Capacitating local governments for the Digital Earth vision: Lessons learnt from the role of municipalities in the South African spatial data infrastructure

Lindy-Anne Siebritz[a b*], Ahmad Desai[a b], Serena Coetzee[b], Antony K Cooper[b c]

[a] *National Geo-Spatial Information, Department of Agriculture, Rural Development and Land Reform, Cape Town, South Africa*

[b] *Department of Geography, Geoinformatics and Meteorology, University of Pretoria, Pretoria, South Africa*

[c] *Smart Places, CSIR, Pretoria, South Africa*

Abstract

The Digital Earth vision foresees the availability and accessibility of geospatial information to achieve the goals of sustainable development, economic growth and social well-being. In the case of urban areas, up-to-date geospatial information is essential for managing a city towards achieving these goals. The rapid shift from rural to urban areas globally, puts pressure on local governments and they often struggle to find and organize the resources required to collect and maintain geospatial information that can help to address urban growth challenges. A spatial data infrastructure (SDI) can facilitate the availability and accessibility of geospatial information towards addressing national objectives, however, the involvement of local governments in an SDI can be a challenge. In this paper, we critique the role of municipalities against the backdrop of the developments of the South African SDI (SASDI) to date. The critique identifies five high-level shortcomings of the SASDI that have led to limited participation of municipalities. Based on the shortcomings, we provide recommendations for capacitating municipalities through SASDI so that the Digital Earth vision can also be achieved for municipalities. These recommendations are aimed at involving the local sphere of government in a national SDI and are equally applicable to other countries.

Keywords: SDI; SASDI; municipalities; service delivery; data governance

*Corresponding author. Email: lindy-anne.siebritz@dalrrd.gov.za

1. Introduction

Geospatial information is essential, not only for the management of cities, but also for planning and facilitating the transition from rural to urban areas. The Digital Earth vision foresees the availability and accessibility of geospatial information to achieve the goals of sustainable development, economic growth and social well-being. However, due to rapid urbanization, local governments in many parts of the world are under-resourced and often struggle to find and organize the resources required to collect and maintain geospatial information.

A spatial data infrastructure (SDI) can facilitate and coordinate the exchange of geospatial information and services between stakeholders from different levels in a community (Hjelmager et al. 2008). Increasingly, countries are adopting a national SDI approach. A functioning SDI has become imperative for addressing national objectives towards sustainable planning and development, which requires the participation of all role players. However, involving local governments in an SDI has its challenges (Harvey and Tulloch 2006; Coetzee et al. 2018; Coetzee et al. 2019). One of the crucial elements of effective and efficient functioning of local governments is the availability of authoritative geospatial information, facilitated by the geographical information systems (GISs) for efficiently capturing, storing, retrieving, maintaining, manipulating, analysing and displaying this information (Cooper 1993). Moreover, it is the proper management of this data that ensures sustainable planning and service delivery for the country. The involvement of local government in SDI is especially challenging in developing nations, who have a scarcity in resources and thus cannot afford duplication of data. The Integrated Geospatial Information Framework (IGIF), developed by the United Nations Expert Committee on Global Geospatial Information Management (UN: GGIM) was

originally developed with the intention of addressing the data management challenges in developing countries but was expanded to include all nations.

In South Africa, beyond the organisational data management practices, the Department of Agriculture, Rural Development and Land Reform (DARD&LR) is responsible for providing a governance framework for all public sector geospatial information that ensures access to all users, promotes data sharing amongst data producers and eliminates duplicate data capture. This governance framework, the South African Spatial Data Infrastructure (SASDI), comprising the technical, institutional and policy framework, is legislated by the Spatial Data Infrastructure Act No. 53 of 2003, which also provides for the coordinating body, the Committee for Spatial Information (CSI), and the online platform for accessing public geospatial information, the electronic metadata catalogue (EMC) (South Africa 2003). There is no doubt that the SASDI, through its fundamental principles of access to data, sharing of data and no duplication of data capture, holds great potential to improve the data management practices in the local sphere of government which can have a significant impact on service delivery. South African municipalities are one of the most important role players but have been sorely overlooked in the development and implementation of the SASDI (refer to Appendix A). Moreover, they have not been sufficiently capacitated to meet the SASDI requirements and to achieve its benefits, even though they are required to comply with legal obligations of SASDI. In response to this predicament, the Municipal Capacity Building Project was initiated to assist municipalities with their data management plans and practices in the context of SASDI.

The purpose of this paper is to assess the role of municipalities in SASDI based on SASDI developments to date and to make recommendations for enhancing the role of

municipalities within SASDI towards finding sustainable solutions for their data management plans and practices. This assessment forms part of the project (explained in section 3.1). Other than the study by Makanga and Smit (2010) which presented the status of many African SDIs, including the SASDI, more than a decade ago, no other review on the progress of the SASDI has been undertaken.

The paper is structured as follows: section two provides background about the role of municipalities and geospatial information in the context of the three spheres of South African government. In section three, we present the Municipal Capacity Building Project and explain how we assessed the role of municipalities in SASDI developments as part of this project. Section four discusses the central findings of the assessment, based on which recommendations are presented for capacitating municipalities and other stakeholders with SDI implementation. Section four concludes.

2.   Background

2.1.   *The three spheres of South African government*

The 1996 Constitution of South Africa, in section 40(1), defines the three distinct, interdependent and interrelated spheres of government: national, provincial and local (South Africa 1996). As illustrated in Figure 1, the local sphere comprises three categories of municipalities, metropolitan (category A), local (category B) and district (category C), which collectively make up the nine provinces and cover the whole territory of the country (South Africa 1996, section 151(1)). Local municipalities 'share municipal executive and legislative authority in its area with a category C [district] municipality within whose area it falls' (South Africa 1996, 75). Section 88 in the Local Government Municipal Structures Act No. 117 of 1998, states that district and local municipalities are required to cooperate with and support each other, whether technical, administrative or

financial support (South Africa 1998). Local municipalities comprise several departments, each of which are responsible for providing a different aspect of public services. As a result, local municipalities programmatically capture and maintain a wide variety of geospatial data, spanning various disciplines and needs. Generally, local municipalities tend to be the most under-resourced, which impacts their ability to deliver services, such as water, sanitation and refuse removal for their area of jurisdiction (Department of Cooperative Governance 2019). This often-times culminates in unrest and protest, which ultimately reflects in poor audit reports and lack of investment. Local municipalities, therefore, in most instances require the support of the other spheres of government and often outsource data capture services to the private sector. District municipalities, on the other hand mainly acquire the data they need from different sources to respond to specific requests.
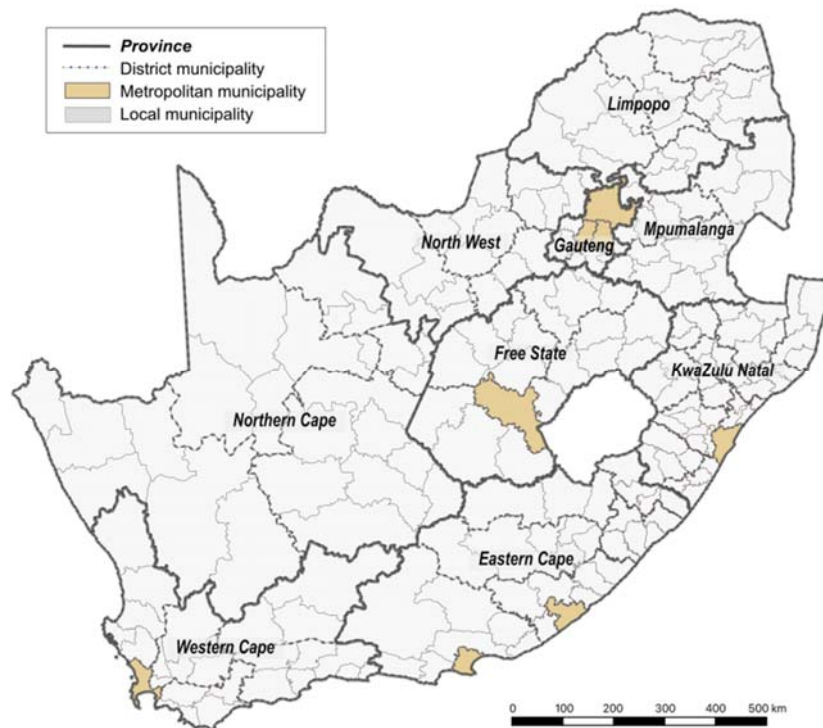

Figure 1: The provinces of South Africa with the boundaries of the three categories of municipalities (Data source: Municipal Demarcation Board, 2018; StatsSA, 2011)

2.2. *Geospatial information and the three spheres of government*

Each sphere of government has the responsibility toward the availability and management of geospatial information. However, the management practices differ significantly between spheres and even between organisations. Typically, within the local sphere, geospatial information is captured on local computers and may be connected to a central server, but very often a server is not available or the human capacity to setup, manage and maintain such infrastructure and systems is not made available. Nevertheless, there are examples of municipalities that have managed to implement centralised systems (enterprise GIS), often developed by service providers, that link geospatial information to revenue processes, e.g. in the Drakenstein Municipality (Drakenstein Municipality 2020) and the City of Cape Town Open Data Portal (see url: https://web1.capetown.gov.za/web1/opendataportal/) in the Western Cape (City of Cape Town 2018). At the provincial level, more sophisticated systems have been adopted. These systems centralise data for the various provincial departments and may provide public access via the internet; they may even provide basic mapping or analysis capabilities. National departments may operate on similar principles as provincial departments, although national departments may only provide the discipline-specific data for which they are mandated e.g. see Department Environmental Affairs EGIS website https://egis.environment.gov.za/ (Department Environmental Affairs Forestry and Fishery 2021).

3. Method

3.1. *SASDI and the Municipal Capacity Building Project*

The Municipal Capacity Building Project (hereafter referred to as "the project") was initiated in August 2019 by employees of the National Mapping Agency (NMA). The

following year, the project was endorsed by the CSI under the subcommittee that is responsible for educating and training organisations in SASDI implementation. The project team includes representatives from the National Geospatial Information (i.e. the NMA), Western Cape Department of Local Government (provincial government body with the specific mandate to capacitate municipalities), City of Cape Town Metropolitan Municipality, Garden Route District Municipality, the University of Pretoria and the Council for Scientific and Industrial Research.

The purpose of the Municipal Capacity Building Project is to assist municipalities with their data management plans and practices with the aim of establishing SDIs at the local level. The project was initiated for three reasons, firstly, many stakeholders still have difficulty in understanding the concept of the SASDI and how it is intended to improve organisational functioning. SDI is perceived as an abstract concept, thus when the structures and instruments that provide guidance on the practical implementation are lacking or not available, SDI remains intangible. Secondly, the SASDI message has been focused on organisational compliance, rather than capacity building that would enable organisational compliance. Thirdly, and more specifically to the municipal context, municipalities do not have a bottom-up influence on the development and implementation of the SASDI.

Establishing local SDIs builds on the hierarchical SDI governance model introduced by Rajabifard, Feeney, and Williamson (2002), where SDIs are established for each sphere of government and are aligned with the public administrative structures of government. In their hierarchical model, the SDIs between spheres are interrelated (vertical relationships), while SDIs within the same sphere may have a similar structure (horizontal relationships) (Rajabifard, Feeney, and Williamson 2002). Rajabifard et al.

(2006) provides further discussion on the role that local (or sub-national) governments can play within the hierarchical SDI model: the authors propose that local government implement an SDI with an operational focus (i.e. data collection and production), while NSDIs take on a strategic SDI approach, allowing for national coordination of SDI activities.

Figure 2 shows a simplified roadmap of the project, where the hierarchical SDI model is used as the starting point for informing the Geospatial Empowerment Framework. The Framework, which is based on the Ordnance Survey Maturity Assessment (van Loenen and Van-Rij 2008; Ordnance Survey 2021) was adapted by the project team for the South African context. It was designed to understand the data management challenges that municipalities face so that appropriate SDI implementation plans may be developed to address those challenges. Therefore, periodic user needs analyses, an aspect that has been missing in SASDI development, is a critical part of the Framework. However, as with the model by Rajabifard, Feeney, and Williamson (2002), SDIs at different levels are interlinked and there are aspects of SDIs at other levels that the local SDI will have to align with (e.g. national metadata standards). In this way, no SDI is operating as a silo.

As shown in Figure 2, the process of implementing local SDIs will be tiered and for each tier, the capacity building opportunities are identified and undertaken. Capacity building refers to any activity (e.g. training sessions) or instrument (e.g. collaboration agreements) that improves SDI knowledge and implementation, both at the individual and organisational level. Ultimately, this process will empower municipalities in their data management, which will enable them to improve their service delivery. The approach for this project was specifically designed to respond to the issues around inclusive SDI

governance and the practicality of the SASDI requirements for municipalities that will lead to an inculcated SDI culture.
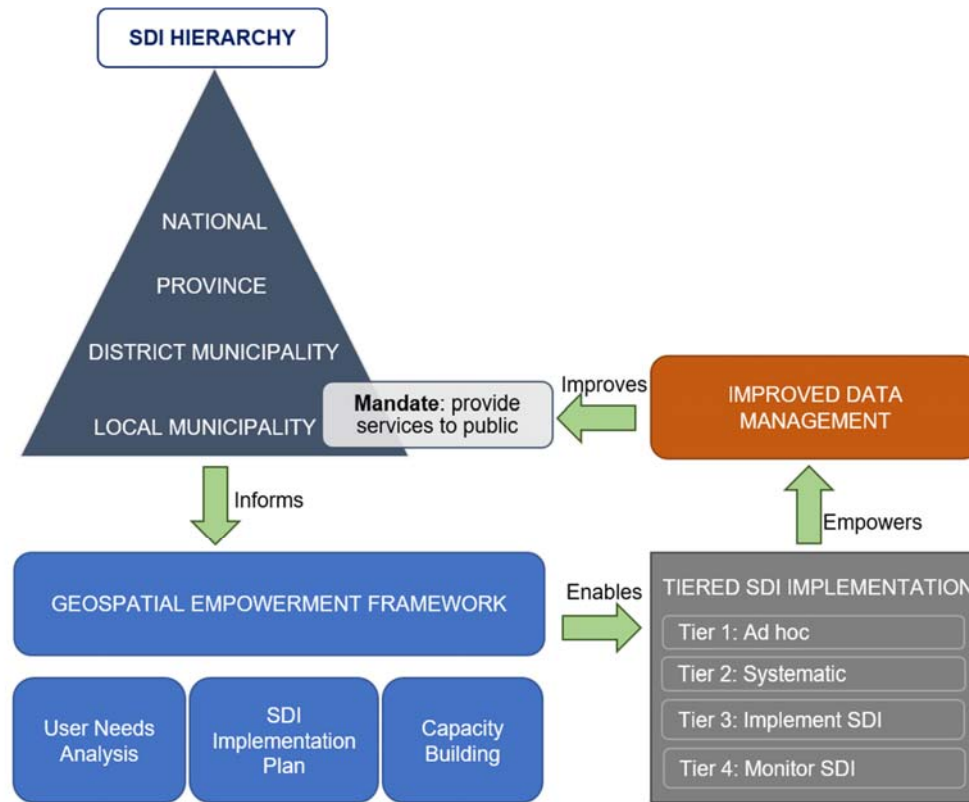

Figure 2. Roadmap of Municipal Capacity Building Project, adapted from Rajabifard, Feeney, and Williamson (2002).

The project has an overarching objective to reach 100 of the 278 municipalities by the year 2022 (Desai and Siebritz 2020a; Desai and Siebritz 2020b). Figure 3 outlines the project objectives and key results. This paper responds to the "SASDI review and analysis" (highlighted in Figure 3) under objective 3, "Establish Alignment", i.e., to establish balance between the SASDI requirements and the municipal needs. Instead of prescribing to municipalities how they should function in order to comply with the SASDI ("one-size-fits-all" solution), the requirements for a functioning SDI are divided into tiers, where each tier responds to the status of the municipalities' ability to manage their data

and to implement an SDI (see Figure 2). Moving from one tier to the next demonstrates an improvement in SDI implementation. For tier 1, we assume there is no SASDI awareness, that their data management practices are undertaken in an ad hoc way and that municipalities at this level have limited resources. As capacity is built over time and resources become available, municipalities progressively improve their data management (i.e. tier 2: systematic level) until they have a local SDI (i.e. tier 3: implement SDI). Once they have implemented their SDI, they then need to monitor its progress, implementation and impact on their organisational processes (i.e. tier 4: monitor SDI).

The purpose of the SASDI review and analysis is three-fold, firstly, it is to ensure that the capacity building solutions presented to municipalities align with the vision, intention and objectives of the SASDI; secondly, it is to determine how the SASDI structure and operations have responded to organisational needs, especially within the local sphere. Thirdly, the review should report on the resources that are available through the SASDI for municipal SDI development and implementation. This paper supports the second purpose of the SASDI review and analysis by assessing the role of municipalities in the SASDI structure and operations from a governance perspective. The process of alignment is iterative: it can be refined, based on periodic reviews of the project outcomes and their impact on municipalities.
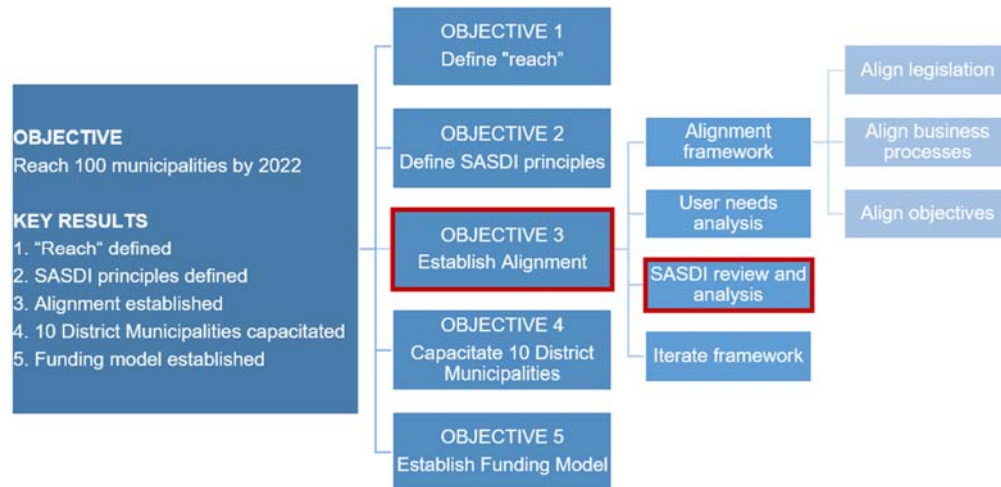
Figure 3. Objectives and key results of the Municipal Capacity Building Project (Doerr 2018).

3.2. *Assessment approach*

A number of methods for assessing SDIs have been developed over the years, each one designed to address a specific goal (Grus, Crompvoets, and Bregt 2008). For this research, we wanted to assess the SASDI from a governance perspective. As Sjoukema, Bregt, and Crompvoets (2017, 4) states: "each SDI component, the interactions between them, as well as the SDI itself are in need of governance". We wanted to provide a qualitative description of: i) how the SASDI components developed over time; ii) the current status of the components; iii) how the components have influenced each other over time; and iv) the overall impact of the SASDI on organisational processes. This approach closely aligns with the INSPIRE State of Play assessment introduced in (Vandenbroucke, Janssen, and Van Orshoven 2008a; Crompvoets et al. 2018). More specifically, our assessment is comparable to the pragmatic State of Play approach proposed by Vandenbroucke, Janssen, and Van Orshoven (2008b), except that our indicators are aligned with the South African context. Table 1 maps the relevant INSPIRE State of Play indicators to the indicators that we assessed. The table only shows those INSPIRE State of Play indicators that were relevant to our assessment. In some cases, we

combined the State of Play indicators (e.g. "legal framework" and "policy and legislation on access to PSI") and in other cases more than one of the SASDI indicators (e.g. "participants" is covered by the "coordinating bodies" and the "role of municipalities" in our assessment) relates to a State of Play indicator. In Table 1, this is depicted by arrows of the same colour. We included two additional indicators, 'international context' and 'international involvement' (shown in red). These two aspects allowed us to determine how the SASDI evolution relates to international SDI trends and whether it was influenced by these developments and/or South African participation in international events.

State of Play Indicator		Indicator in this assessment
Organisational Issues		International context
Level of SDI		Focus
Coordination		Legislative framework
Participants		Coordinating bodies
Legal Issues		International involvement
Legal framework		Available Resources
Policy and legislation on access to public sector information (PSI)		Outputs
Metadata for reference data and core thematic data		
Availability of metadata		Role of municipalities
Metadata catalogue availability and standard		
Standards		

Table 1: Mapping applicable INSPIRE State of Play indicators to our method of assessing SASDI (Vandenbroucke, Janssen, and Van Orshoven 2008b)

We collected information about the indicators by reviewing the SASDI legislation, SASDI policies, CSI minutes, reports and newsletters, CSI subcommittee minutes, scientific articles, and additional information found through internet searches. As part of the Municipal Capacity Building Project, we also conducted workshops (two

in total), which were preceded by an online questionnaire. In the questionnaire we asked various municipalities in the Western Cape province to provide us with information on their geospatial data management with specific reference to municipal spatial planning, since all municipalities are required to undertake spatial planning within an integrated plan, as per their legislative requirements (Johnstone 2019). We received four completed questionnaires. After the workshops, we undertook follow-up unstructured interviews (four in total) and semi-structured interviews (12 in total) with municipal representatives. The semi-structured interviews were actually undertaken as part of a PhD thesis of one of the authors, but since the areas of interest overlap, the interviews were used as a supplementary source for the project. The interviews were undertaken with municipal representatives in two provinces; they included spatial planners, town planners and GIS experts. The questions relate to the municipal business processes for land use management, which includes the legislative requirements, stakeholder interactions, geospatial data capture aspects, SDI awareness and resource issues.

The table in Appendix A summarizes our review of the seven indicators for four periods: before 1994, 1994-2000, 2000-2009 and 2010 onwards. Based on this review, we identified five cross-cutting themes that hindered the progress of SASDI and limited municipal participation over the years: stakeholder involvement, disjuncture between different government spheres, limited involvement of municipalities in SASDI, lack of vision and strategy and shortcomings in the legal framework. We decided on the themes because it allowed us to demonstrate the interrelatedness of the seven indicators and the impact thereof, rather than simply reporting on the indicators chronologically. For example, in section 4.1 we discuss how the CSI (relates to assessment indicator "coordinating bodies" in Table 1) has been unsuccessful in providing sustainable technical systems (relates to indicators "available resources" and "outputs" in Table 1)

which has caused stakeholders, such as municipalities to lose interest in the SASDI (relates to indicator "role of municipalities" in Table 1), firstly because they cannot find the data they need for their day-to-day operations and secondly, they cannot contribute their own metadata, which facilitates access to users.

4. A critique on the role of municipalities in SASDI

4.1. Stakeholder involvement

After 1994 various organisations, mainly national departments were participating in the South African SDI on a voluntary basis, up until 2003 when the SDI Act (No. 54 of 2003) was promulgated and obligated all public institutions to participate and comply with the requirements of the Act. With the establishment of the statutory CSI, the subcommittees, legislative framework and technical platforms, some periods saw progress in the implementation of the SASDI. However, for other periods, these components were missing, impeding the progress of the SASDI. Almost twenty years on, the SASDI is again undergoing a period where much of the momentum gained in the first half 2010-2020, has been lost. Reasons such as delaying the appointment of CSI and subcommittee members for more than a year, including only some stakeholders in SASDI and the unavailability of the EMC since 2018 all contribute to this situation. This situation has caused increased loss of stakeholder interest and stakeholder participation over the years.

Initially, the concept and implementation of SDIs was promoted and developed by national governments mandated to collect and map small-scale geospatial data, that is, a top-down approach was followed. Establishing an infrastructure was seen as a national role, especially in developing countries where sub-national and local governments are generally not well developed (Rajabifard et al. 2006). A top-down approach made sense in the 1980s leading up to the 2000s where centralised databases were managed by NMAs

because bandwidth was limited. However, with the introduction of Web 2.0, more providers of geospatial data emerged (e.g. Google, OpenStreetMap), which not only made data more accessible, but also the services that relied on the data. These services are important because users are interested in the services based on geospatial data, rather than the data itself, which should be an important driver for data producers. It seems that these international developments were lost on SASDI, as there is still limited involvement of municipalities and users (see also 4.3).

Though the hierarchical coordination from national government provides for standardisation, the bottom-up influence of sub-national government allows for diversity and inclusive governance (Masser 2005). When policies are enforced top-down from the national level, there is no real driving force for municipalities and the private sector to participate in SDI development. In other countries, involvement of municipalities and the private sector, who are not as coordinated as national governments, led to more uncoordinated SDI activity (Rajabifard et al. 2006), which inevitably led to duplicate data capture and services. Ultimately, both municipal and private sector activities should form part of the SDI to improve the coordination of data capture amongst stakeholders. South Africa could better harness the potential of geospatial information by a top-down approach (from the NMA) supplemented by a strong bottom-up influence (from municipalities and other users). This offers a mechanism to use the already limited resources more effectively, thereby relieving financial and delivery demands placed on both the NMA and the municipalities.

Globally, third generation SDIs emerged in the second half of the 2000s to promote proactive inclusion of all stakeholders, including sub-national government, the private sector and general users, who's geospatial information needs were seen as an

important driver for evolution (Rajabifard et al. 2006; Hennig and Belgiu 2011; Crompvoets et al. 2018). Further to this, the recently developed UN-GGIM IGIF seeks to strengthen geospatial capacities of nations at a strategic level through integration of the various sectors, policies, programmes and enabling technologies while at the same time leveraging existing information systems such as those that form part of an NSDI. The Framework emphasizes the inclusion of local knowledge, skills and needs (e.g. through partnerships) to ensure well-informed decision-making and suitable, sustainable solutions (UN-GGIM 2020a; UN-GGIM 2020b; UN-GGIM 2020c). In South Africa, this role is taken up by local authorities (e.g. platforms for public participation and public participation through various bodies) with the support of the other governmental spheres, highlighting the important role that municipalities have to play in the SASDI (further discussed in section 4.3).

Recommendations:

- A SASDI governance structure that describes the various SDI stakeholder roles must be defined, including all spheres of government, as well as the private sector. Not only will it allow for accountability but will assist to protect the interests and resources of the vulnerable stakeholders, in this case municipalities. The governance structure should be dynamic, it must allow for changes in the way stakeholders interact with each other and their resources. In South Africa, the local sphere has experienced fundamental changes with the introduction of new legislation (e.g. Spatial Planning and Land Use Management Act) and government programmes (e.g. the District Development Model). The SASDI governance structure must able to accommodate such changes.

- The SASDI, as part of its development planning, should make provision for wider consultation with stakeholders across disciplines, that travels upwards (i.e. user-centric focus). When stakeholder interests are taken into consideration, they are more likely to participate and respond to the requirements of the infrastructure. This is good way to raise awareness not only of the SASDI but of geospatial information in general.

- A sustainable online system that provides free access to public geospatial data, as per the SASDI Policy of Pricing of Spatial Information Products and Services (Committee for Spatial Information 2015) should be made available. The policy states that public geospatial data for which organisations are mandated, must be made freely available to the public; organisations may charge a fee for the medium used to distribute the data or product. Access to good quality geospatial data may be one of the easiest ways to encourage stakeholder participation – if they can see the direct benefit to them, they are more likely engage with SASDI.

4.2. Disjuncture between different spheres of government

In the years pre-ceding the establishment of the SASDI, many municipalities had established GISs for capturing and maintaining their geospatial data. These GISs served their own needs; they required geospatial data to plan, manage and maintain the infrastructure and services for their respective jurisdictions. Nationally, the perspective on the need for geospatial data was very different. For example, the NMA established a GIS for topographic mapping with national coverage and the national Department of Environmental Affairs established a GIS for nature reserves and protected areas (Department Environmental Affairs Forestry and Fishery 2021). It was therefore the national departments who drove the first initiatives for coordinated GIS activities in the

country, such as the transversal National Land Information System (NLIS) established by the NMA in 1988. Initially, the NMA was the main pioneer on the journey to establish a South African SDI. Since then, alternative providers of topographic information have emerged (Google Maps, here maps, OpenStreetMap, etc.), often with more current topographic information, however, the NMA still has a strategic focus on topographic mapping with national coverage that does not support any operational objectives of municipalities. The role of the NMA has never been revisited and redefined in the context of decentralised data management by municipalities, emerging technologies and trends or national and international sustainability goals. This makes the role of the NMA increasingly irrelevant in any geospatial data related developments supporting national imperatives. In contrast, the geospatial data maintained by the Department of Environmental Affairs is widely used for environmental impact assessments and conservation studies.

There is little influence of the provincial sphere on geospatial data management and the implementation of the SASDI as can been seen in Appendix A, where there is no mention of the provincial sphere in our findings. According to legislation, the provincial sphere has to provide a supportive and coordinating role to municipalities, which includes the institutionalisation of systems to support geospatial data management for effective and efficient service delivery (South Africa 1996). SASDI has always been owned and driven by national government– all instructions regarding the SDI are thus prescribed from the top, down to the provinces and municipalities (refer to Appendix A). The SDI Act (No. 54 of 2003) provides for representation on the CSI by each province, as well as the national department of Provincial and Local government on the CSI, but in reality, not all provinces have nominated representatives. No specific role has been defined for the provincial departments to coordinate SDI implementation in municipalities. Aside

from provincial geospatial forums where municipalities can voice their concerns (WCSIF 2019b), their needs are not formally communicated upward, to the CSI. In the Western and Eastern Cape provinces, the provincial forum is established by the Office of the Premier. Quarterly forum meetings are held where representatives from various institutions are invited to present on geospatial related information and technologies. Generally, the invitations are limited to the list of invitees held by the forum; it is not an open platform for all municipalities. During the meetings, a brief question-and-answer session is allowed but there are no in-depth discussions on the challenges related to the SASDI implementation. The provincial forum meetings are largely equivalent to a town hall meeting – the real issues (e.g. why there is no online platform where municipalities can access the data they need, why do some national custodians refuse to share public data freely and why are complaints about data quality disregarded by the responsible custodians, etc.) are not discussed, and the message never gets heard at the decision-making level which leads to frustrated, disgruntled communities. Provincial forums are not coordinated nationally; every province may establish this type of forum as they see fit.

These developments in the SASDI evolution have led to a disjuncture between the spheres of government in terms of the objectives for managing geospatial data, reflected in the way geospatial data is still being managed today. National departments capture fundamental geospatial datasets at scales that are inappropriate for municipal requirements, which results in municipalities re-capturing the same data at the scale they require. As an example, there is no coordination or collaboration between the NMA and the municipal sphere, other than an agreement with some municipalities that the NMA will provide topographical data at the NMA's scale of capture to them (Chief Directorate: National Geospatial Information 2020; Chief Directorate: National Geospatial

Information 2021), bypassing the provincial sphere. This agreement does not meet the end users' needs of large-scale topographic data to plan, manage and maintain the infrastructure and services within their jurisdictions (Anonymous 2021d). Similarly, the aerial photography provided by the NMA does not meet municipalities' temporal and spatial resolution, which means they either spend their budget on acquiring their own imagery or on field verification, which can be a very time-consuming process (Anonymous 2021b; Anonymous 2021a; Anonymous 2021d; Anonymous 2021c). Currently, the NMA acquires aerial imagery for South Africa over a three-year period at a ground sample distance (GSD) of 25cm, while municipalities require better than 10cm GSD annually, to meet their planning and service delivery needs. An NMA that supports provinces and municipalities with their data specific requirements can make a significant contribution to SASDI and service delivery. This disjuncture between different spheres of government is not unique to geospatial data management. The public governance structure of South Africa defines clear-cut roles for the three spheres, but the interrelatedness of those spheres and thus the support structures mandated by the Constitution, from national government to the local sphere is not clearly defined (Van Wyk and Oranje 2014; Johnstone 2019).

Recommendations:

- To implement a hierarchical SDI model, existing organisational mandates, administrative structures and institutional instruments must be acknowledged and leveraged. South African municipalities in particular are driven by legislation and directives given though their political and administrative structures. Anything outside of this structure is not prioritised. Secondly, organisations over time, develop their own culture of working and it is important

to acknowledge those efforts instead of requiring them to readjust to something completely new that may hinder their progress.

- There is an opportunity and need to establish objective-based, coherent provincial forums geared toward municipal support for SDI implementation. These forums have to be interactive, allowing municipalities to voice their challenges and collectively propose solutions with the support of provincial coordinators. It may be feasible to elect officials at the district level to represent the local municipalities in their respective jurisdictions at the provincial forums. This may allow for better vertical alignment of SDIs.

- The NMA should review its role and its strategic direction, with specific focus on how the it could provide coordination, guidance and support to municipalities with respect to the availability and access to relevant geospatial information.

4.3.   *Limited involvement of municipalities in SASDI*

The SASDI was intended to eliminate duplicate data capture in the country by coordinating the data capture activities of organs of state. The top-down focus (i.e. hierarchical coordination approach) followed since its inception, has made it difficult to reduce the duplication of data. Over the years, most of the SASDI resources were spent on capacitating national data custodians but hardly any progress on SASDI objectives is evident, aside from the appointment of custodians for fundamental datasets and the publishing of the two policies. Though a top-down approach is necessary to establish standardisation of geospatial data and good practices, concurrent mechanisms for incorporating the diversity and local perspective that the municipal sphere has to offer are equally important for an SDI. SDIs should serve local needs effectively in order to contribute to sustainable urban planning (Nedovic-budic et al. 2004; Budhathoki and Nedovic-Budic, 2007). In Belgium, with the Flemish SDI the data capture and

maintenance responsibilities were decentralised to the municipalities in 2011, but activities related data integration and exchange are coordinated centrally by the regional Flemish Information Agency, responsible for SDI implementation (Coetzee et al. 2019). The authors of this study note that even though municipalities implement decisions directed from the regional level, decision-making processes should not alienate municipalities. Coetzee et al. (2018) demonstrate how a similar situation exists in the Netherlands between the municipalities and national bodies. The study reveals the complex governance structure that is required to provide integrated datasets that are adequate for users at different levels of government. These examples could serve as guidance for the SASDI.

Though the SASDI municipal participation, through their CSI representation may be considered high (i.e. municipal representatives are appointed in terms of the SDI Act requirements), in reality one or two individuals to represent the highly diverse 278 municipalities is insufficient. As a result, municipal needs and challenges with SDI implementation are not brought to the attention of the CSI, and secondly, awareness of the SASDI in the local sphere is limited. Up until today, most municipalities remain uninformed of the SASDI (User Needs Analysis Working Group 2020c; Patel 2020), despite their willingness to follow the principles of an SDI, such as providing access to geospatial data and avoiding duplicate data capture (Anonymous 2021b; Anonymous 2021a; Anonymous 2021d; Anonymous 2021c). It makes sense for municipalities to follow these principles as much as they are able to because they understand that by not following them, their already scarce resources will not be used effectively and efficiently, and they risk failure to meet their mandates and provide adequate forward planning through their various programmes. One such municipality that has demonstrated their pro-active pursuit to implement a local SDI is the City of Johannesburg (Anonymous

2021a). Over the years, it has made great strides to establish a data governance structure and promote sustainable data practices within the different of the municipal departments (Anonymous 2021a). In many cases though, data management and data governance structures that facilitate these principles, are sorely lacking in municipalities and the mechanisms to support such structures through provincial government and national departments have not proved useful in many cases (User Needs Analysis Working Group 2020c; User Needs Analysis Working Group 2020b).

Recommendations:

- Municipalities have to be capacitated for local SDI implementation. A tiered approach to SDI implementation for municipalities should be provided. In the Municipal Capacity Building Project, we propose four tiers (see Figure 2). For each tier the practical guidance is provided to implement a local SDI. As discussed in section 3.1, local SDIs must but interlinked with provincial and national SDIs. Nationally this role is assumed by the CSI, although it could be done in conjunction with Department of Cooperative Governance and Traditional Affairs (CoGTA) and the South African Local Government Association (SALGA). Provincially there is an opportunity for the CSI to engage with the respective provincial CoGTA departments to coordinate municipal SDI capacity building.

4.4. *Lack of vision and strategy*

The lack of a vision that is clearly defined and accepted by all stakeholders (refer to Appendix A) is a concern, because this is a crucial element of an SDI according to Kok and van Loenen (2005), Masser (2005) and Crompvoets et al. (2008). Another concern is the absence of a national geospatial data management strategy and the action plan to

implement such a strategy. The United States SDI, the Netherlands SDI and the Australian SDI (ASDI) are three examples that demonstrate the value of a strategic plan to guide the implementation of the NSDI. The US SDI strategic plan displays great effort toward integration and harmonisation of information, including non-spatial information (Federal Data Strategy Development Team 2020; Federal Geographic Data Committee 2020). Within the Netherlands SDI strategy, municipalities play an important role, to capture and maintain fundamental geospatial data, which is integrated by the NMA into a national dataset (Coetzee et al. 2018). The ASDI with its vision to 'provide a transparent supporting structure for spatial decision making and information access that will be used on a regular basis by all members of society' in its strategic plans, highlights the importance of stakeholder engagement, raising awareness and understanding user needs (Geomatic Technologies 2008; ICSM 2019).

After the SDI Act was passed into law in South Africa in 2003, little happened and the geospatial community of South Africa was 'vocal in their condemnation of the lack of progress' (Clarke 2011). The establishment of the statutory CSI in 2010 provided some drive for the development and implementation of the SASDI with the subcommittees responding to their respective programmes of work. Most CSI members in the first two terms had already been involved in the management of spatial information at their respective organizations before the CSI was established. In other words, organisations already involved in SDI-like practices and the promotion of SDI principles formalised their existing practices through the CSI. However, the establishment of the CSI and the other prescriptions of the Act did not necessarily result in a functioning SDI (e.g. participation of all stakeholders and publishing of metadata).

According to Sjoukema, Bregt, and Crompvoets (2017) adaptability of the SDI governance should be a foremost feature of SDI. A strategy of adapting to a wider pool of stakeholders with changing needs is one of the key drivers for SDI evolution. However, this has not happened in South Africa. The SDI Act mentions only organs of state. The private sector is not currently represented in SASDI, even though most municipalities rely on service providers for capturing certain geospatial data and for providing the systems they require. SDIs in other countries have recognised the importance of the private sector for an SDI, but also acknowledge that balance is required to ensure sustainable partnerships (Rajabifard et al. 2006; Janssen and Dumortier 2007; Coetzee et al. 2019; Coetzee et al. 2018).

Apart from formalizing existing practices, the CSI subcommittees undertook training events, workshops and presentations at conferences, research and research collaborations, identified standards for SASDI, developed the Data Capture Project Register (DCPR), etc. However, all the activities were happening and continue to happen outside a national strategy, creating an environment amenable to inconsistencies and opportunistic behaviour. The general lack of political support for the SASDI in the last decade has hampered the progress of SDI in South Africa. This in turn has been exacerbated by the incoherent management of SASDI, characterised by the lack of vision and strategy, and lack of implementation of an agreed upon infrastructure – the antithesis of symbiotic relationship. Furthermore, because the vision and strategy are not clearly defined with reference to national objectives for sustainable development and planning, it is difficult, if not impossible, to monitor and evaluate the impact of the capacity building activities and of SASDI as a whole. In other words, there is no accountability.

Recommendations:

- The CSI must review and establish a clear, coherent vision for the SASDI. This vision which must be understood and accepted by its stakeholders should guide the development of a strategic plan and following that, an implementation plan. As part of the implementation plan, an indicator framework which is tied to national objectives needs to be developed. If the CSI can demonstrate that it has responded to those objectives, it may generate better political support and secure national funding for the development of the SASDI.

- Effort toward a national data governance, data management research and development programme co-ordinated between government, the private sector, non-governmental organisations, etc. and supported by SDI relevant education and training at tertiary institutions is required. Such a programme may drive objective-based decision-making toward sustainable solutions because graduates may then be better equipped for the workplace.

4.5. *Shortcomings in the legal framework*

The SASDI legal framework has been lacking. Firstly, the Act is vague in many regards, and does not provide enough information on the institutional and policy frameworks, respectively. These issues have yet to be addressed in the Act. Secondly, the Act has not been integrated with any other legislation, thus when there were important changes in the way municipalities operate, empowered through pertinent legislation like the Spatial Planning and Land Use Management Act (No. 16 2013), the SASDI has not facilitated in any obvious or significant ways. Thirdly, the CSI has acted with an agency of compliance to the Act even though the lack of stakeholder participation suggests that a different approach is required. During forums and stakeholder engagement sessions, participants

have openly expressed their organisations' inability to meet the legal SDI requirements and that suitable capacity building is still required (WCSIF 2019a). The CSI proposes punitive measures for non-compliance (Department of Rural Development and Land Reform 2014). This is contradictory to the narrative of dynamic, evolving SDIs which respond to changing user needs, are objective-driven, promote capacity building and inclusive governance. Janssen (2008) who presented a conceptual model for assessing the legal framework of an SDI argues that an SDI legal framework must be compliant (with the SDI legislation and other legislation related to geographic information), coherent (i.e. assessing complementing versus contradicting rules) and its quality (i.e. if the legislation enables the SDI to meet its goals) must be known.

Recommendation:

- The SASDI legal framework should be assessed in terms of the compliance, coherence, and quality as proposed by Janssen (2008).
- The municipalities are well placed to evaluate the SASDI legal framework in that they already interpret various pieces of legislation and apply it to service delivery. Working with the municipalities to guide the review of the SASDI legal framework would circumvent unnecessary revisions. The vision of 'smart cities' which has been promoted by the South African President in his 2021 State of the Nation address (Ramaphosa 2021), can only be realised through municipalities facilitating the various pieces of legislation that enable this vision.

5.   Conclusion

In this paper we critiqued the role of municipalities in SASDI developments to date as part of the Municipal Capacity Building Project because we recognised the lack of

awareness and participation from the local sphere. At the onset of the Project, three reasons were proposed for the lack of SASDI implementation in municipalities, namely, difficulty in understanding the SDI concept, insufficient capacity building and no mechanisms for bottom-up influence from municipalities. This paper provides a holistic understanding of why those challenges exist: not having a clearly defined SASDI data governance structure, a strategic plan that proactively includes the local sphere and mechanisms to ensure the sustainability of the SASDI (such as tertiary institutions including issues such as data management and data governance within geomatics education).

Municipalities have an important role to play in terms of service delivery and SASDI has the potential to impact the access to public services. Five high-level shortcomings of the SASDI provide insight into the lack of municipal participation in SASDI: stakeholder involvement, a disjuncture between the spheres of government, limited involvement of municipalities, lack of vision and strategy and shortcomings in the legal framework.

Municipalities also have a responsibility toward the SASDI principles of making data accessible, sharing data and avoiding duplicate data capture because these contribute to the sustainability goals of government. Many of them are already practicing the principles, even without knowledge of the SASDI, but because they do not know the purpose of the SASDI and its provisions, they do not voice their data-related concerns and challenges to those who are responsible for assisting them in this regard.

There is a significant role that the NMA could fulfil, even though it does not have a specific mandate to support municipalities: their vision is to be 'South Africa's foremost organisation supplying fundamental geospatial information' (Chief Directorate: National

Geospatial Information 2020). In the 2021 strategic plan of the NMA, it states the need to relook at its products and services over the next five years, to ensure that user needs are met and that the organisation maintains its relevance. This can be interpreted to include the 'fundamental geospatial information' required by municipalities. Municipalities recognise the potential value of the data that the NMA could provide to them, but without the necessary engagement and strategic alignment with user needs, the NMA data remains unsuitable for municipalities to utilise in their daily processes.

This study provides a valuable contribution to the body of literature about the South African SDI, but it is also useful for other countries with similar public administrative structures, who have not identified municipalities as a vital SDI stakeholder or who are still finding it difficult to define the role of their municipalities in the NSDI. For example, Sinvula et al. (2017) in their comparative analysis of SDI stakeholder roles in South Africa, Ghana and Namibia, conclude that further investigation is required to distinguish between local, provincial and national government data producers. Further to the role of the data producer, the authors propose coordinator and integrator roles. In this paper, we have proposed that the NMA take up this type of role in South Africa. The end goals of SDIs around the world may be different, but principles of SDI are common (i.e. access to data, sharing of data and reuse of data/ eliminating duplicate data capture). The recommendations we have provided responds to those principles, making it possible for other countries to apply our approach.

Our study confirms that SDIs may be viewed as, and therefore assessed as complex and adaptive systems (CAS) (Grus, Crompvoets, and Bregt 2010). In the case of SASDI, we have observed certain CAS characteristics and behaviours such as the interaction between the different components, sensitivity to initial conditions (e.g. SASDI

vision not clearly defined in the earlier years) and non-linear development (e.g. the lack of political support that impeded progress). But, we have also presented how other CAS characteristics, which are not observed with SASDI can be leveraged to improve the development and longevity of SASDI, which may be applicable to NSDIs in general.

NSDI should align its governance and implementation to other governance structures and legislation in the country (i.e. provides clear SDI architecture for different spheres of government (Grus, Crompvoets, and Bregt 2010)). A national strategy or plan that explains the NSDI objectives and how these align to national imperatives can serve as a road map for getting stakeholders on board. The road map should be developed in consultation with all stakeholders, also those at the 'bottom', such as municipalities, and should align with how they operate (i.e. contributes to an open SDI (Grus, Crompvoets, and Bregt 2010)). 'Going solo' with an NSDI does not support the cause, especially not in resource constrained developing countries.

Our review also shows the need for an SDI to adapt (Grus, Crompvoets, and Bregt 2010). Governments are known to move slowly, which provides stability on the one hand but can also lead to stagnation. While a legal framework to support an SDI can mobilize resources and funding, it can also become a significant barrier to SDI implementation if it is not flexible enough to allow the SDI to adapt and evolve (e.g., to include additional stakeholders) or if it is so vague that nobody understands their roles and responsibilities. Finally, an SDI requires endurance and continuous attention. Implementing an SDI in a stop-and-go fashion causes important stakeholders to lose trust and interest.

Africa faces many challenges related to the transition from a mostly rural to a predominantly urban society, and geospatial information is essential for planning and facilitating this transition. NSDIs can play as strong role in achieving the Digital Earth

vision of having geospatial information to achieve the goals of sustainable development, economic growth and social well-being in the transitioning to an urban society, but only if municipalities are appropriately involved.

Data Availability Statement

The information used in this article is available. The only information sources that are restricted are interviews conducted with municipal representatives, which were done anonymously.

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