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The South African Spatial Data Infrastructure – Where are the Municipalities?*

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Abstract

Many municipalities in South Africa, especially those in rural areas, do not have the resources to maintain the geospatial information required to deliver essential services. Conversely, National Geo-spatial Information (NGI), the national mapping agency (NMA), captures data themes required by municipalities but not at scales suitable for municipal purposes. In 2003, the South African Spatial Data Infrastructure (SASDI) was initiated through national legislation as the 'national technical, institutional and policy framework' to govern public geospatial information. However, involvement of the country's more than 250 municipalities in SASDI has been limited. In order to better understand the role of municipalities in the development and implementation of SASDI, we reviewed this over four periods: (1) before 1994, i.e., before the new Constitution of South Africa came into force; (2) 1994 to 2000, when the idea of an SDI emerged through voluntary participation; (3) 2000 to 2009, when the SASDI legislation was enacted but nothing really happened; and (4) from 2010 to date, starting with the first meeting of the Committee for Spatial Information, the SASDI coordinating body. The review confirms that unless SASDI steps in to provide coordination mechanisms between different spheres of government, the NMA will continue to supply unsuitable data and municipalities will be left to their own devices. A SASDI that caters for diverse user needs through bottom-up influences could greatly improve local

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municipalities' service delivery. We have used the results of our study to propose a governance framework where all spheres of government are involved in SASDI and municipalities have an opportunity to communicate their data needs from the bottom, upward.

Keywords: SASDI, SDI evolution, municipalities, bottom-up SDI, decentralised SDI, service delivery

1. INTRODUCTION

1.1. South African Municipalities for Service Delivery

In South Africa, under Constitutional Law, the three spheres of government are established as the national, provincial and local spheres, and collectively they are described as: "distinctive, inter-related and inter-dependent" (South Africa, 1996). The entire Republic is made up of 278 contiguous municipalities, each one having jurisdiction over the area within its demarcation. Municipalities are supported by their respective provincial government offices; there are nine provinces in total. Provincial offices are supported by national government. The municipal sphere is directly responsible for providing services to the public, such as clean water and sanitation. As such, they rely heavily on good quality spatial information, both from their internal departments and from external organisations. For those municipalities that are under-resourced, a common case in South Africa, access to external fundamental spatial information becomes crucial for the municipalities' day-to-day functioning. Though this inter-dependency exists, the intergovernmental relationships required to meet the needs of municipalities still needs much work. By its very nature, national spatial data infrastructures (SDIs) can facilitate and coordinate those fundamental stakeholder relationships.

1.2. SASDI and the Municipal Capacity Building Project

The South African spatial data infrastructure (SASDI) was enacted in 2003 by the Spatial Data Infrastructure Act (No. 54 of 2003) (or SDI Act) as the 'national technical, institutional and policy framework' to govern public geospatial information (South Africa, 2003). The SASDI governance structure, which is coordinated by the Committee for Spatial Information (CSI), comprises a variety of stakeholders, including municipalities. The degree of involvement and thus the level of influence of all stakeholders are determined by the CSI. Municipalities have been represented mainly through CSI membership and participation on the various subcommittees, who are responsible for advising the CSI on SASDI development and implementation. According to Siebritz et al. (2021), the municipal representation on the CSI has been insufficient and, as such, has not offered much assistance to municipalities in their management of geospatial information. Adding to this, there has not been any consultation with the local sphere with respect to the hinderances to effective and efficient data management. This has had negative consequences for the local sphere. Many municipalities, especially those situated in rural areas, do not have the resources to capture and maintain the geospatial data they require to deliver essential services to the public. Other organisations, such as the National Geo-spatial Information (NGI), the national mapping agency

(NMA) of South Africa, captures data themes required by municipalities but not at the scales suitable for municipalities (Siebritz et al., 2021). Unless SASDI provides the coordination mechanisms whereby municipal data needs are relayed to the NMA, the NMA will continue to supply unsuitable data and struggling municipalities will be left without the required support. Conversely, if SASDI is able to cater for diverse user needs through bottom-up influences, it could greatly improve service delivery in the local sphere (Siebritz et al., 2021).

The Municipal Capacity Building Project, initiated in August 2019 was motivated by the need to assist municipalities with their data management plans, based on SASDI principles: access to data, sharing of data and no duplication. The project employs a bottom-up approach whereby municipalities are actively engaged to understand their context and determine their data management challenges (Siebritz et al., 2021). This article supports the project by reviewing the role of municipalities in the development and implementation of SASDI for the past four decades. This will help us to understand the degree to which SASDI has responded to the municipal data challenges in the past and will provide a baseline for future planning to better assist municipalities.

To this purpose a longitudinal study was undertaken, spanning four periods: before 1994, 1994-2000, 2000-2009 and 2010 onwards. For each period, we briefly review relevant international SDI trends, and then present the SASDI vision and objectives, legal framework, operations, available resources and the role of municipalities available for the period. Our review of these SASDI components allowed us to understand how each component has developed over the four periods and how the interaction of the components have influenced the overall trajectory of the SASDI over time, in other words the SASDI governance. From this, we were able to understand the extent to which SASDI has supported municipalities with their data management to support their core business, which is service delivery. Based on our findings and on our stakeholder engagement through the Municipal Capacity Building Project, we propose a governance structure for municipal involvement in the national SDI. In Siebritz et al., (2021) we present a critique on the role of municipalities in SASDI developments and include recommendations to capacitate municipalities in SDI participation and implementation.

The article is structured as follows. Section 2 briefly reviews SDI development trends; Sections 3 to 6 provide a summary of SASDI activities for each period, Section 7 presents the summary and results of our study which includes the proposed governance structure for SASDI, and the conclusions are provided in Section 8.

2. LITERATURE REVIEW

The intended purpose of the SDI concept has changed over time, at first it was seen as a way to centralise and standardise spatial information from the national perspective. According to SDI literature, this first generation of SDIs emerged from the 1980s, following a mostly top-down product-based approach, in which national mapping agencies played a major strategic and operational role (Rajabifard et al., 2006). In the early 2000's a second generation of process-based SDIs took

advantage of the capabilities of the Internet and the World Wide Web (Rajabifard et al., 2006; Masser, 2009). The focus shifted from data in itself to creating an infrastructure and facilitating information access, e.g. through Web services, so that data can be used (Rajabifard et al., 2006). Up until this point, national government was still taking the lead in SDI development, while the role of sub-national government in NSDIs remained unclear. In an investigation by Harvey and Tulloch, (2006), the authors found that data sharing in US local government continued to happen informally and infrequently – i.e. as data is required or requested, despite the national NSDI policies which called for coordinated sharing practices. The authors concluded that second-generation SDIs can only be effective if the uptake of SDI in local government is improved.

By the mid-2000s a third generation of SDIs had already emerged. With a greater focus on SDI governance, specifically decentralised SDI governance, defining the roles and influences of sub-national government, the private sector and users, became vital (Rajabifard et al., 2006; Budhathoki et al., 2008; Masser, 2009). Unlike the second generation of SDIs, which were propelled by technological advances, the third generation SDI required a shift from the prescriptive, top-down approach to promote inclusive governance and to ensure that SDIs respond to user requirements adequately. In other words, empowering the various stakeholders to participate in the SDI in their respective roles became priority - shifting the focus away from data production. Two examples of proactive municipal integration into national SDIs can be observed in the Netherlands and Flanders, respectively. In both cases, municipalities are responsible for producing the data and ensuring the data remains up-to-date, while the coordination and centralised access to the data is undertaken by a dedicated organisation at the national level (Coetzee et al., 2019; Coetzee et al., 2020).

3. SASDI AND THE ROLE OF MUNICIPALITIES BEFORE 1994

3.1. International Context

The term *spatial data infrastructure* (SDI) first appears in the literature in 1990, in the review report, *Spatial Data Needs: The Future of the National Mapping Program*, conducted by the National Research Council for the United States Geological Survey (National Research Council, 1990). This led to the influential Executive Order, *Coordinating Geographic Data Acquisition and Access: The National Spatial Data Infrastructure*, which defined the National Spatial Data Infrastructure as 'the technology, policies, standards, and human resources necessary to acquire, process, store, distribute, and improve utilization of geospatial data' (Clinton, 1994).

Of course, primitive SDI-type developments happened around the world before 1990. The term *geographical information system* (GIS) was first coined in late 1963, in the name for the first such system, the Canadian Geographical Information System (CGIS) (Tomlinson, 1988). Indeed, some might consider CGIS to have been an SDI, as well as having been the first GIS. CGIS catered for 'physical, biological, social, and economic data [...] for land use planning and management at national, provincial, regional, and local levels' (Fisher and MacDonald, 1980). CGIS began as the core of the Canadian Land Inventory (Tomlinson, 1988) and

has been so successful that it is still in use today, though obviously much changed and it is more comprehensive than it was in the 1960s.

3.2. Vision and Objectives

The first geographical information systems (GISs) in South Africa were imported or developed locally during the 1970s, such as a computerized thematic mapping capability developed at the University of Stellenbosch from 1972 onwards (Zietsman, 2002), a computer-aided cartographic facility developed at the Council for Scientific and Industrial Research (CSIR) (Roets, 1974), and a collaboration between the CSIR and the University of Saskatchewan in Canada on the automatic vectorization of scanned maps (Peuquet, 1981). By the start of the 1980s, several private companies, government departments, municipalities and other organisations began buying commercial GISs, as opposed to using systems cobbled together in-house. The CSIR's research and development led ultimately to the design and development of a comprehensive GIS, handling alphanumeric, vector and raster data, and managing maps and aerial photographs (Cooper, 1989). This work laid the foundation for the National Exchange Standard (NES) and the commercial South African GIS, ReGIS (Cooper and Hobson, 1991). Geospatial data across organisations, that is, fledgling SDI concepts, were first made at local conferences in the 1980s.

3.3. Legal Framework

Before 1994, no legislation was developed in South Africa for SDIs. During the 1980s and early 1990s, the primary legislative concern was over copyright, for two reasons. Firstly, and most obviously, was the concern by those creating datasets of maintaining their income streams. It was expensive to produce datasets, with most data being collected in the field or manually digitised off paper map sheets or mylar overlays (on which data had been transcribed manually). Only limited remotely sensed data were available, from aerial photography or satellites (primarily Landsat). The imagery was so expensive that when a researcher or academic managed to obtain a single image (whether digital or a physical photograph), that was all they had to work on for a long time.

The second concern over copyright related to the manual digitising of paper maps that were then portrayed as being true copies of the original. The quality of the manual digitising varied significantly between different operators (unsurprisingly). The job specifications for digitising map sheets were often limited to specific features (with contours invariably being omitted because of the sheer volume and difficulty of digitising them manually) or even only parts of the map sheet. In addition, the operator was not necessarily given the latest edition of the map sheet; and generally, no metadata was ever provided. Consequently, the major map producers were concerned that their reputations were being tarnished by the quality of all the digitising done in contravention of their copyright and by all the competing digital versions of their maps now in circulation. Hence, several map producers considered prosecuting such contraventions of copyright, but it is not certain that any cases came to court.

3.4. Operations

The State inter-departmental Coordinating Committee for the National Land Information System (CCNLIS) was established in March 1988. At that stage, the main objectives of the CCNLIS was to coordinate national land information by:

- "ensuring that all institutions can participate within the National Land Information System (NLIS);
- eliminating duplication of time, data and effort;
- drawing up standards for data and the exchange of geo-referenced information; and
- ensuring that the specifications and standards for the NLIS are adhered to" (Andersen Consulting, 1991).

In May 1988, NLIS was declared a transversal system by the then Commission for Administration, with the then Chief Directorate: Surveys and Land Information (now Chief Directorate: National Geospatial Information) of the Department of Public Works and Land Affairs as the secretariat for the CCNLIS (Andersen Consulting, 1991). Effectively, this meant that the CCNLIS was responsible for coordinating GIS and related activities in government departments. In practice, its primary focus was on coordinating the capture of aerial photography. The CCNLIS was chaired by the Chief Surveyor General within the Department of Agriculture, Rural Development and Land Reform (DARD&LR) (Cooper, 1993).

Founded in 1975, the National Programme for Remote Sensing (NPRS) was one of several National Programmes of the Foundation for Research Development (FRD) that funded scientific and engineering research in South Africa during the 1980s. During 1989, with the re-organisation of the FRD, all the National Programmes were phased out, and the FRD introduced new Special Programmes (Arndt, 1988). The National Programmes provided a framework for proposals for research projects in specific fields. In April 1986, the CSIR and the Chief Directorate of Surveying and Mapping (CDSM) (now Chief Directorate: National Geospatial Information) proposed developing a national standard for the exchange of digital geographically referenced information, funded mainly by the NPRS. This resulted in the South African standard for the exchange of digital geographically referenced information, known as the National Exchange Standard (NES) (Clarke et al., 1987; Standards Committee, 1991).

3.5. Available Resources

During this period, resources were extremely limited and expensive, partially because widespread use of computers only started, but also due to sanctions being imposed on South Africa during the apartheid era.

3.6. Outcomes

The National Topographic Information System (NTIS) was developed between 1986 and 1997 by the Chief Directorate: Surveys and Mapping (CDSM). First, maps were scanned, and vectorised, next, geospatial data was structured and populated into a geographic information system. In June 1988, a locally developed GIS software product, called ReGIS, was acquired for this endeavour (Vorster,

2003). ReGIS could store non-spatial data in industry standard relational database management systems. In 1994, data from a 'continuous digital database', captured and maintained with ReGIS, was used in the production of an illustrated atlas of Southern Africa (Reader's Digest, 1994).

3.7. Role of Municipalities

The Durban Corporation (now called eThekwini Metropolitan Municipality in the Kwa-Zulu Natal province) was probably the first South African municipality to acquire a GIS in the early 1980s. Several municipalities followed during the 1980s, such as Cape Town, Johannesburg, Randburg, Sandton, Midrand and Pretoria.

4. SASDI AND THE ROLE OF MUNICIPALITIES FROM 1994 TO 2000

4.1. International Context

First generation, product-based SDIs tended to be led by data producers and national mapping agencies, focusing on data production, database creation, and centralization. Data was a key driver of product-based SDIs (A. Rajabifard et al., 2006).

Two international, technical standards bodies were established in 1994, the Technical Committee of the International Organization for Standardization, ISO/TC 211, Geographic information/Geomatics, and the Open Geospatial Consortium (OGC). They have collaborated closely on many standards and related matters. During the early years, important groundwork was laid, so that by the early 2000s the first versions of technical standards were published, including the first metadata standard (ISO 19115:2003), ISO 19139:2007, ISO 19111:2003 and ISO 19101:2002. South Africa, and Africa as a whole, has had very limited participation in the OGC, primarily because of the cost of membership.

4.2. Vision and Objectives

The vision to establish the National Spatial Information Framework (NSIF) as a Sub-directorate in the Department of Land Affairs came from the National Mapping Agency in 1999. The NSIF was aimed specifically at establishing an SDI in South Africa. During those start-up years, the NSIF quickly built up a team of young professionals and progress was made on drafting the SDI Act and meetings were held with the nascent Committee for Spatial Information (CSI) and its subcommittees. These were not statutory committees but were rather created from those available and interested. The members of these committees were drawn largely from the public sector but included some participants from the private sector.

4.3. Legal Framework

The most important legislation passed during this period was The Constitution of the Republic of South Africa (South Africa, 1996). This provided the framework for the Promotion of Access to Information Act (PAIA) (South Africa, 2000), which changed dramatically the availability of geospatial data from the three spheres of government, which could now be obtained for free or for a nominal cost. Initially, this caused significant problems for the departments and municipalities with a

deluge of requests for data, but this settled down quickly as they streamlined their processes. A key part of this was making datasets available online, though it would be some years before the available bandwidth was sufficient to download even moderately sized datasets. During this period, work began on drafting the SDI Act (South Africa, 2003).

4.4. Operations

In 1999, SC71E, Geographic information (now SABS/TC 211), the local mirror committee for ISO/TC 211 was established. South Africa was a member of ISO/TC 211 from the start (ISO/TC 211, 1994), but it was only in 1998 that the first South African participated in an ISO/TC 211 Plenary (in Beijing, China). From 2000 onwards, several South Africans took leadership positions in ISO/TC 211.

4.5. Available Resources

Apart from the spatial data discovery facility (SDDF), there was not anything available to help institutions to implement SDI.

4.6. Outcomes

The SDDF was established by the NSIF and populated with metadata files, mainly by users outside of government.

4.7. Role of Municipalities

From 1994 onwards, major changes were made to the administrative structures across the whole of South Africa, with four provinces and the former homelands (four being nominally independent) being merged and split into nine provinces. Municipalities were also combined in various ways (and sometimes split, because of politics). Consequently, municipalities' primary concerns were over the complexities of merging their different corporate systems (including GISs) and processes, rather than on SDIs.

5. SASDI AND THE ROLE OF MUNICIPALITIES FROM 2001 TO 2009

5.1. International Context

Since 2000, Western governments started moving away from a market perspective on governance. Concepts such as 'trust' and 'transparency', which are characteristic of the network approach also gained importance (Sjoukema et al., 2017). This led to the 'open government' concept in which the freedom of information was deemed important to ensure accountability, trust and public participation towards facilitating the democratic process (Sjoukema et al., 2017). In Europe, this led to Directive 2003/98/EC on the re-use of public sector information followed by the INSPIRE Directive in 2007, which established an SDI for Europe (European Parliament, 2007; European Parliament, 2013).

During this period, around 2004, it became possible to edit and update information on the Web, commonly referred to as Web 2.0, and which resulted in user-generated content, volunteered geographic information and crowdsourcing (Coetzee, 2018). Web 2.0 spawned virtual communities or virtual social networks,

whose members shared data - with each other and with the public (Cooper et al., 2011). Users, specifically non-professionals, could now play a much more active role, evident from initiatives such as Wikimapia (www.wikimapia.org) and OpenStreetMap (www.openstreetmap.org), which emerged during this period. Siebritz et al., (2012) assessed the volunteer contributions to OpenStreetMap between 2006 and 2011 for different settlement areas in South Africa and concluded that the contributions are strongly correlated to the geographic location – densely populated areas received more contributions than less populated areas. Moreover, at the time, there were no clear trends of increased user contributions over the years.

Web 2.0 led to an increase not only of geospatial data volumes, but also of diversity in geospatial data. For the first time, location-based data produced by anyone on social media platforms, such as Twitter and Facebook, could be mapped and analysed. This new diversity created challenges (e.g. heterogeneous data models) and opportunities (e.g. additional kinds of data) for map production.

Second generation process-based SDIs took advantage of the capabilities of the Internet and the World Wide Web. The focus shifted from data in itself to creating an infrastructure and facilitating information access, e.g. through Web services, so that data can be used. Data sharing drives the process-based SDI, facilitating reuse of data collected by a wide range of organizations for a variety of purposes (Rajabifard et al., 2006).

The Committee on Development Information (CODI), later renamed to the Committee on Development Information, Science and Technology (CODIST), hosted by the United Nations Economic Commission for Africa. CODIST aimed to 'advise on the building, maintenance and dissemination of regional development databases, including textual and spatial databases, and assist in strengthening the capacity of member States to improve their national information systems'. The subcommittee on geoinformation focus on this specifically. South Africa participated in several sessions and meetings (e.g. United Nations Economic Comission for Africa, 2003; Cooper, 2009).

A final international development of interest is the formation of the Global Spatial Data Infrastructure (GSDI) Association in 2004 (GSDI, 2015a). It had organizational members (academic and research institutions, government agencies, commercial companies, not-for-profit organizations, and national or regional associations) and individual members (professionals and students). The GSDI was involved in capacity building, e.g. by hosting workshops, seminars and training opportunities, and funding GSDI projects and the GSDI Small Grants Program. A few grants were awarded to projects related to the South African SDI (GSDI, 2015b).

5.2. Vision and Objectives

SDI legislation was enacted early in this period, with the objective to 'establish the South African Spatial Data Infrastructure, the Committee for Spatial Information and an electronic metadata catalogue; to provide for the determination of standards and prescriptions with regard to the facilitation the sharing of spatial information; to

provide for the capture and publishing of metadata and the avoidance of duplication of such capture' (South Africa, 2003). This presented a shift from voluntary participation to a legislative approach to SDI implementation (Clarke, 2011).

The predecessor of the statutory Committee for Spatial Information (CSI) had the same name but was an Inter-Governmental Committee with the aim to, amongst others, 'eliminate overlapping and duplication of the collection and capturing of geographical Information' (Committee for Spatial Information, 2003). The objectives of the Act extended this aim to include standards and a metadata catalogue.

5.3. Legal Framework

Coetzee and Cooper, (2008) noted that in the period from 1998 to 2004: 'the national mapping organisation, a major supplier of geospatial information, obtained approval for a policy shift in the pricing model for geospatial information'. Information products were provided at the cost of supplying such products. This led do significantly increased use of geospatial information and many private sector opportunities for providing value-added services.

The NSIF initiated the SDI Act (South Africa, 2003), however, by then the NSIF was in decline and lost most of its staff over an 18-month period (Harvey et al., 2012). Apart from passing the SDI Act into law in early 2004 and drafting regulations in support of the Act, the South African SDI effectively came to a standstill. The online metadata catalogue was still operational, but users were not contributing any metadata records to the catalogue (Smit et al., 2009).

5.4. Operations

The Inter-Governmental CSI had three subcommittees (Committee for Spatial Information, 2003):

- The Policies subcommittee developed policies for promoting access to and sharing of geospatial information, covering issues such as pricing, data custodianship and information sharing.
- The Liaison subcommittee was tasked with communicating CSI activities to all spheres of government.
- The Technical subcommittee focused on development and implementation of standards and tools, development of product specifications and undertaking national projects.

According to Clarke, (2011), implementation of the SDI Act after its enactment was slow. For example, the CSI, tasked with facilitating SASDI implementation and advising the Minister accordingly, was not established. As a result, very little progress was made with SASDI, the metadata catalogue, standards, etc. A geoportal was developed but not maintained, metadata was scarce. One of the reasons for this was the NSIF losing most of its staff.

Even though officially little happened in this period, SDI-like activities could be observed and led to several outputs (Harvey et al., 2012). For example, the National Department of Agriculture, together with all nine provincial departments

dealing with Agriculture and the Agricultural Research Council developed the Agricultural Geo-referenced Information System (AGIS) (AGIS, 2011). The Earth Observation unit of the South African National Space Agency (SANSA) at Hartebeeshoek had been receiving, processing and archiving satellite imagery for many years, and the imagery was available through an online catalogue. In April 2007, the first multi-government license for SPOT 5 imagery was put into place, a first anywhere in the world. Through this, ortho-rectified and mosaicked images were accessible to anyone in government, universities and schools in South Africa (CSIR, 2008).

By the end of the first decade of the 21st century, SDI activities in South Africa resembled different generations of SDIs. SANSA's top-down approach of providing satellite imagery to the whole country is typical of first-generation product-based SDIs in the 1990s. AGIS (2011) put the focus on users and problem-solving, as seen in second generation process-based SDIs. In contrast, Smit et al., (2009) states that the City of Cape Town Metropolitan Municipality (CoCT) within the Western Cape adopted a user-driven bottom-up approach to data sharing. However, the study defines 'users' to be the departments within the municipality, and not any other institutions or the general public. The CoCT and other municipalities appointed private sector companies to maintain national datasets for streets, cadastre and addresses, based on various types of bi-directional data sharing agreements with municipalities (Smit et al., 2009; Sebake and Coetzee, 2011).

5.5. Available Resources

There was not anything available to help institutions to implement SDI, e.g. catalogue, training, standards. The standards development process was facilitated by the South African Bureau of Standards (SABS), who also provided financial support for South African representatives to attend international ISO/TC 211 meetings. A research project by the National Research Foundation provided some financial support for the SANS 1883 project leader, but other than that, there was no financial support for the development of standards.

5.6. Outcomes

In 2001, Gavin, (2001) reported that an 'operational metadatabase', the SDDF, contained nearly 3,000 metadata records about public and private sector datasets covering the SADC region. In July 2003, the proposed layout of a new metadata capturing tool was presented to the CSI Technical subcommittee who provided feedback. The tool was based on the newly published ISO 19115:2003 metadata standard (CSI Technical Subcommittee, 2003), however there is no evidence that the new layout was implemented during this period.

SANS 1877:2004, A standard land-cover classification scheme for remote-sensing applications in South Africa, provides the three-level hierarchical classification used for the 1994/5 National Land Cover (NLC94) database (Thompson, 1996), NLC2000 (Verhulp and Denner, 2014) and other projects. The classification was designed to conform to that used for the AFRICOVER project of the Food and Agriculture Organisation (Thompson, 1996), which subsequently spawned ISO

19144-2:2012, Geographic information – Classification systems – Part 2: Land Cover Meta Language (LCML).

In 2003, SC71E initiated a project to develop a South African National Standard as a standard framework for South African addresses with the aim of facilitating interoperability of address data. Development of the standard commenced in 2006, attracting wide participation from private and public sector organizations (Coetzee and Cooper, 2007), including several municipalities. In 2009, two parts of the addressing standard were published (SANS 1883-1:2009 and SANS 1883-3:2009).

5.7. Role of Municipalities

Section 5 of the SDI Act establishes the CSI. Provision for municipal influence is provided for through the members representing the national department of Provincial and Local Government and two local municipalities (South Africa, 2003). Other stakeholders who may indirectly represent the interests of the local sphere are the South African Local Government Association (SALGA) and the national Department of Cooperative Governance and Traditional Affairs (CoGTA). In principle, the legislation allowed municipalities to be represented on the CSI, but no CSI members were appointed until 2010.

6. SASDI AND THE ROLE OF MUNICIPALITIES SINCE 2010

6.1. International Context

Third generation SDIs, which emerged during this period introduced the concept of governance and more specifically, decentralised governance. Despite the growing importance of SDI governance, Coetzee and Wolff-Piggott, (2015) note the paucity of literature on this topic. It may be that during the last decade, countries have still been navigating the transition from a data management to a data governance approach, which requires a significant paradigm shift. In the Netherlands and Flanders however, considerable research has been presented on SDI governance systems and coordination approaches (Crompvoets et al., 2008; Geudens et al., 2009; Macharis and Crompvoets, 2014; Sjoukema et al., 2017; Sjoukema et al., 2020; Sjoukema et al., 2021), motivating that SDI governance should align with the principles and concepts of public governance. Furthermore, some of these and others have argued that well-functioning SDIs can contribute to a system of ‘good governance’ (Jacoby et al., 2002; Craglia and Johnston, 2004; Crompvoets et al., 2008; Timo et al., 2018), which is built on principles such as transparency, equity, and participation (Iftimoaei, 2015) – principles that are common to third-generation SDIs.

Another trend with third-generation SDIs, is the integration of SDI into wider government programmes, such as eGovernance. This practice was adopted in the context of INSPIRE and has been included in NSDI strategies of member states such as the Czech Republic (Vandenbroucke, 2011). NSDI has also been embedded into the eGovernance in Europe through registers (Rajabifard et al., 2010; Čada and Janečka, 2016; Coetzee et al., 2019; Coetzee et al., 2020). A register is a digital authoritative dataset that can be accessed by all, centrally.

Within the African continent an important initiative was established in 2014, the United Nations Initiative on Global Geospatial Information Management in Africa (UN-GGIM: Africa), following the decision taken by the Committee on Development Information, Science and Technology (CODIST-III) in March 2013. The aim is to identify relevant geospatial information management issues, initiate actions and discussions, and contribute to the direction of the UN-GGIM (UN-GGIM-Africa, 2016). The regional Committee, which is one of five such regional committees reports to the global United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM), established in 2011. Within the African initiative, several working groups and expert groups work on geospatial information management.

The UN-GGIM: Africa used to cooperate with the GSDI (McKee, 1996; UN-GGIM-Africa, 2016). This cooperative relationship was seen as vital, since the GSDI had put great effort toward SDI development in Africa. In 2018, the GSDI was dissolved and its remaining resources handed over to the UN-GGIM with the intention that the UN-GGIM would continue to carry out the vision and mission of the GSDI (GSDI, 2018).

Further to the work by the UN-GGIM and the regional committees, a decision was taken in 2017 that the UN-GGIM and the World Bank would collaborate on the development of the Integrated Geospatial Information Framework (IGIF). The purpose of the Framework is to strengthen geospatial capacity and development within UN member countries (UN-GGIM, 2018a). The Framework, which is to be implemented at the national level goes beyond the traditional concept of NSDI and is motivated by the lack of awareness of geospatial information management and its vital role in contributing to national development (UN-GGIM, 2018a). However, not disregarding the role of existing, enabling information systems such as national SDIs, but rather enhancing its capabilities through integration with intergovernmental aspects that lead to more sustainable geospatial information management (UN-GGIM, 2018a). The Framework has three parts, two of which are already available (UN-GGIM, 2018b). Part one provides the overarching strategic framework and part two is the implementation guide – the aim is to provide practical guidelines that make implementation easier for UN member countries (UN-GGIM, 2018a). During the process of developing the parts, all UN member countries were invited to comment on the documents. South Africa participated in this. Part three, which is still under development, will provide the country-level action plan.

6.2. Vision and Objectives

The CSI was legislated in 2003 when the SDI Act was passed, but 2010 marks the year when the first statutory CSI was inaugurated. At the CSI inauguration meeting, the Statistician-General highlighted that the newly elected CSI would have to focus on providing outcomes-based strategies for resource mobilisation where the end goal is improved service delivery - rather than supporting individual, competing organisational agendas (Lehohla, 2010). Following the event, van Zwieten, (2010) provided a strong narrative on the need for the CSI to provide a strategy to ensure successful SASDI implementation, essentially calling for coordination and collaboration amongst stakeholders.

The 2010 CSI presented its vision as: '*to provide an implementation framework to ensure availability, access to and utilization of accurate, relevant, authoritative and comprehensive sources of geospatial information on interventions, support, progress, or lack thereof in the achievement of government outcomes*' (NSIF, 2010). The same document outlines the three-part mission for the CSI, which comprises a partnership framework for the acquisition and provision of data, a policy implementation framework and a technology implementation framework. As per the evolutionary trend of SDI generations, this type of vision-mission encapsulates a first generation, product-based SDI approach (Rajabifard et al., 2006).

The SASDI vision, which is, 'appropriate choice is made by all stakeholders in the development process and everyday life through the effective use of meaningful geospatial information for the benefit of all humankind and the environment' (Clarke, 2011), aligns with the product-based SDI approach. Stakeholders are categorized as end users of geospatial data; thus, the focus is on providing access to the data. In other words, the SASDI belongs to national government who hold the decision-making power regarding development and implementation, while end-users do not have an influence over the final products they require (i.e. hierarchical coordination).

The documentation around this start-up period for the CSI provides the goals and planned activities, but the purpose of the SASDI was not clearly understood by all stakeholders and it is apparent that much planning and strategic thinking was still required (NSIF, 2010; Cooper et al., 2010). The vision contained in the CSI documents was product-based, but at the same time this and other CSI discussion documents emphasize a coordination and facilitation role for the SASDI, which leans more toward the process-based SDI (i.e. second-generation SDI), where the linkages between stakeholders and the data are important (Rajabifard et al., 2002; Hennig and Belgiu, 2011).

6.3. Legal Framework

By the time the CSI had been appointed, the SDI Amendment Bill (i.e. the Bill to amend the existing SDI Act) was already on the CSI's agenda. Based on the archived CSI meeting documents, there is a general understanding that the SDI Act was lacking, but the details of this are not provided in the documentation. In 2012, however, the CSI was requested to remove the SDI Amendment Bill from the parliamentary review process, as a strategic plan for the SASDI had to be drafted first. A 2014 country report compiled by the DARD&LR (then the Department of Rural Development and Land Reform or DRD & LR) - presented at the 48th meeting of the Regional Centre for Mapping of Resources for Development (RCMRD) - states that the Spatial Data Infrastructure Amendment Bill had been approved by the Minister for submission to the Cabinet (Department of Rural Development and Land Reform, 2014). The report mentions the main amendments, which include updated definitions and penalties for non-compliance. In 2019, stakeholders were invited to a workshop to review the proposed SDI Amendment Bill. During the workshop stakeholders highlighted many issues with the SDI Amendment Bill, which included the absence of a strategic plan. Also, the introduction of punitive measures for non-compliance of data custodians was not

received well, especially since organisations had expressed their need for capacity building.

Though initial work for the SASDI strategy, the South African Geospatial Information Management Strategy (SAGIMS) had started in 2010, the 2014 parliamentary decision on the SDI Amendment Bill propelled the work on the strategy. Three commissions (capacity building, technology and data) were tasked by the CSI to undertake the necessary research for developing the strategy. The archived documentation shows that much time and effort was committed to the research. However, in 2014, the work on the strategy came to an abrupt halt because the term of the CSI had ended, and a new CSI was only appointed in 2016. For a period of almost two years, SASDI was without a coordinating body. To date, no further work on the strategy has been undertaken, even though it is included in the CSI's programme of work.

Despite the 2014 recommendation to first establish a strategic plan, the Regulations (subordinate legislation) in terms of the SDI Act, the two policies (Base Data Set Custodianship Policy and the Policy on Pricing of Spatial Information Products and Services) and the Compliance Guidelines (first mentioned in 2013 CSI minutes) were developed. The two policies were passed in 2015. The 2017 CSI meeting minutes mentions the development of two other policies, but these policies were not published. Nationwide workshops were held in 2016, where stakeholders were invited to give their comments on the Regulations. However, these Regulations have not been passed and as a result the Compliance Guidelines have not been adopted, which means neither can be enforced.

6.4. Operations

In terms of the CSI composition, the respective organisational categories and affiliations are contained in the Act and the Minister responsible for Land Affairs (now DARD&LR) elects the final committee members. As per the SDI Act, the committee serves for a period of three years and is responsible for advising the Minister on all matters related to the SASDI (South Africa, 2003). The first committee appointment in 2010 had their term extended to 2014. The CSI terms of reference was compiled in 2011 and was not changed in subsequent terms. The next committee was appointed in 2016 and again the term was extended to the end of November 2020. At the time of writing, the process for appointing the committee is still underway.

In 2010, the statutory CSI introduced a new subcommittee structure, from three to six subcommittees, which is in place since then. Each subcommittee operates according to its terms of reference and programme of work, compiled by the subcommittee and approved by the CSI. Generally, the subcommittees advise the CSI on the development and implementation of the SASDI, which is based on research, member expertise and stakeholder engagement. All final decisions regarding the SASDI are made by the CSI. Around 2010, there was a CSI proposal to establish another subcommittee that would be solely responsible for monitoring the SASDI. The subcommittee would 'consist of external stakeholders and will conduct audits and speaks about data strategy in terms of data interoperability and integration' (Cooper et al., 2010). However, this subcommittee was never

established, instead individual subcommittees are tasked with providing quarterly reports on their progress as per their programme of work. The six subcommittees are:

- Data;
- Technical systems;
- Policy and legislation;
- Education and training;
- Marketing;
- Standards

The SDI Act Regulations makes provision for a secretariat, responsible for administrative and secretarial support to the CSI. Since the Act was passed, NSIF has fulfilled this role and has provided a liaison person for each of the six subcommittees.

According to the Act, other stakeholders, such as representatives of public entities and academia, should be represented on the CSI and may also form part of the subcommittees. In 2010, the CSI recommended that the private sector should have the opportunity to participate in the SASDI. This recommendation was supported by industry bodies (GISSA, 2010; van Zwieten, 2010). It was proposed that agreements with the private sector could be put in place to allow for such interaction (Cooper et al., 2010) or through forums (GISSA, 2010). However, as it stands, the Act does not extend to the private sector and no formal mechanisms exist within the SASDI to allow the influence from the private sector.

In terms of participation in international SDI initiatives, the Minister of DARD&LR (then DRD & LR) advised the CSI in 2010, to 'form partnerships with regional and global bodies to eradicate poverty' (Gwanya, 2010). Before the dissolution of the GSDI, South Africa was one of the participating countries. Since the UN-GGIM: Africa was established, South Africa has been participating on the working groups and expert groups, for example, as convener of the working group on Fundamental Datasets and Standards. Through this participation, the Data Subcommittee of the CSI has adopted the list of global fundamental geospatial data themes, which was developed by the Working Group on Global Fundamental Geospatial Data Themes (United Nations Committee of Experts On Global Geospatial Information Management, 2019). Prior to this, the subcommittee had provided a South African list of fundamental geospatial data themes, later fundamental geospatial datasets were identified for each. In 2020, the subcommittee undertook the process to align the South African data themes with the UN-GGIM adopted themes.

6.5. Available Resources

After the collapse of the SDDF in the late 2000's, the NSIF outsourced the metadata cataloguing service to the South African Environmental Observation Network (SAEON) in 2015. The Electronic Metadata Catalogue (EMC) was made publicly available that same year. It provided an online platform for organisations to submit their metadata in one of the three CSI approved metadata standards. According to the Act, all organs of state are obliged to submit their metadata to this system, but the EMC was open to all data providers (South Africa, 2003). The

purpose of the EMC was to facilitate the findability of public geospatial data to all users from a central place. Though the online application for submitting metadata was simple, the metadata standards required for compliant metadata was new to most organisations. Through the Subcommittee for Education and Training, various training workshops on metadata capture and online publishing were offered to organisations responsible for certain geospatial datasets. The training mainly targeted national departments, only a few municipalities were invited to attend. All training material and guideline documents were made available through the SASDI portal, also hosted by SAEON. Despite the training workshops, very few organisations successfully submitted their metadata records. There were various reasons: technical problems (such as firewalls), organisations struggling to implement sustainable metadata business processes, difficulty in understanding geographic standards and a lack of support, following the workshops. In 2018, the contract with SAEON expired and no subsequent metadata system was developed or implemented.

Around 2014-15, the DARD&LR undertook to develop the SASDI website. The intention of the website was to create SDI awareness and make all related documentation available to the public (e.g. legislation, policies, CSI decisions etc.). The Data Capture Project Register (DCPR) was included in the SASDI website. As its name suggests, the DCPR was intended to be a register of public data capture projects, providing users with information on the data they can expect in future and creating transparency amongst data providers to avoid duplicate data capture. Due to lacking technical skills and inadequate hosting infrastructure, the website only became available in 2020 (Department of Agriculture Rural Development and Land Reform, 2019).

During this period, SABS continued to provide financial support for South African representatives to attend ISO/TC 211 meetings.

6.6. Outcomes

The work on geographic information standards by the SABS/TC211 continued and a number of locally developed standards were published:

- SANS 1878-1:2011, South African spatial metadata standard Part 1: Core metadata profile;
- SANS 1880:2014, South African geospatial data dictionary (SAGDaD) and its application;
- SANS 1876:2018, Rules for unique feature identifiers in South African geospatial datasets; and
- SANS 1883-2:2018, Geographic information - Addresses Part 2: Addresses data exchange, based on ISO 19160-1:2015.

The Data Subcommittee published a list of fundamental geospatial data themes in 2016-17 and thereafter the fundamental geospatial datasets for each theme. Since publishing the list of datasets, the subcommittee has been appointing national departments as data custodians for each dataset, as required by the SDI Act and Base Data Set Custodianship Policy. The purpose of appointing custodians is firstly to ensure that the organisations capture, maintain and provide access to those

datasets for which they are responsible and secondly, to let users know the authoritativeness of the datasets.

Lastly, members from the Education and Training Subcommittee collaborated with academia and industry bodies to publish papers on SASDI education related topics.

6.7. Role of Municipalities

When the first statutory CSI was appointed in 2010, one representative from the Ehlanzeni District Municipality (representing rural municipalities) and one representative from Mogalakwena Municipality (representing urban municipalities) were elected (Department of Rural Development and Land Reform, 2010). While the Act allows the appointment of alternate members, none were appointed for municipal representation in the first term. By 2011 the representative for urban municipalities had withdrawn from the CSI (Department of Rural Development and Land Reform, 2011). The representative from the Ehlanzeni Municipality was elected again in 2016 as a member of the CSI and a representative from the City of Johannesburg (CoJ) was elected to represent a data custodian under section 5(2)(j) of the SDI Act (Department of Rural Development and Land Reform, 2016). Municipalities were also asked to participate on the subcommittees. Other than through the membership on the CSI and the subcommittees, there is no governance structure which outlines the role of the local sphere within SASDI, and no governance instruments (such as policies or frameworks) that allows for the bottom-up influence from the local sphere.

7. SUMMARY AND DISCUSSION

7.1. Analysis of Municipal SASDI Participation

From our review, it is apparent that municipalities have had limited involvement in SASDI over the last four decades. In Siebritz et al., (2021) we provide a table summarising the SASDI activities for the last four decades. There have been at most, four municipal representatives on the CSI and several municipalities have participated in the subcommittees with the participation becoming wider in recent years. This is problematic since participating members are expected to represent the interests of and make decisions on behalf of the 278 municipalities in the country. From our experience, there is no diffusion to municipalities that are not participating in the SASDI. This adds to the existing inter-governmental relations issue in South Africa. However, simply increasing the representation will not be sufficient because there is a disjuncture between SASDI and the functioning of municipalities: municipalities are aligned with specific national objectives, realised through respective legislation, but SASDI has no strategic or implementation plan to address national objectives. As such, SASDI still resembles a first-generation SDI.

Though municipalities themselves have a responsibility to take up the legislative and policy requirements of SASDI, from what we have observed, municipalities believe that the principles of SASDI are necessary for effective data management and thus organisational functioning (Siebritz et al., 2021). Because SASDI awareness in the local sphere has remained low over the years, municipalities do

not necessarily associate the principles of data sharing, avoiding duplicate data capture and making data accessible with an SDI and therefore the mechanisms available through SASDI to enable those principles, are not well-known to them. For example, while some municipalities advocate for standardised metadata capture using their own internal standards, which may assist their internal record keeping and data distribution mechanisms, many other municipalities do not include standardised metadata capture in their data models. SASDI on the other hand, requires metadata that is captured according to national standards to allow for increased accessibility and widespread interoperability, but the implementation of national standards is not straightforward, and stakeholders require extensive capacity building in this regard. In this case, data custodians from national departments were prioritised for the SASDI metadata training workshops (Siebritz et al., 2021). The SASDI requirements for municipal compliance are stringent and it is done without the SASDI being able to articulate the benefits to municipalities. Without understanding the potential benefits, municipalities are not likely to take up the SASDI. On several occasions municipalities have emphasized that the support and drive from senior management is critical for improved data management whereby their internal departments all participate in a coordinated system.

However, the problem is greater than awareness, the problem lies in the SASDI governance. The very things that should define and shape the SASDI governance have been lacking. The SASDI vision has been unclear, does not respond to any specific national objectives and has not been reviewed since it was first established. There has been no strategic plan to map out the intended development trajectory and no implementation plan which distinguishes the various role players and how they are expected to interact. In the case of municipalities, there are no clearly defined roles for SASDI participation and no mechanism that allow for bottom-up influence, without which it becomes impossible for national government to adequately respond to the needs of the local sphere. This translates to poorly defined indicators, which do not support or measure the principles of SASDI i.e. access to data, sharing data, no duplicate data capture. Without these mechanisms to measure and monitor the usefulness of SASDI in responding to user needs, how will the SASDI, as a complex system be able to adapt to the changing environment (Siebritz et al., 2021)?

7.2. Framework for Municipal SDI Implementation

We used the results of our review together with the feedback from the stakeholder engagement undertaken for the Municipal Capacity Building Project (Siebritz et al., 2021), to address the SASDI governance challenges. To this end, we have proposed a SASDI governance structure based on the hierarchical SDI model introduced by Rajabifard et al., (2006), where SDIs are implemented at each government administrative level (in our case, for each government sphere), by leveraging existing resources. An important aspect of this hierarchical model is that the SDIs need to be inter-linked, i.e. horizontal relationships exist between organisations within the same sphere and vertical relationships exist between organisations from different spheres. These linkages between SDIs establish formal lines of communication and enable alignment between spheres and inter-

organisational collaboration, reducing opportunities for SDIs to operate as silos and, thereby inculcating an SDI culture (Siebritz et al., 2021).

SDIs for the three different spheres will be different because the mandates for each sphere is different. In South Africa, municipalities are seen as the primary data producers, provincial government is required to coordinate and support municipal activities and national departments are required to be more strategic in their role to support provincial and local government. Even so, the foundations (or basic components) of the SDI model may be applied to all spheres, therefore it is possible to superimpose a generic SDI implementation framework for each sphere, while the responsibility to provide details on SDI implementation remains with the organisations. For our generic framework, as shown in Figure 1, we have proposed a tiered SDI implementation approach, which was adapted from the Ordnance Survey Maturity Assessment (van Loenen and Van Rij, 2008; Ordnance Survey, 2021) to suit the South African context (Siebritz et al., 2021). We coined our framework the Geospatial Empowerment Matrix or GEM (Siebritz et al., 2021). For each of the SDIs within the GEM (i.e. hierarchical of SDIs), tiers are defined, where each tier represents the level of SDI implementation (i.e. columns in Figure 1) and moving from one tier to the next means that the organisation has improved on their SDI implementation. On the left side of Figure 1 (i.e. the rows), we list the components that are required to implement an SDI model in an organisation.

Figure 1: Overview of Geospatial Empowerment Matrix

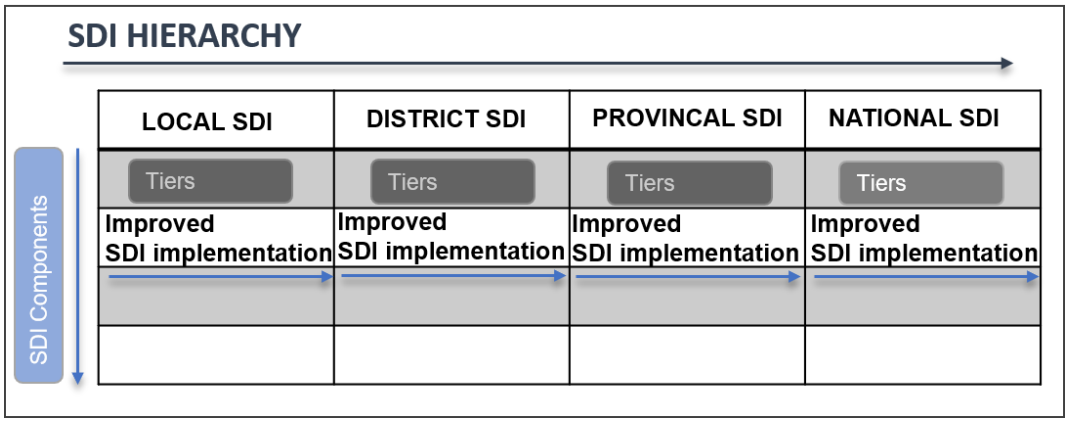
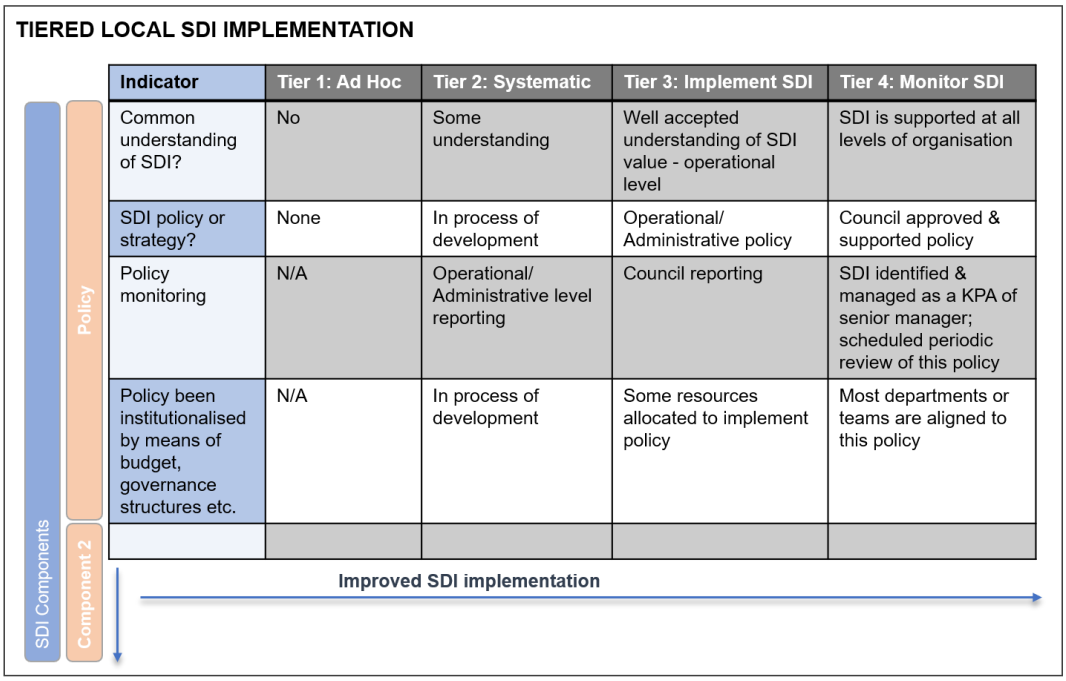


Figure 2 shows an extract of the framework for local SDI implementation for the “policy” component. At the lowest level (Tier 1) we assume that there is no SDI awareness and implementation and therefore data management happens in and “ad hoc” way. At the next level (Tier 2) the municipality has taken steps to implement systematic data management practices, for example they have aligned their day-to-day activities to the organisational objectives to some degree. At the third tier (Tier 3), the municipality has implemented an SDI model, an SDI strategy has been developed and has largely been implemented. Finally, at Tier 4, the municipality has put measures and indicators in place to monitor the effectiveness of their SDI in organisational functioning. We apply the tiers to each of the SDI components, which in the end provides a good idea of the overall status of SDI implementation within the organisation. This generic tiered approach takes the

organisations' data challenges, resource availability and their context (e.g. geographic location and extent) into consideration. Furthermore, because all spheres are included in the GEM, it allows for clearly defined roles but the relationships between the spheres are dynamic because the organisations decide on the details of their interactions. Lastly, the GEM provides the practical steps to implement an SDI.

An example how this model may be applied, is in the context of the South African National Biodiversity Institute (SANBI), who has the mandate for a sustainable South African environment. The SANBI has developed an online Biodiversity GIS that provides free access to the relevant data (see: https://bgis.sanbi.org), for which they require municipal data. The current practice is to engage each of 278 municipalities directly regarding their biodiversity data (F Daniels, 2020, personal communication, 19 March 2020). The GEM can greatly assist them with effective inter-governmental structures for more sustainable methods of engagement, leading to reliable audits.

Figure 2: Extract of local SDI implementation framework



Indicator	Tier 1: Ad Hoc	Tier 2: Systematic	Tier 3: Implement SDI	Tier 4: Monitor SDI
Common understanding of SDI?	No	Some understanding	Well accepted understanding of SDI value - operational level	SDI is supported at all levels of organisation
SDI policy or strategy?	None	In process of development	Operational/ Administrative policy	Council approved & supported policy
Policy monitoring	N/A	Operational/ Administrative level reporting	Council reporting	SDI identified & managed as a KPA of senior manager; scheduled periodic review of this policy
Policy been institutionalised by means of budget, governance structures etc.	N/A	In process of development	Some resources allocated to implement policy	Most departments or teams are aligned to this policy

8. CONCLUSIONS

In this article we inspected the role of municipalities in SASDI over four periods. We undertook a longitudinal study, reviewing various aspects of the SASDI for each of the four periods and then analysed the municipal involvement in SASDI during the time. It was important for us to contextualise the trajectory of the SASDI in terms of international SDI trends. In doing so, we were able to characterise the coordination mechanisms used and identify the factors which have impeded its progress and more specifically municipal participation.

Since its inception, only a small number of municipalities were involved in SASDI, either as CSI members or through participation in the various subcommittees responsible for advising the CSI on SASDI development and implementation. However, for various reasons, such as the inadequate municipal representation on the CSI and the lack of SASDI mechanisms to allow for bottom-up influences, this has not offered much assistance to municipalities in their management of geospatial information and ultimately their service delivery. Unless there is a strategic change of direction, e.g., by SASDI focusing on facilitating the coordination mechanisms so that municipal data needs can be supported by the other vital stakeholders like the NMA, nothing is bound to change. At the crux of it, an efficient SDI is completely reliant on the designated people and organisations fulfilling their responsibilities, which requires integrity, transparency and accountability, etc. (i.e. good governance).

Using the results of our study and the stakeholder feedback from the Municipal Capacity Building Project, we have proposed a hierarchical governance framework for SDI capacity building and implementation for each sphere of government. The framework promotes and facilitates alignment of the SDIs between the various spheres and aids intergovernmental relations. The framework is generic, providing organisations with a practical guide to implement SDI in phases (i.e. a tired approach). In this way organisations can decide on the details of their SDI that is suitable for their context (e.g. drivers, resources, existing business process etc.).

The review presented in this article showed that to date municipalities had been involved only marginally in SASDI, and therefore SASDI could not impact the functioning of municipalities. If SASDI changed to focus on the needs of municipalities, it could greatly improve service delivery in the local sphere of government.

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