will potentially benefit and therefore there is no satisfactory participation.

Table 3. Summary of Assessment Results

	Central Africa	North Africa	East Africa	Southern Africa	West Africa
<b>NSDI Coordination</b>	1 out of the 3 countries has a NSDI coordinating team.	3 out of 5 countries have a NSDI coordinating team.	3 out of 5 countries have a NSDI coordinating team.	6 out of 9 countries have a NSDI coordinating team.	6 out of 9 countries have a NSDI coordinating team.
<b>Political Support</b>	1 out of 3 countries has a reasonable level of political support	1 out of 3 countries has a reasonable level of political support	3 out of 5 countries has a reasonable level of political support	2 out of 9 countries has a reasonable level of political support	3 out of 9 countries has a reasonable level of political support
<b>Funding</b>	Gabon is the only country that has reasonable funding for NSDI	No country has reasonable funding for NSDI	Rwanda is the only country that has reasonable funding for NSDI	Swaziland is the only country that has reasonable funding for NSDI	Nigeria is the only country that has reasonable funding for NSDI
<b>Stakeholder Participation</b>	1 country has maximum stakeholder participation for the NSDI initiative	1 country has maximum stakeholder participation for the NSDI initiative	2 countries have maximum stakeholder participation for the NSDI initiative	1 country has maximum stakeholder participation for the NSDI initiative	1 country has maximum stakeholder participation for the NSDI initiative
<b>Clearinghouses</b>	1 NSDI Clearinghouse	No NSDI Clearinghouse	1 NSDI Clearinghouse	No NSDI Clearinghouse	1 NSDI Clearinghouse
<b>Legal Component</b>	1 country has at least a component of NSDI Legal framework implemented	2 countries have at least a component of NSDI Legal framework implemented	No country has at least a component of NSDI Legal framework implemented	1 country has at least a component of NSDI Legal framework implemented	2 countries have at least a component of NSDI Legal framework implemented

Kenya and Chad have got operational NSDI Clearinghouses. Although there are some NGO initiatives that have created clearinghouses and geo-portals for data discovery and download, they are mainly for the datasets that are specific to particular projects. Two examples of such initiatives are SAHIMS ([http://www.sahims.net/gis/GIS%20input/GIS\\_Library\\_Regional.asp](http://www.sahims.net/gis/GIS%20input/GIS_Library_Regional.asp)), which has spatial data and metadata for the SADC region, and FAOSWALIM's online Atlas (<http://www.fao.org/geonetwork>) where spatial data for Somalia is available. There still remains a lot of data in disparate unknown locations that require being communicated through a NSDI clearinghouse.

Six countries have at least a component of the legal framework implemented. Most countries are still in the process of advocating for a legal framework to be in place through their NSDI coordinating bodies. Some countries have acts pertaining to spatial data creation that were created in line with survey standards and these can contribute to the new legal frameworks for NSDI.

## **5. Conclusions and Recommendations**

There is a clear need to speed up implementation of NSDIs in Africa. In 2003 there were 2 African countries that had established NSDI clearinghouses (Crompvoets et al, 2003) and 5 years later there are only 3. In fact at the time of writing, the two previously established clearinghouses had ceased to be operational. The following sections suggest some recommendations that can propell SDI implementation on the continent.

### **5.1. A bottom up approach**

The work and resources that have been invested in Thematic SDIs and other informal SDI initiatives through NGOs and Private mapping companies will potentially go to waste if there is a poor handover strategy. Although it would be easier to establish a NSDI after attaining full political support for the initiative, getting political attention has proven to be a task that is beyond the immediate reach for most NSDI agencies all over Africa. This means that organisations that are playing key roles in the data creation and coordination efforts and have realised the importance of SDI should make use of existing structures to cement institutional relationships and partnerships to make SDI's work with minimal political support. The SDI-East Africa (SDI-EA) initiative for example has required minimal funding because of using already existing structures (Wilson et al, 2008). This calls for a bottom up approach, where eventually the SDI initiative will gain political support after the benefits are communicated in tangible ways. It however does not mean that outreach efforts to Politicians must stop; the establishment of a formal NSDI needs a thorough legal framework and this requires high government support.

### **5.2. Handover Strategy**

There is also a need for plans on how to handover current projects that contribute to the NSDI to governments so that the efforts don't go to waste when a project comes to completion. This may involve teaming up with government, even at low levels, so that they are aware of the SDI initiatives are happening.

### **5.3. Role of FOSS4G**

Free and Open Source Software for GIS (FOSS4G) plays an important role in the overall development of SDI in Africa. It does not generally involve a charge for field support unlike with proprietary software (Lakhani & Von Vippel, 2002). This will cushion most African countries where there is minimal funding in support for SDI initiatives. Human resources capable of making a difference for SDI activities in Africa are major challenge (Clarke, 2008). With FOSS4G, there is diverse technical support and documentation from previous experiences. Diverse technical environments and comprehensive user demands require using several different products in implementing GIS systems for distributed applications, such as SDI. Among these, the open source

software products offer a viable and attractive alternative to the commercial solutions for such systems (Paluszynski et al, 2007)

This research has identified areas that need research for the future of SDIs in Africa; these are

- Quantifying Informal SDI activity
- Funding Models for SDI in an African Context
- How to make SDI development sustainable projects
- Models for handing over informal SDI activity to governments

### **Acknowledgements**

The Authors would like to acknowledge SDI-Africa which is the main source for most of the documents used in this assessment and all the people that managed to create time to fill in the questionnaire that was used in this study.

### **References**

- Clarke, D. D. (2008). Status of GIS in Africa. *GIS Development* .
- Crompvoets, J., & Bregt, A. (2003). World Status of National Spatial Data Clearinghouses. *Urban and Regional Information Systems Association* .
- Crompvoets, J., Bregt, A., Wachowicz, M., Hofstede, G. J., Pieter, V., & De Man, E. (2007). Exploring Worldwide the Impact of Society on the success of National Spatial Data Clearing houses. *Global Spatial Data Infrastructure 10*.
- Delgado, T., Lance, K., Buck, M., & Onsrud, H. (2005). Assessing an SDI Readiness Index. *Pharaohs to Geoinformatics, GSDI 8* , 1-10.
- Groot, R. (1997). Spatial Data Infrastructure (SDI) for Sustainable Land Management. *ITC Journal* .
- Grus, L., Crompvoets, J., & Bregt, A. (2007). Multi-View SDI Assessment Framework. *International Journal of Spatial Data Infrastructure Research* , 33-53.
- Henver, A., March, S., & Park, J. (2004). Design Science in Information Systems Research. *MIS Quartely* , 75-105.
- Hjelmager, J., Delgado, T., Moellering, H., Cooper, A., Danko, D., Michel, H., et al. (2005). Developing a Modelling for the Spatial Data Infrastructure.
- Lakhani, K., & Von Vippel, E. (2002). How open source software works: "Free" user-to-user assistance. *Elsevier* , 923-943.
- Lance, K. (2003). Spatial Data Infrastructures in Africa. *GIS Development* , 35-41.
- Marian, B., Elizabeth, M., & Helen, S. (2003). Evidence, Understanding and Complexity: Evaluation in Non-Linear Systems. *Sage Publications (London)* , 265-284.
- Nebert, D. D. (2004). *Developing Spatial Data Infrastructures: The SDI Cook Book*. GSDI.

Paluszyński, W., Waniak, A. Ś., & Kubik, T. (2007). BUILDING SPATIAL DATA INFRASTRUCTURE AT COUNTY LEVEL USING OPEN SOFTWARE.

UNECA. (2001). *The Future Orientation of Geoinformation Activities in Africa*. Addis Ababa.

Vandenbroucke, D., & Jansse, K. V. (2008). *INSPIRE State of Play: Generic Approach to assess the status of NSDI*.

Von Hagen, C. (2006). Towards a Spatial Data Infrastructure in Somalia using Open Source Standards.

Wilson, M., Von Hagen, C., & Carrie, H. (2008). Field-testing SDI in East Africa. *The International Journal of SDI Research* .