A comparative analysis of stakeholder roles in the spatial data infrastructures of South Africa, Namibia and Ghana[*]

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Abstract

Spatial data infrastructures (SDIs) at various levels (global, regional national, local and corporate) are being developed by and in countries around the world. We assess here the SDI developments in three African countries, Ghana, Namibia and South Africa, using the SDI models developed by the Commission on Geoinformation Infrastructures and Standards of the International Cartographic Association (ICA), focusing on the stakeholders and their roles: the Policy Maker, Producer, Provider, Broker, Value-Added Reseller (VAR) and End User. SDI development in all three countries has involved a variety of stakeholders and has taken a long time, waxing and waning depending on the availability of funding and the commitment of the stakeholders, particularly the Policy Makers. This research on the similarities and differences of the SDI stakeholders in Ghana, Namibia and South Africa improves the understanding of

SDI development and we hope that the results can help other countries with their own SDI developments. Based on our work, we make recommendations for refining the ICA's stakeholder typology.

Keywords: spatial data infrastructure, SDI, stakeholder, Namibia, Ghana, South Africa, ICA SDI stakeholder model

1. INTRODUCTION

Spatial data infrastructures (SDIs) emerged in the 1990s, mostly as national initiatives implemented by governments to facilitate spatial data sharing. They provide a basis for geospatial data discovery, evaluation and application for a variety of users and providers (Nebert, 2012). SDIs are constantly evolving in response to new technologies, stakeholder roles and user demands. Many African countries have also initiated SDIs. Some of these countries started facilitating the discovery and sharing of spatial data without the required political support and have struggled to maintain SDI momentum (Lance and Bassolé, 2006; Makanga and Smit, 2010). National SDI development and implementation vary from country to country because of local conditions – particularly the stakeholders. Hence it is useful to compare and contrast the challenges, failures and successes of SDIs and their stakeholders. Such a comparison documents the experiences of researchers and practitioners, thereby establishing a knowledge base from which others can learn.

The Commission on Geoinformation Infrastructures and Standards of the International Cartographic Association (ICA) used the Reference Model for Open Distributed Processing (RM-ODP) (ISO/IEC, 1998) to develop formal models of the enterprise, information and computational viewpoints of an SDI (Hjelmager et al., 2008; Cooper et al., 2012). In the enterprise viewpoint, the focus of this paper, six SDI stakeholders were identified and described; see Figure 1. The ICA's stakeholder model of the enterprise viewpoint was further refined into various roles and special cases of the roles, termed 'sub-types' and 'sub-sub types' in Cooper et al., (2011). An individual stakeholder can have different roles and functions, e.g. an organization could be the policy maker in the role of legislator and secretariat, and could also be a producer and provider of data and services in an SDI (Sinvula et al., 2013).

Based on the ICA's SDI model, Owusu-Banahene et al. (2013) and Sinvula et al. (2013) identified the stakeholders and described and discussed their roles in the spatial data infrastructures of Ghana and Namibia, respectively. Both papers emphasized the value of understanding the roles and motivations of stakeholders in contributing towards the implementation of a national spatial data infrastructure in a developing nation. The ICA's model has been applied by others, for example, by Oliveira et al. (2016) for a corporate SDI.

**Figure 1: The ICA's stakeholders from the enterprise viewpoint of RM-ODP
(Source: Hjelmager et al., 2008)**
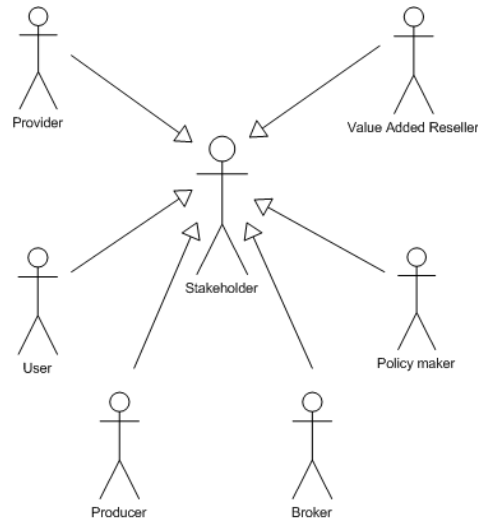
In related work, the complex, dynamic and multifaceted nature of SDIs is acknowledged (Béjar et al., 2009; Grus et al., 2010; Mansourian et al., 2006; Dessers et al., 2012). A variety of models have been used to describe the constituent parts of an SDI and how they interact with each other. The ICA's SDI model is one such example. Other examples are: Rajabifard et al., (2002) identified people and data as components that are linked through the access network, policy and standards components; Grus et al., (2010) presented the SDI as complex adaptive systems; Béjar et al. (2009) describe an SDI as a system of systems; Béjar et al. (2012) model technical and non-technical components of an SDI using an RM-ODP viewpoint; Mansourian & Abdolmajidi (2011) applied the systems dynamic technique to model and simulate the complexity of SDI development over time; and Lubida et al. (2015) applied the theory of planned behaviour to SDIs. Authors who studied SDIs from the perspective of information infrastructures (Georgiadou et al., 2005; de Man, 2007; Béjar et al., 2009) comment on the strong emphasis on technical aspects in SDI research. They call for the study of SDIs from a socio-technical perspective (Georgiadou et al., 2005; de Man, 2007; Hendriks et al., 2012). Very few studies of SDI developments in different countries were found in scientific literature, one exception is Singh (2009) on India.

In this paper, the roles and characteristics of individual SDI stakeholders in three sub-Saharan countries, namely South Africa, Namibia and Ghana, are identified, analysed and compared, based on the ICA's stakeholder typology. The three countries were selected because the authors are citizens of them and participate and/or observe SDI dynamics in their respective countries; the results come out

of a collaborative research project. To our knowledge the SDI developments of Ghana, South Africa and Namibia have not been compared to each other before. Understanding similarities and differences in SDI stakeholder roles helps to understand which stakeholders initiate SDIs and how; how the stakeholders influence SDI development and implementation; and how the SDIs are maintained and sustained by stakeholders. This understanding may contribute to the success of SDI implementations in Africa and in other parts of the world. Based on our work, we make recommendations for refining the ICA's stakeholder typology.

Figure 2: Geographical location of South Africa, Namibia and Ghana in Africa

South Africa, Namibia and Ghana are geographically located in sub-Saharan Africa (Figure 2) with land surface areas of 1.2 million km^2 for South Africa, 824,290 km^2 for Namibia and 238,540 km^2 for Ghana. South Africa has 55 million inhabitants (45 people/km^2), which makes it the most populous country in Southern Africa. The population of Namibia is 2.5 million, and with a population density of 3 people/km^2 it is, apart from Greenland and Mongolia, the least densely populated country in the world (together with Australia, Iceland and Suriname). Ghana has a population of 27.4 million and a population density of 120 people/km^2 (World Bank, 2015a, 2015b, 2015c). In the Global Competitive

Index, the South African economy is ranked 49th among 140 economies in the world, making it Africa's second-most competitive economy (after Mauritius). Namibia and Ghana are ranked 85th (4th in Africa) and 119th (17th in Africa), respectively (World Economic Forum, 2015). Ghana is accredited as the most democratic and politically stable West African nation (Ayee et al., 2011).

The South African Spatial Data Infrastructure Act (South Africa, 2003) established the Committee for Spatial Information (CSI), which is responsible for developing the South African SDI (SASDI) and the electronic metadata catalogue. More recently, the Namibian SDI came into existence through Part IX of the Statistics Act (Namibia, 2011), the legal basis for the establishment of the Namibian SDI and its objectives. Ghana does not have a legislative framework for an SDI; however, the country is working towards establishing a legally mandated SDI through efforts by the government, the World Bank and other donor organisations (Owusu-Banahene et al., 2013). Ghana's National Framework for Geospatial Information Management (NAFGIM) was one of the earliest SDIs initiatives in Africa (Masser, 2005), but support for it eroded, primarily due to constraints on resources (Yawson et al., 2010).

The remainder of this paper is structured as follows. Milestones in SDI development in the three countries are described in section 2. These milestones provide the context for the stakeholder comparison. The SDI stakeholders in South Africa, Namibia and Ghana, as well as their roles and functions, are presented and compared in section 3. A discussion and conclusions follow in sections 4 and 5 respectively.

2. DEVELOPMENT STAGES OF THE SPATIAL DATA INFRASTRUCTURES IN SOUTH AFRICA, NAMIBIA AND GHANA

2.1. South African SDI

The Coordinating Committee for the National Land Information System (CCNLIS) was created in 1985 to share experiences across government in South Africa with digital geospatial data (Clarke, 2011). The National Programme for Remote Sensing (NPRS) and CCNLIS were responsible for the South African National Exchange Standard (NES), published in 1987 (Clarke, 2011; Cooper, 1993). The CCNLIS also coordinated the planning, collection and sharing of aerial photography and data. The aim was to minimize duplication and to advance sharing of data at various scales. The then Chief Surveyor General initiated a study on the feasibility of a centralized database for South Africa's national geographic information system (Harvey et al., 2012). This was the initial groundwork that led to the foundation of an SDI in South Africa.

By 1998, databases from several government organisations were integrated successfully to plan the 1999 elections (Clarke, 2011). The National Spatial Information Framework (NSIF) Directorate was established in the former Department of Land Affairs in 1997 to establish the technical and policy framework for enabling unimpeded access to, and utilization of, spatial data for effective and efficient governance, planning and decision making in all spheres of government (Cooper and Gavin, 2005). The South African Constitution (South Africa, 1996) protects the right of access by the public to information held by the state. The Promotion of Access to Information Act (South Africa, 2000) gives effect to this right and specifies reasonable measures to alleviate the financial and administrative burden on the state. With this Act in place, it was necessary to make sure that the right of access to information applies also to geospatial information. The NSIF initiated and pioneered the South African SDI by developing a legal framework for the coordination, sharing, maintenance and distribution of spatial data among stakeholders (South Africa, 2003) and establishing an online metadata catalogue of about 3000 records by 2002 (Harvey et al., 2012). South Africa's SDI had reached infancy, but the NSIF's operation and activities declined and the SDI withered (Smit et al., 2009).

During this (mainly) dormant period, a number of SDI-related activities continued, such as the publication of a South African metadata profile in 2005 (SANS, 2005); the signing of a multi-government licence for SPOT 5 imagery (Harvey et al., 2012); and the publication of the South African address standard (SANS, 2009).

Figure 3: Milestones in the South African SDI, 1987 – 2016
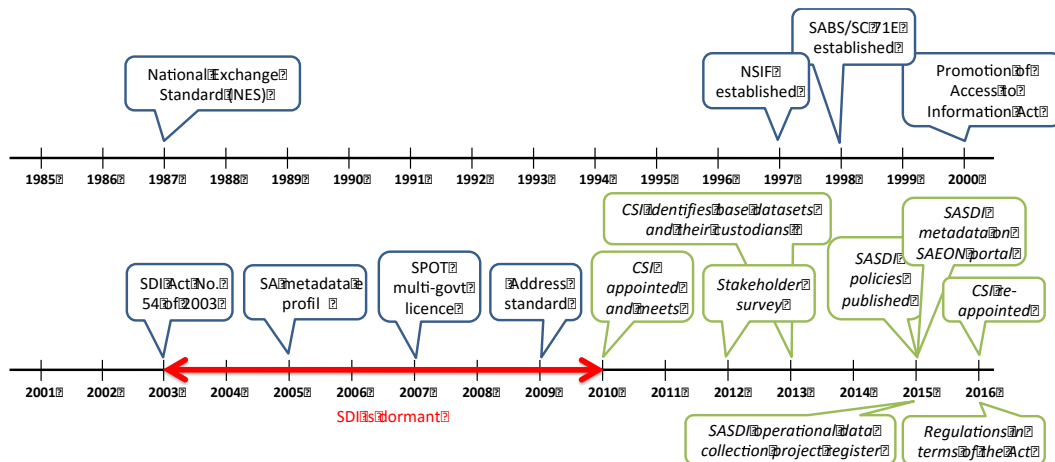
The Committee for Spatial Information (CSI) was eventually appointed in 2010 in terms of the Spatial Data Infrastructure Act (South Africa, 2003), and re-appointed for a second term in 2016. Since then, the CSI has identified the base data sets for SASDI and their custodians (NSIF, 2013); finalised regulations in

terms of the Act (NSIF, 2016), as well as policies on custodianship and pricing (NSIF, 2015); re-established a metadata catalogue (NSIF, 2014), hosted by the South African Environmental Observation Network (SAEON); developed an operational data collection project register (NSIF, 2014); and established a site licence with the South African Bureau of Standards (SABS) for relevant South African standards for the custodians (CSI, 2016). CSI has also spawned development of the South African Geo-spatial Information Management Strategy (SAGIMS) (NSIF, 2013). Figure 3 shows the milestones in the South African SDI. A green frame indicates milestones achieved by the CSI established through the SDI Act.

2.2. Namibian SDI

The genesis of SDI in Namibia came as a result of government's strategy to minimize duplication of spatial information through sharing, coordinating and distributing metadata. As early as 1990, the Office of the Surveyor General, by virtue of its mandate, distributed spatial data to the general public in various formats, such as registration maps, base maps, topographic maps and aerial photographs. The launch of the Information and Communication for Service Sustainable Development (INFOCOM) program in 1998 led to the sharing of more than 130 environmental monitoring programmes and datasets (Noongo and Willemse, 2004). INFOCOM's activities and operations ceased to exist immediately after donor funding evaporated (Ministry of Foreign Affairs of Finland, 2004).

Individual government departments and/or agencies have developed electronic repositories or portals of spatial information, shared and distributed the data on an ad hoc basis to stakeholders and users. For example, the Geological Survey of Namibia captured, maintained and distributed fundamental geological datasets at cost (Namibia Geological Survey, 2005), whereas the Roads Authority is responsible for distributing fundamental road network datasets by virtue of their mandate (Namibia, 1999).

In 2009, a project of the National Planning Commission (NPC), funded by the Governments of the Republic of Namibia and Luxembourg, reignited the concept of spatial data sharing and distribution to end users. This project led to the development of the Namibian SDI policy and standards, which later formed part of the Namibia Statistics Act (NSDI, 2016).

The Committee for Spatial Data (CSD) was established through Part IX, National Spatial Data Infrastructure, of the Statistics Act (Namibia, 2011). CSD members were appointed in 2011 and the first meeting was held in 2014. The CSD reviewed and gazetted the Namibian SDI policy in 2015 (Namibia Statistics Agency, 2015). The CSD also crafted the Namibian SDI strategic plan and

governance structure which was later approved for implementation. In 2016, the CSD signed memorandum of understanding agreements with key stakeholders of the Namibian SDI (NSDI, 2016). Figure 4 shows milestones in the Namibian SDI. A green frame indicates milestones achieved by the CSD established through the NSDI provisions in the Statistics Act.

Figure 4: Milestones in the Namibian SDI 1990 – 2016
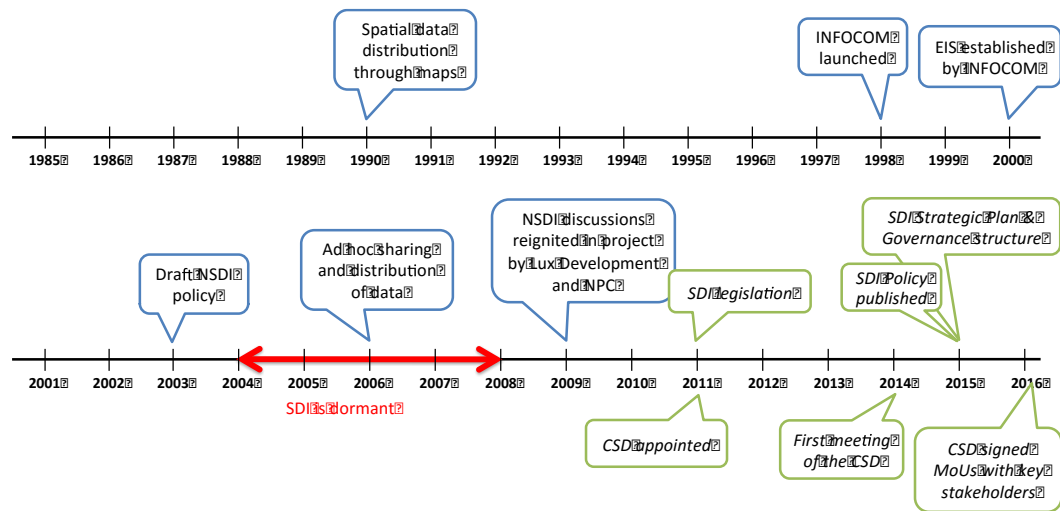
2.3. Ghana SDI

The conception of Ghana's SDI was a result of strategic plans by international organizations to promote Environmental Information Systems in Sub-Saharan Africa (EIS-SSA) (Owusu-Banahene et al., 2013). The National Environmental Action Plans (NEAPs) programme initiated by the World Bank and other international donor agencies in Africa was established in 2004 (Ezigbalike, 2004). The preparation (1988) and adoption (1991) of NEAP by the Government of Ghana was aimed at striking a balance between economic development and sustainable management of renewable resources. During the NEAP initiation stage, land information availability was identified as a key priority that provided an opportunity for a more coherent framework on environmental and resource information management. The decision for Ghana's National Environmental Information System (NEIS) was birthed during the adoption process of NEAP in order to rectify the deficiencies on the state of environmental information. The environmental information system (EIS), a subcomponent of the Environmental Resource Management System (ERMS) of the Ghana Environmental Resource Management Project (GERMP), a five-year project to implement the NEAP was developed and became operational in 1993. The aim of the EIS was to strengthen stakeholders that were involved in the collection, processing and

analysis of environmental information and the creation of core datasets for environmental planning in Ghana (Owusu-Banahene et al., 2013).

Some institutions, such as the Survey Department, the Lands Commission, the Soil Research Institute, the Meteorological Services Department, and the Centre for Remote Sensing and Geographic Information Services (CERSGIS), were identified to produce and collate the relevant land-related datasets for the project, under the sponsorship of the Government of Ghana, the World Bank and the Danish International Development Agency (DANIDA). These participating institutions felt the need for, and initiated the creation of, a framework for sharing data and for coordinating the production and harmonisation of their spatial data products. This initiative led to the establishment of NAFGIM in April 2000 with: a secretariat (comprising a secretary, technical staff and a coordinator); a steering committee; and an inter-agency forum (Owusu-Banahene et al., 2013). By 2006, NAFGIM was declining (Karikari, 2006; Yawson et al., 2010).

Further proof can be found in Crompvoets and Bregt (2007) who compared different aspects of national SDI developments. Between 2000 and 2005, they periodically conducted surveys, taking inventory of national clearinghouses on the Web by measuring eleven characteristics of a clearinghouse, such as the number of data suppliers, the number of datasets available and the number of monthly visitors. From these characteristics a clearinghouse suitability index was calculated from 2002 to 2005. The index showed that in 2005 NAFGIM scored 21; 14 points lower than in 2002, indicating that NAFGIM was declining.

The Land Administration Project (LAP) was launched in 2003, as a long term (15-25 years) land administration program to implement policy actions recommended in the National Land Policy document of June 1999 (Ministry of Lands and Forestry, 1999). The first phase of the reforms under LAP-1 implemented from 2003 to 2010, laid the foundation by reviewing the statutes on land, carrying out institutional reforms and undertaking pilots on a number of initiatives, such as customary boundary demarcation, the establishment of the Customary Lands Secretariats, Digitizing Land Records, Establishment of Land Courts and Systematic Title Registration (Ministry of Lands and Natural Resources, 2016).

In 2010, the second phase of the programme, namely LAP-2, identified the development of a surveying and mapping policy, a geodetic reference network, continuously operating reference stations, a national spatial data infrastructure, production of digitized base maps and the establishment of a street addressing system as important activities for consolidating, regulating and strengthening land administration and management systems in Ghana (Ministry of Lands and Natural Resources, 2011). This ongoing land adminstration programme presents another opportunity for the establishment of a legally mandated SDI in Ghana, after the demise of NAFGIM (Owusu-Banahene et al., 2013).

Currently, the frameworks for the following policies are complete: National Spatial Data Development Policy, National Survey and Mapping Policy, and Geodetic Reference Policy (Ministry of Lands and Natural Resources, 2016). These policies are necessary for the take-off of a national spatial data infrastructure in Ghana. Yawson et al. (2010) suggest that having laws for the right of access to information can create opportunities for SDI development, but that much more (e.g. institutional frameworks and technical infrastructure) is needed than just the legislation. Yawson et al. (2011) found that participants from multiple SDI stakeholders in Ghana ranked discoverability and retrievability of geospatial data as the most important objectives that an SDI should achieve. In this paper, both GERMP and NAFGIM are used as reference to describe SDI stakeholders in Ghana. Figure 5 shows SDI development milestones in Ghana.

Figure 5: SDI development milestones in Ghana, 1988-2016 (expanded from Owusu-Banahene et al., 2013)
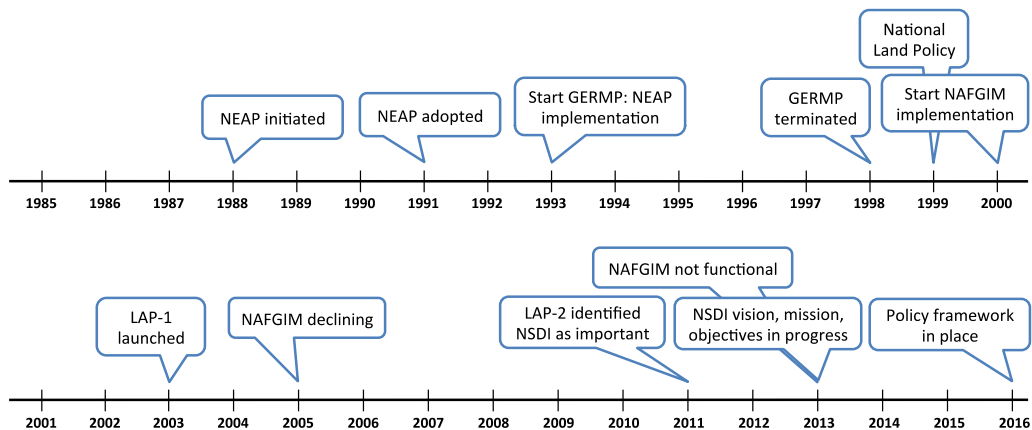
3. COMPARATIVE ANALYSIS OF STAKEHOLDERS

This section presents the stakeholder comparative analysis of the SDIs in Namibia, South Africa and Ghana SDI using the ICA's stakeholder typology (see Table 1). The stakeholder typology for each country was informed by a review of relevant documentation (e.g. legislation, project reports) and scientific literature; direct observations by the authors who have been directly involved in SDI developments in their countries; and workshops of the collaborative project reviewing elements of the targeted national SDIs, variably including geospatial practitioners and scholars from Namibia, South Africa and Ghana, as well as members of the ICA Commission. The discussion in section 4 draws on a detailed description of the Policy Maker, Producer, Provider, Broker, Value Added Reseller (VAR) and End-User, and their critical functions in SDI development stages and growth in South Africa, Namibia and Ghana in Sinvula et al. (2017).

Table 1. Stakeholders in the ICA SDI model (Source: Cooper et al., 2011)

Policy Maker
The *Legislator* is an "external" authority that determines the framework within which the SDI has to exist. The *Legislator* does not necessarily understand anything about the SDI.
The *Decision Maker* makes policies and understands geospatial data and the applications, constraints, etc. It is often a committee of representatives of stakeholder communities.
The *Secretariat* is the 'glue' of the SDI. It is often a government department with the mandate and budget to support the SDI.
The *Champion* promotes the SDI and does not necessarily have a mandate, but could be motivated by the need to promote social justice, by environmental awareness, or by commercial interest. The *Champion* could be the initiator of the SDI.

Producer
Status: Official Mapping Agency, Commercial Mapping Agency, Community Interest, Crowd Sourcer
Motivation: Special Interest, Economic, Process
Role: Captor of Raw Data, Submitter of Revision Notice, Passive Producer, Database Administrator
Skill: Neophyte, Interested Amateur, Expert Amateur, Expert Professional, Expert Authority

Provider
Data Provider: A Producer that is its own Data Provider, a Data Distributor or a Data Arbiter
Service Provider: A Producer that is its own Service Provider, a Service Distributor or a Service Arbiter.

Broker
A *Crowd-sourcing Facilitator* which provides access to on-demand, scalable resources.
A *Finder* is a 'Clients/user Finder' who promotes and sells a portfolio of data and services from *Producers*, *Providers* and *VARs*, to *End Users*; or it is a 'Providers Finder' who sources data or services for an SDI.
A *Harvester* harvests metadata on data and services and integrates them.
A *Cataloguer* builds and maintains a catalogue.
A *Negociant* brings *End Users* and *Providers* together and assists in the negotiation of contracts between them.

Value-Added Reseller
A *Publisher* takes data from various sources, and integrates and edits them to produce a new product, such as an atlas or a location-based service (LBS). A *Publisher* could add some of its own data.
An *Aggregator/ Integrator* is a 'Service Integrator' or a 'Data and Metadata Aggregator/Integrator'.

End User
The *Naïve Consumer* uses whatever is available with limited ability to determine the quality of the data or services.
The *Advanced User* has expert domain and/or geospatial expertise and hence can make informed decisions about the data and services to use and can provide informed, technical criticism of the data and services.

4. DISCUSSION

In this section the SDI development stages and results of the stakeholder comparison are summarized and discussed.

4.1. SDI development stages

In Namibia, the legal recognition and planning of the NSDI originated in the National Planning Commission under the Office of the President, while the South African SDI legislation was conceived in the Department of Rural Development and Land Reform. SDI legislation in Namibia is embedded in the Statistics Act (Namibia, 2011), while South Africa has an SDI-specific Act (South Africa, 2003). Ghana is currently transitioning into a legislative SDI.

The conception of SDIs through legislation provides a solid framework for the development and growth of SDIs because the legislation provides and preserves the rights and functions of different stakeholders. This is evident, for example, by the SDI development progress in South Africa during the first term of the CSI and subsequent slow-down after expiration of the first term and before appointment of members for the second term. The non-legislative SDI is at risk due to non-binding legal frameworks governing its stakeholders.

Early SDI development in Namibia and Ghana was donor driven and did not include elements critical for the successful implementation of SDIs, such as a legal framework (Sinvula et al., 2013; Owusu-Banahene et al., 2013). The first attempt at an SDI in Namibia and the NAFGIM project in Ghana are textbook examples of SDIs that were not sustainable due to funding that stopped. A legislative framework can prevent this, provided the government of the day has the funds and political will to allocate funds to SDI implementation.

The stages of SDI development in South Africa, Namibia and Ghana vary significantly, but each SDI has had periods of stagnation and deterioration. In Namibia and Ghana, for example, SDI development initiatives started based on foreign donor funding and these initiatives stagnated and/or died a natural death immediately after the projects closed operations. In South Africa, SDI development followed a more legislative and institutional process, but there was a long dormant period between the SDI Act coming into force and the appointment of CSI members for its term.

An interesting observation is the difference in the main driver behind SDI development: drivers differ from one country to another, and may also change over time in a particular country. In South Africa, an early driver of the SDI was the Chief Surveyor General's Office, responsible for national mapping and the cadastre. In Namibia and Ghana, the first SDI initiatives were driven by the need

for environmental information. Today, the driver behind the legislated SDI in Namibia is the integration with statistical information, and in Ghana, SDI initiatives aim to support the development of land policies for land administration.

4.2. Policy Maker

In all three cases, Parliament acts as the *Legislator* who determines the SDI framework through legislation. The Department of Rural Development and Land Reform (formerly Department of Land Affairs) prepared and tabled the South African SDI legislation in Parliament, while the National Planning Commission of Namibia prepared and tabled the Statistics Bill in their Parliament. The Parliament in Ghana will assume the role of *Legislator* to pass the bill into a law.

The Ministers responsible for Rural Development and Land Reform in South Africa and for Economic Planning in Namibia, respectively appoint the CSI (SASDI) and the CSD (NSDI). The Minister and the respective committee play the roles and functions of *Decision Maker* in SASDI and NSDI, whereas NAFGIM established a steering committee, which acted as the *Decision Maker*.

The functions of *Secretariat* are carried out by the NSA (NSDI) and the NSIF (SASDI), as specified in the respective SDI laws. In Ghana, the NAFGIM secretariat fulfilled this role.

While specific government departments in Namibia and South Africa acted as *Champions* of their SDIs before and after the promulgation of the Acts, there were also individuals who strongly promoted the sharing of spatial information long before the Acts were drafted. In Ghana, the World Bank and DANIDA were the NAFGIM *Champions*, while the LAP-1 and LAP-2 projects in the Ministry of Lands and Natural Resources *championed* the latest SDI policy framework.

Apart from individuals who acted as *Champions*, the policy makers in Namibia and South Africa are predominantly government institutions or agencies. The current transitioning in Ghana also reflects this trend.

4.3. Producer

The ICA stakeholder typology describes *Producers* in terms of their *Status*, *Motivation*, *Role* and *Skill*.

4.3.1. Status

In the stakeholder analysis, most *Producers* in the three countries were public sector organizations. The stakeholder typology does not include attributes to distinguish between different official producers; therefore all public sector organizations were listed with the *Status* of *Official Mapping Agency*.

Examples are the Survey Department (Ghana), the Department of Survey and Mapping (Namibia) and the Department of Rural Development and Land Reform (South Africa) are responsible for producing the national geodetic frameworks, aerial photography and digital terrain/elevation models. In Ghana and Namibia, they are also responsible for delineating national, provincial/regional, and constituency/district, metropolitan, municipal and town boundaries; in South Africa, this is the responsibility of the Municipal Demarcation Board.

Major official data producers in Ghana are the Survey Department, the Lands Commission, the Soil Research Institute, the Meteorological Services Department, and CERSGIS, whose role is to collate and produce relevant spatial datasets conforming to standards. Government agencies and institutions of similar status as those in Ghana are responsible for producing spatial datasets for the NSDI and for SASDI.

In South Africa, Namibia and Ghana there are various examples of *Commercial Mapping Agency*, such as MapIT (MapIT, 2017), AfriGIS (AfriGIS, 2017), Southern Mapping (Southern Mapping, 2017), and GeoTerraImage (GeoTerraImage, 2017) in South Africa, Geo Business Solutions (Geosol, 2017) in Namibia, and CTK Aviation Ltd in Ghana. Such private companies are sometimes contracted by government agencies to produce data, but they are not part of the SDIs.

While the Environmental Information System managed by Raison in the early (non-legislative) Namibian SDI initiative resembled a *Crowd Sourcer*, today, none of the SDIs has a data or service *Producer* with the *Status* of *Community Interest* or *Crowd Sourcer*.

4.3.2. Motivation

Most *Producers* in the three countries can be regarded as having an *Economic Motivation*: 1) Organizations with a *Status* of *Official Mapping Agency* produce data and services for SDIs because it is mandatory for them and hence they do this for economic purposes (i.e. their budget provides for this). 2) Organizations with a *Status* of *Commercial Mapping Agency* are profit-driven.

In Namibia and Ghana some of the *Producers* have a *Special Interest as Motivation*. For example, CERSGIS in Ghana produced community-based social infrastructure maps. No *Producers* with *Process* as *Motivation* were identified in any of the three countries.

4.3.3. Role

The organizations with a *Status* of *Official Mapping Agency* in the three countries play the *Role* of *Raw Data Captor.* In NAFGIM, selected private companies with the *Status* of *Commercial Mapping Agency* performed this role.

Users of spatial data and services within the SDIs are responsible for reporting errors and therefore have the *Role* of *Submitter of Revision Notice*.

In South Africa, *Passive Producers* of data exist, but this data is not included in SDI base datasets. No other *Passive Producers* were identified.

Individual data *Producers* administer their databases, i.e. each one of them has the role of *Database Administrator*. In Ghana, the NAFGIM secretariat played the role of *Database Administrator*.

There are many more roles that could be assigned to data *Producers*, e.g. in the South African SDI, one of the custodians will play a coordinating role by arranging that street centrelines from local, provincial and national government are integrated into a single national base dataset. Another example is the producers of derived datasets who use one dataset to prepare another (therefore they do not play the role of *Raw Data Captor*). These roles become clearer as the SDI is implemented and matures. The ICA's stakeholder typology could be extended to include additional *Producer Role* descriptions that are commonly found in SDIs.

4.3.4. Skill

The *Producers* in the three countries were classified mainly as *Expert Professional* and *Expert Authority*. *Expert Amateurs* were reportedly involved in Ghana. None of the *Producers* were classified as *Neophyte* and *Interested Amateur.*

Describing the organizations identified as *Producers* in the three SDIs according to the *Skill* level was problematic because organizations comprise many individuals, often with very different *Skill* levels. An improved characterization of *Producers* should acknowledge that a single *Producer* may be represented by multiple individuals and include a description of the maturity of the organization. The comparative analysis for the *Skill* of *Producers* is based on perceptions and typical job descriptions at these organizations. More in-depth studies of different *Producer* organizations can be done to better understand the skills at each of them.

4.4. Provider

In the three countries, *Producers* are typically also *Data Providers* and *Data Distributors* of the data that they produce, both for use within their organization and for the external use by others. Additional *Data Distributors* include the NSA in Namibia, NSIF and NGI in South Africa, and EPA and CERSGIS in Ghana.

Many of the *Producers* are also *Service Providers* for internal use and these services are sometimes made available to other stakeholders. Additional *Service Providers* are currently limited. No *Service Distributors* were identified at this stage.

No *Data Arbiter* and *Service Arbiter* were identified in any of the countries.

4.5. Broker

Brokers in the role of *Finder,* e.g. organizations selling data portfolios to users or sourcing data for users, exist in all three countries. *Brokers* acting as *Cataloguer* also exists in each of three SDIs.

A *Broker* acting as *Harvester* existed in Ghana and there are plans for such brokers in Namibia and South Africa. *Brokers* in the role of *Négociant* were identified in Namibia and Ghana, and may appear in South Africa in future as and when the SDI matures.

No *Brokers* acting as *Crowd-sourcing Facilitator* were identified in any of the three countries.

Based on the results of the comparative analysis, it seems that *Finders* and *Cataloguers* emerge at an early stage of SDI development, while it is expected that the other types of *Brokers* will appear at more mature stages of the respective SDIs in the three countries. This remains to be seen.

4.6. Value-Added Reseller (VAR)

In all three countries, there are public and private sector *VARs* in the role of *Publisher* of SDI datasets. There are also *VARs* acting as *Aggregator/Integrator. VARs* in the public and private sector exist, such as AfriGIS and SPISYS in South Africa; the Ministry of Environment and Tourism in Namibia; and EPA, CERSGIS, and the Soil Research Institute in Ghana.

 'Reseller' in the name of this stakeholder type is misleading because some public sector organizations do not *sell* the data and services to which they have added value.

4.7.   End User

Examples of *End Users* in the three countries are citizens, visitors, government employees, consultants and private companies.

The distinction only between a *Naïve User* and an *Advanced User* is limited. It is quite easy to imagine a range of other roles for *End Users*, e.g. based on how data is used (e.g. view, manipulate, transform), the purpose for which the data is used (e.g. mapping, visualization, analysis) and whether the *End User* is an organization or an individual. Identifying such roles will require in-depth analysis of more than one fully functioning SDI.

5. CONCLUSION

In this paper, SDI developments in three African countries were described and analysed. The stages of SDI development in South Africa, Namibia and Ghana vary significantly, but each SDI has experienced periods of waxing and waning. A legislative framework, the availability of sustainable funding and the commitment of stakeholders, particularly the *Policy Makers*, were seen to be essential for SDI development in the three countries.

SDI stakeholders in the three countries were described based on the stakeholder typology in the ICA's SDI model: the *Policy Maker*, *Producer*, *Provider*, *Broker*, *VAR* and *End User*. Apart from individuals who acted as *Champions*, *Policy Makers* in Namibia and South Africa are predominantly government institutions or agencies. The current transitioning in Ghana also reflects this trend; and the same can be said for *Producers* in the three countries. The other stakeholders (*Provider*, *Broker*, *VAR* and *End User)* are typically found in the public and the private sector. Based on the comparative analysis, it seems that *Brokers* acting as *Finders* and *Cataloguers* emerge at an early stage of SDI development, while it is expected that the other types of *Brokers* will appear at more mature stages of the SDI.

Drawing on the application of the ICA's stakeholder typology to SDIs in South Africa, Namibia and Ghana, we consider the typology to have been useful for comparing stakeholders but a number of recommendations for refining the typology can be made:

1. The typology refers to sub-types but these are not always subordinate or special kinds of the more general type. In some cases, the so-called sub-type is a descriptive attribute (e.g. status, motivation and skill of the producer); in other cases the sub-type is not subordinate to the type, e.g. not all decision makers are necessarily policy makers. The typology could be refined to include both attributes and sub-types and existing sub-types

should then be renamed and restructured appropriately. As part of this revision and refinement, additional stakeholder types, such as researchers and educators could also be added. Additional attributes, e.g. legal mandate as a motivation for producers, could also be added.

2. Currently, *Official Mapping Agency* is the only type of public sector *Producer*. More types are needed to describe different public sector *Producers* more accurately, for example, to distinguish between local, provincial and national government *Producers.* Organizations, other than mapping agencies that produce data for the SDI (e.g. statistical agencies and other government agencies), should also be included.

3. The typology could be extended to include additional *Roles for a Producer. Role*, such as coordinator, integrator and producer of derived datasets, which are commonly found in SDIs. Currently, there are four Roles: Captor of Raw Data, Submitter of Revision Notice, Passive Producer, Database Administrator.

4. There is room for improving the characterization of *Producers* by acknowledging that a single *Producer* may be represented by multiple individuals and by including a characterization of the maturity of the organization.

5. 'Reseller' in *Value-Added Reseller* is misleading for this stakeholder type because some public sector organizations do not *sell* the data and services to which they have added value.

6. The distinction between only two types of *End User*, namely *Naïve User* and an *Advanced User,* is limited. Further refinement is required, e.g. based on how data is used (e.g. view, manipulate, transform), the purpose for which the data is used (e.g. mapping, visualization, analysis) and whether the *End User* is an organization or an individual. Identifying such roles will require in-depth analysis and comparison of the users in more than one fully functioning SDI.

The collective understanding and application of the ICA stakeholder typology by the authors provides a basis for similar application in other countries. While most of the stakeholders in this research were from the public sector, SDIs can exist without having government institutions as stakeholders and the ICA's stakeholder typology can also be applied to them. However, unless there is a clear delineation of what is 'within' and what is 'outside' the SDI, there could be additional stakeholders and SDI-related activities that are not yet represented in the model (Owusu-Banahene et al., 2013).

Additional applications of the stakeholder typology would provide useful input for refining the stakeholder typology. It would also contribute to understanding stakeholder roles in SDIs. If enough applications are done, some findings of this research could be generalized to SDIs in Africa, developing countries or the world. Future work could also look at how SDI stakeholder roles change over time, e.g. as the SDI matures.

SDIs are emerging in many countries around the world. This research improves the understanding of SDI stakeholders and SDI development. The comparison reveals which stakeholders are critical for successful SDI development and implementation. We hope that the findings can help others with understanding their SDIs and influencing them to evolve into fully functioning and sustainable SDIs.

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