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Inclusivity in Spatial Data Infrastructure Assessment

How to measure SDI performance in non-Western contexts

With a case study on South Africa & the City of Cape Town

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Abstract

Spatial Data Infrastructures (SDIs) play a crucial role in enabling access to and use of geographic information, yet assessing SDI development in non-Western contexts remains a major challenge. Existing assessment frameworks such as the United Nations Integrated Geospatial Information Framework (UN-IGIF) provide valuable guidance but were designed with the assumption that foundational infrastructure is already in place. In non-Western contexts, these conditions regarding connectivity, stable electricity supply, and access to digital devices cannot be taken for granted, and their absence from assessment frameworks produces an incomplete assessment of SDI.

This research develops an SDI Assessment Framework specifically designed to be more inclusive for non-Western contexts. Inclusivity in SDI is defined as a situation where all stakeholders (including data contributors, end users and policy makers) can participate and benefit both individually and collectively, requiring affordable access to ICT, capacity building in digital and spatial skills, accessible datasets with clear standards, and equal stakeholder representation in data governance and funding mechanisms. To capture the realities of non-Western contexts, the framework extends conventional SDI components with a dedicated connectivity component covering internet access, device availability, and electricity supply. The framework was developed through a literature review of existing SDI and digital inclusion frameworks, refined through semi-structured interviews with eight international SDI experts, and tested through an embedded case study on the South African national SDI and the local SDI of the City of Cape Town.

The results show that the framework produces a more inclusive assessment of SDI than existing SDI assessment frameworks, highlighting structural barriers such as limited device access, single-language portals in multilingual contexts, incomplete spatial coverage, and weak municipal participation overlooked by conventional frameworks. Applying the framework also revealed practical limitations, particularly where data on certain indicators is not yet systematically collected. These findings contribute to academic understanding of SDI development in non-Western contexts and offer practical guidance for policymakers seeking to identify bottlenecks in SDI performance through an inclusive assessment approach.

Key words:

Inclusivity, digital divide, digital literacy, spatial data infrastructure,

Glossary:

SDI – Spatial Data Infrastructure

CAS – Complex Adaptive System

SDG – Sustainable Development Goals

SASDI – South African Spatial Data Infrastructure

NSIF – National Spatial Information Framework

CSIR – Council for Scientific and Industrial Research

UN-IGIF – United Nations Integrated Geospatial Information Framework

Statement on the Use of Artificial Intelligence Tools:

During the preparation of this thesis, limited use was made of AI-based language tools, specifically Anthropic's Claude. Use of these tools was restricted to the revision stage of writing, including grammatical correction, improvement of clarity, and refinement of phrasing.

All substantive academic content and final editorial decisions are the sole responsibility of the author. All AI-generated suggestions were critically reviewed, adjusted where necessary, and verified before inclusion in the final text.

Contents

1. Introduction

Spatial Data Infrastructures (SDIs) are dynamic and multi-disciplinary frameworks that allow for access, reuse and sharing of geospatial information (Crompvoets et al., 2008). SDIs allow governments, organizations, and communities to collect, share, and use geographic information. With strong SDIs, decision-makers can respond better to global challenges such as climate change, rapid urban growth, and natural disasters (Crompvoets et al., 2008). Mulder, Wiersma, and van Loenen (2020) show how national SDIs in Canada and the Netherlands are helping users access open spatial data in efficient ways.
The development of SDI is not without costs. In 2000, Rhind (2000) estimated an expenditure of approximately $10 billion for the US SDI and $2 billion for the SDI of the UK (see Van Loenen et al. 2010). In 2006, Crompvoets estimated that worldwide around €120 million each year is spent just on the management of geoportals (Crompvoets, 2006). These significant costs have justified research into SDI performance and SDI assessment frameworks.

Research into SDI assessment frameworks started around the beginning of the 2000s with as most important overview result the Multiview SDI assessment framework (see Crompvoets et al., 2008; Grus, 2010; Grus et al., 2011). Although these frameworks do provide insights in how an SDI may perform, they are mostly developed for and in a Western context in mind. However, assessing the status of the SDI in non-Western contexts has proven a challenge (Ahmad et al., 2024; see also Makanga and Smit, 2010; Ogunbiyi, 2021). In this thesis, the term non-Western contexts is used to describe countries and communities shaped by historical and ongoing inequalities that continue to produce economic dependence, climate vulnerability, health crises, and poverty (Ngcamu, 2023; Oduro-Marfo & Clarke, 2018).

Supinajaroen (2022) emphasizes the importance of having the right technology in place for SDI to function in non-Western contexts. He explains that in Thailand, findings from National Continuously Operating Reference Station (NCORS) implementation efforts led to a better understanding of the SDI by incorporating the availability of basic technologies regarding connectivity. Likewise, in Surinam, the development of SDI initiatives highlights that technological readiness, such as connectivity and involvement of local communities, is a critical factor influencing adoption and sustainability (Bhola, 2024). These cases show that progress is very dependent on the availability of relevant technology. However, this aspect is typically overlooked in high-level SDI assessment frameworks that implicitly assume the presence of a base infrastructure.
In addition, Ali et al. (2021) explain that Pakistan's SDI has some positive features, but still suffers from weak institutional capacity and poor coordination. Similarly, in the past Cooper et al. (2014) noted that countries such as South Africa, Brazil, India, and China recognize the value of SDIs, but often struggle with political and institutional issues.
SDI development is further shaped by the social and political environment. Coetzee and Wolff-Piggott (2015) argue that in non-Westen contexts there is little focus on bottom-up, community-driven SDI models, even though these may help create more inclusive systems.

A notable exception to the Western-context dominated SDI assessment frameworks is in the United Nations Integrated Geospatial Information Framework (UN-IGIF). The UN-IGIF has been used to assess the performance of several UN-member states in both Western- and non-Western contexts (UN, 2024, p. 72). Despite its popularity, the UN-IGIF also has limitations. Calzati & van Loenen (2023) highlight the reductionist character of IGIF, emphasizing the possibility of tensions between different framework components and the uneven impact on sustainable development goals (SDGs). The IGIF treats its nine pathways as equally important, ignoring important differences and dependencies between the pathways. Furthermore, Cooper et al. (2025) argue that implementing IGIF at a local level might push municipalities to prioritize satisfying the needs of the national government before their own, potentially wasting limited resources. Lastly, IGIF does not specify any concise indicators, making operationalizing the framework rather labour intensive.

The context of SDIs in non-Western contexts is such different than in Western Societies that it would justify a new approach which is specific to non-Western contexts. This project aims to develop such an inclusive SDI assessment framework to support the assessment of non-Western SDIs. In this framework, indicators will be tailored to represent the challenges of non-Western contexts.

The expected results are important for both researchers and policymakers. First, testing the inclusive SDI assessment framework with South Africa and Cape Town as a case study will improve academic understanding of how SDI development can be assessed in the Global South. Second, the inclusive framework developed in this research, will help governments and international organizations to better assess SDI and create better strategies for building SDIs in non-Western contexts. As Herrera Murillo (2025) points out, collective intelligence and community participation are essential for making geospatial systems more effective. The same lesson applies to SDIs: technology alone is not enough, to improve inclusiveness more factors need to be assessed.

This thesis is structured in ten chapters. Chapter 2 sets out the research objectives, sub-questions, and scope. Chapter 3 describes the mixed-methods research design, including the iterative three-phase framework development process, the semi-structured expert interviews, and the embedded case study approach. Chapter 4 develops the conceptual foundation of the research: it defines what inclusive SDI assessment should emphasize, reviews existing global and non-Western SDI assessment frameworks, and presents the first draft of the Inclusive SDI Assessment Framework (V1). Chapter 5 refines the framework through expert feedback, transforming its indicators into SMART measures and producing the intermediate version (V2). Chapter 6 applies V2 to the embedded case study of the South African national SDI and the local SDI of the City of Cape Town, and evaluates the performance of the framework itself against the SMART criteria. Chapter 7 presents the final version of the framework (V3), incorporating the revisions identified during the case study. Chapter 8 discusses the findings in relation to the broader literature. Chapter 9 presents the conclusions of the research, and Chapter 10 provides recommendations for researchers, policymakers, and SDI practitioners.

2. Research Objectives

The main goal of this research is to develop a framework to assess performance of SDI's in non-Western contexts. For this, the framework must be tailored to fit non-Western realities and highlight constraints in foundational infrastructure. This framework will be tested through an embedded case study on the South African SDI (SASDI) and the Local SDI of the City of Cape Town in South Africa.
This research will first develop an inclusive framework designed for assessment of non-Western contexts. A number of currently existing frameworks, including the UN-IGIF and the GKI Readiness Index will be evaluated for how inclusive they are towards non-Western contexts in their SDI assessment. The insights gained from this evaluation are then used as a starting point for the new, inclusive SDI assessment framework. Then this framework will be evaluated and improved with feedback of experts on SDI's in non-Western contexts. The final inclusive framework will be applied to the embedded case study on the SDI of South Africa and the SDI of the City of Cape Town.

South Africa provides a relevant case for studying inclusive SDI assessment. While the country has a relatively well-established National Spatial Data Infrastructure (NSDI) and a number of local SDI initiatives, strong inequalities remain in access to digital infrastructure, skills, and basic services such as internet connectivity and electricity (OECD, 2023; City of Cape Town Corporate GIS, 2024). Even in the Local SDI of Cape Town, one of the more highly developed cities, there will be inequalities regarding SDI accessibility. This makes South Africa and the City of Cape Town a suitable environment for an embedded case study to explore SDI assessment for non-Western contexts.

2.1 Sub-Objectives

For this research, the most important sub-objective is to develop a SDI-evaluation framework for assessing SDI in non-Western contexts. by incorporating variables that are both relevant and feasible for these contexts. Another objective is transforming these variables to make them Specific, Measurable, Attainable, Relevant and Trackable ('SMART') as described by the United Nations Development Programme (UNDP, 2006).

2.2 Research Questions

The main research question for this research is "How to measure SDI performance in non-Western contexts?"

Sub questions:
1. What should an inclusive SDI assessment framework measure?
2. What would an inclusive SDI assessment framework look like based on theory and existing SDI assessment frameworks?
3. What modifications do SDI-experts recommend for this first draft?
4. What does the inclusive SDI assessment framework reveal about the status of SDI in South Africa and Cape Town?
5. What modifications for the framework can be deducted from the case study?

2.3 Research Limitations and Scope

It is important to recognize the limits of this study. Ideally, the research would include a wide range of case studies, one for each major South African city, or even other Sub-Sahara African cases. However, time constraints mean that only a small number of cases can be analysed in depth. Secondly, the indicators are each linked to one of the Figure 3: SDI components by van Loenen (2006) as well as a new component (connectivity). This aligns the framework to better match non-Western realities, but also this extension cannot cover every single detail of SDI development. Thirdly, SDI development is dynamic due to the influence from fast-changing technologies and political contexts (Sofianopoulos et al., 2025). This study will therefore offer a snapshot in time, rather than a long-term analysis. Finally, the research does not seek to design technical SDI systems or evaluate specific geospatial technologies. The main focus is on structural and governance aspects, as these have been shown to strongly shape SDI outcomes (Coetzee & Wolff-Piggott, 2015).

3. Methodology

This research uses a mixed-methods, embedded case study design. This means the case is assessed at two levels: the National SDI of South Africa and the Local SDI of the City of Cape Town (Yin, 2014). The approach combines qualitative and quantitative techniques to capture the complexity of SDI development across different scales. The methodology follows an iterative cycle consisting of theoretical framework design, expert validation, and practical application in a case study, after which the framework is revised based on the findings.

The first phase, shown in yellow in Figure 1, begins with a literature review that defines what inclusivity means in the context of SDI. This will help understand what an inclusive framework should emphasize. Existing SDI assessment frameworks are then reviewed, and indicators relevant to non-Western SDI assessment are identified and grouped. This phase produces the first draft of the framework, version one (V1).
The second phase, shown in green, uses the draft version (V1) as a starting point. Expert opinions on the quality of indicators are gathered through semi-structured interviews, and the framework is adjusted based on the feedback. This produces V2, the intermediate version of the framework.
The third phase, shown in blue, applies the intermediate framework (V2) to the case study of South Africa and the City of Cape Town. Based on the case study application, the framework gets evaluated on achievability using the SMART principles. Lastly, the framework is adjusted one final time, resulting in V3, the final inclusive SDI assessment framework.
The dashed arrows between the phases show that each version of the framework feeds into the next phase.
Finally, the last iteration of the inclusive framework will be assessed on it's added value compared to traditional assessment frameworks, revealing to what extent the inclusive framework is the answer to the main research question.

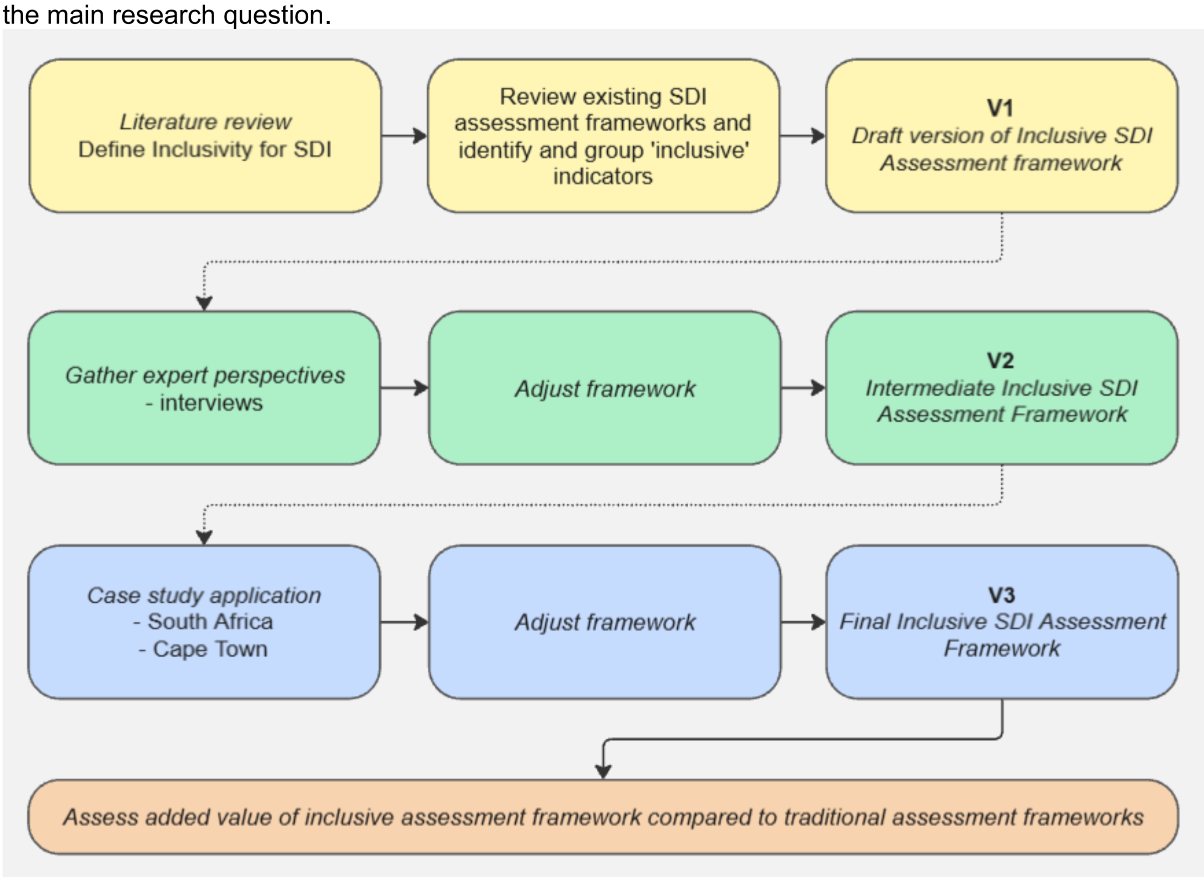

Figure 1: Flowchart of research methodology

Main research question: How to measure SDI performance in non-Western contexts?

The five research questions each correspond to a distinct phase of this methodology.

RQ1: What should an inclusive SDI assessment framework measure?

To answer the first research question, a definition of inclusivity in the context of SDI is constructed by drawing on existing definitions of ICT inclusion (Eurostat, 2023a; Eurostat, 2023b; Digital Future Society, 2019) and extending them to fit the domain of SDI. This leads to a definition for SDI inclusivity which is used to derive a set of criteria on what an inclusive SDI assessment framework should measure.

RQ2: What would an inclusive SDI assessment framework look like based on theory and existing SDI assessment frameworks?

The second research question is answered by reviewing literature on digital inclusion (Digital Future Society, 2019; Kim and Jang, 2025) and existing SDI assessment frameworks. The main frameworks included in this review are the UN-IGIF (Scott, 2020), the GKI Readiness Index (Geospatial World, 2025), and those of Eelderink (2006), Makanga and Smit (2010), Supinajaroen (2022), and Bhola (2024). The indicators from these frameworks will be evaluated against the criteria established in the first phase. Indicators that fit a non-Western assessment approach are grouped into components derived from van Loenen (2006), supplemented by components from the Digital Future Society (2019) and Kim and Jang (2025) to better match non-Western conditions.

RQ3: What modifications do SDI-experts recommend for this first draft?

The third research question is answered by evaluating and improving the first draft of the framework using insights from semi-structured interviews with a group of academic experts in the field of SDI development and the Global South or South African context. The interview findings are used to refine the framework and transform its indicators. To protect the privacy of participants, all interviewees are referred to by a participant code from P1 to P8. Table 1 provides an overview of the interview participants.

RQ4: What does the inclusive SDI assessment framework reveal about the status of SDI in South Africa and Cape Town?

The fourth research question is answered by applying the revised framework to the embedded case study. The decision to focus on South Africa was substantially motivated by the author's established connections to experts on the South African SDI, allowing for effective case study evaluation through semi-structured interviews with national and local SDI experts (P2, P4, P7, P8). The embedded design is used because the research requires assessment on both national and local level. This creates a more complete assessment and thoroughly tests the tentative framework.

RQ5: What modifications for the framework can be deducted from the case study?

The fifth research question is answered by reflecting on the performance of the framework during the case study application. Indicators that proved difficult to measure, unavailable in existing data sources, or insufficiently specific are identified, and revisions to the framework are proposed accordingly into a Specific, Measurable, Achievable, Relevant, and Time-bound format, following the SMART criteria as described by the UNDP (2006).

3.1 Interview Participants

Code	Role	Organisation	Date (DD-MM-YYYY)
P1	Professor	ITC Twente	02-12-2025
P2	Professor	UN University Dresden	05-12-2025
P3	SDI Researcher	Royal Thai Armed Forces	06-01-2026
P4	Geospatial Industry Lead	ESRI South Africa	06-01-2026
P5	Country coordinator	ITC Twente	14-01-2026
P6	SDI researcher	UNESCO	20-01-2026
P7	SDI researcher	CSIR	22-01-2026
P8	Professor	University of Cape Town	30-01-2026

Table 1: Interview participant overview table

To protect the privacy of participants, all interviewees are referred to by a participant code (P1-P8). Table 1 provides an overview of the interview participants. The eight interview participants were selected because of their expertise in SDI development, the Global South, or the South African context specifically. Some participants have an academic background in geomatics, land administration, or SDI research, while others work in government agencies or international organisations with direct experience in SDI implementation. This combination of academic and practical expertise was deliberately chosen to ensure that the framework was evaluated from multiple perspectives. Participants with experience in non-Western contexts were prioritised, as the framework is specifically designed for those settings.

The interview questions were developed based on the first draft of the framework, V1. For each component and indicator in the framework, a set of questions was formulated to test whether the indicator was considered appropriate for inclusion of non-Western contexts in SDI assessment. The questions were reviewed before the interviews to ensure they were clear and focused on the research objectives. Where participants raised topics that were not covered by the prepared questions, these were followed up within the same interview.

Semi-structured interviews were chosen as the most suitable format for this research because they combine a clear structure with enough flexibility to explore unexpected insights. Since the framework was still under development at the time of the interviews, it was important to leave space for participants to raise issues that the interview guide had not anticipated. A fully structured format would have been too rigid for this. The semi-structured format therefore offered the best balance.

3.2 Data, Software, and Research Materials

The research draws on several types of data. Open datasets on infrastructure, including electricity networks and internet access, are used alongside policy and strategy documents related to national and local SDIs. Qualitative data is collected through semi-structured interviews with experts on SDIs in the Global South or African context.

The interviews were conducted using Microsoft Teams and Zoom. Excel was used for basic data handling. Research materials include academic papers, SDI assessment reports, and data from national geoportals and other open online sources, as listed in Table 11Table 12Table 13Table 14Table 15Table 16Table 17Table 18, used for the case study on South Africa and the City of Cape Town.

Most interviews were conducted online, using Microsoft Teams or Zoom. This made it possible to interview participants based in different countries, including South Africa, Thailand, Greece, and the Netherlands, within a relatively short timeframe. Each interview was recorded with the participant's consent and later transcribed for analysis.

4. Inclusivity in SDI assessment

This chapter addresses the first two research questions: what should an inclusive SDI assessment framework measure, and what would such a framework look like based on theory and existing frameworks? It begins with a discussion of SDI theories and concepts (Section 4.1), which establishes the conceptual foundation for the framework and develops a working definition of SDI inclusivity. It then reviews two major global SDI assessment frameworks to evaluate their treatment of inclusivity (Section 4.2), followed by four SDI assessment studies focused on non-Western contexts (Section 4.3). The chapter concludes by synthesising the inclusive indicators identified across these frameworks into the first draft of the Inclusive SDI Assessment Framework (Section 4.4).

Over the last decades, Spatial Data Infrastructures (SDIs) have developed from simple technical systems for sharing geospatial data into complex social and technical networks that support governance, innovation, and sustainable development. Research now recognizes that SDIs are not only technical tools but also involve relationships among policy, institutions, technology, and society (Grus et al., 2010; cf. Crompvoets et al., 2008). This broader understanding of what SDIs are and what they do is the starting point for evaluating their potential for inclusive SDI performance assessment.

4.1 Theories and Concepts of SDIs

According to Grus, both SDIs and Complex Adaptive Systems (CAS) consist of a number of identifiable components and are complex phenomena due to interactions between these components. Both SDIs and CAS are sensitive to initial conditions, meaning that early decisions significantly shape its future development. Both interact with other sectors as open systems, making its boundaries difficult to define. They share a sense of unpredictability, as it is impossible to anticipate its evolution and future form. Like CAS, the architecture of SDI is self-similar across different levels, meaning building blocks don't change for local, regional, and national scale. SDI is also adaptive, like CAS, it can adjust its structure in response to new user requirements and technological advances. Comparable to an ecosystem both CAS and SDIs can self-organize, often driven by bottom-up initiatives. Both have nonlinear development, a change in political context can affect redirect or slow down progress. Lastly, SDI incorporates feedback mechanisms, like CAS, that allow for evaluation and innovation. The comparative case-study based method of Grus et al. (2010) allows for a smooth reference to this SDI research and shall be treated as a starting point to compare other frameworks.

4.1.1 Components of Spatial Data infrastructure

Early SDI ideas focused mainly on technical standards and data sharing. Later work expanded this to include policy, institutional, human, and technological aspects (Crompvoets et al., 2008; Grus et al., 2010). Crompvoets et al. (2008) suggested a multi-view SDI framework that looks at technical, human, and policy factors together. Grus et al (2010) describes the importance of viewing SDIs as Complex Adaptive Systems (CAS) due to their complex and dynamic nature.

Rajabifard et al. (2002) identified five components for SDI assessment: People, Access Network, Policy, Standards and Data (Figure 2: SDI components by Rajabifard (2002). Its core consists of the Access Network, Policy, and Standards components. These core components enable the people component to interact with the data component. These components are used by Eelderink (2006) as well as Grus (2010).

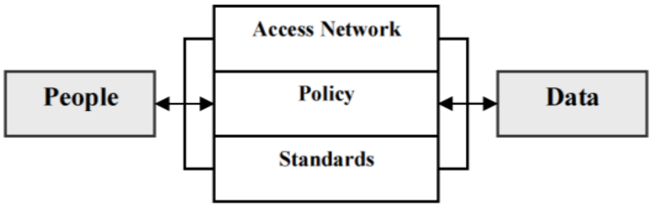

Figure 2: SDI components by Rajabifard (2002)

Van Loenen (2006) identified six components, (seven including ‘Datasets’): institutional framework, financial resources, human resources, standards, technology and policies in his dissertation on the development of SDI (Figure 3). The figure is designed around the generation, dissemination and use of geographic data (‘Datasets’ component) within a community.

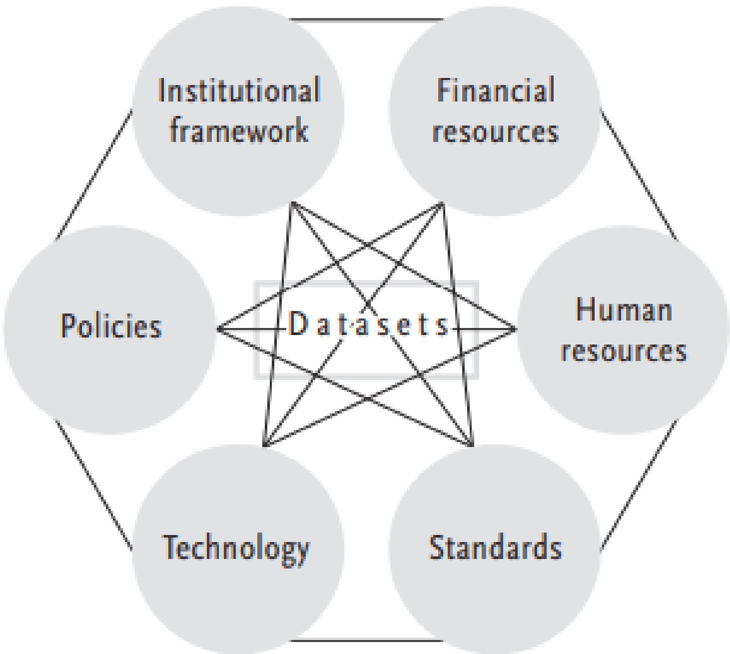

Figure 3: SDI components by van Loenen (2006)

4.1.2 Levels of SDIs

In Figure 4 the building block view, or 'SDI pyramid' by Rajabifard & Wiliamson (2001) is depicted. It contains seven levels of SDI, in which each layer is supporting the provision of spatial data for the layer above. It shows that the National SDI is built upon the Local SDI. For this research it is important to understand the position of the National SDI in relation to the Local SDI.

A National SDI covers an entire nation and typically involves coordination among various government agencies. A local SDI operates on a local or municipal level. For example, a GIS system for a city, managing local data like property records, zoning and utility infrastructure (Bhola, 2024). An SDI may appear to be inclusive on a national scale. However, when reassessing the SDI on local scale, results regarding inclusivity can differ.

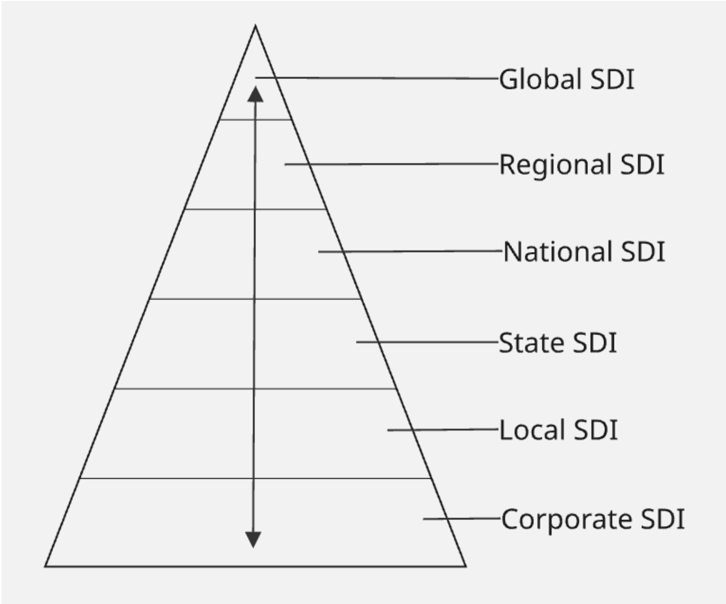

Figure 4: SDI Hierarchy by Rajabifard & Williamson (2001)

4.1.3 SDIs and SDGs

The Sustainable Development Goals (SDGs), were adopted by the United Nations (UN) in September 2015 as part of the 2030 Agenda for Sustainable Development. These goals serve as a universal call to action aimed at ending poverty, protecting the planet, and ensuring peace and prosperity for all by 2030. They succeeded the Millennium Development Goals (MDGs) and consist of 17 goals and 169 targets addressing complex and interconnected global challenges, including climate change, inequality, health, education, and sustainable consumption (United Nations, 2015).

Figure 5: SDG target 9.1 and 9.2 (Statsa, 2023)

South Africa's progress towards achieving the SDGs as described by Statsa (2023) showed that 33% of the targets lack sufficient data to conclude any progress. Another 33% of the targets have a positive trend, 23% have no 'noticeable change' and 11% of the targets evidently show no progress at all. Including target 9.1 (sustainable and inclusive data infrastructures) and 9.2 (promote inclusive and sustainable industrialization), shown in Figure 5 (Statsa, 2023).

Calzati & van Loenen (2023) discuss the importance of georeferenced data and geographic information systems in monitoring and achieving sustainable development goals (SDGs). However, they argue that current approaches, such as the United Nations' Integrated Geospatial Information Framework (IGIF), are based on assumptions that treat geospatial data as direct reflections of the physical world, overlooking important epistemological and ethical issues.

Although SDIs have strong potential to support the SDGs, many challenges remain, especially in developing countries. Technical problems, weak coordination between institutions, and limited funding reduce the effectiveness of SDIs (Ivánová et al., 2019).

4.1.4 ICT inclusion and the Digital Divide

This section develops a definition of SDI-inclusion and clarifies what exactly should be measured by an assessment framework that measures SDI-inclusivity.

The digital divide is defined by the Digital Future Society (2019) as the gap between those who have access to digital devices and content and those who do not. Van Dijk (2006) frames this as a form of social inequality, closely linked to material, educational, and social disadvantage. These types of inequality are common in non-Western contexts (Ngcamu, 2023; Oduro-Marfo & Clarke, 2018). Eurostat (2023b) defines the digital divide more precisely as the distinction between those who can access and use internet-based services and those who are excluded from them, with exclusion linked to gender, age, education, income, and geography.

Digital inclusion is the counterpart to the digital divide. Eurostat (2023a) defines e-inclusion as the situation in which everyone in society can participate in the information society, requiring affordable access to technologies, the usability of ICT tools and services, and the digital skills to use them. The Digital Future Society (2019) defines digital inclusion as the elimination of the digital divide by ensuring that those without access or skills can use digital devices and content confidently, safely, and effectively. The terms digital inclusion and digital inclusivity are used interchangeably in this thesis.

SDIs are not general ICT systems, but they are entirely dependent on them. Without internet access, digital devices, and reliable electricity, no stakeholder can meaningfully participate in an SDI, however well-designed its data, standards, or governance structures may be. This dependency means that existing ICT inclusion frameworks offer a critical starting point for developing an SDI-specific understanding of inclusion. Two such frameworks are discussed below.

Digital Future Society (2019)

The Digital Future Society (2019) proposes a global framework for measuring digital inclusion across four components: Access, Skills, Use, and Supportive Environment. Each component contains subcomponents with associated indicators (Table 2).
Although the framework was not designed for spatial data contexts, several of its components translate directly into the SDI domain. Access to electricity, device ownership, internet affordability, and digital skills are all conditions that determine whether meaningful participation in an SDI is possible. These elements are incorporated into the first version of the inclusive SDI assessment framework developed in Section 4.4.

Digital Future Society (2019)		
Component	**Sub-component**	**Indicators**
Access	Access to electricity	Access to electricity as % of general/rural/ urban population Access to electricity
	Access to telephony	Fixed-telephone subscriptions per 100 inhabitants Mobile phone subscriptions per 100 inhabitants Internet-enabled
	Access to device	Percentage of households with desktop/ laptop computer Presence of personal computer or tablet computer in household Mobile/tablet - Percentage of households with mobile phone
	Access to the internet	Access to the internet (%)
	Quality of connectivity	Average quality of connectivity
	Point of access	% of households with internet access Home (%) Work (%) Hotspot (%) Other (%)
Skills	Adult literacy	Adult literacy (%)
	Academic life expectancy	Enrolment in primary education (%) Gross graduation ratio from primary education (%) Enrolment in secondary education (%) Gross graduation ratio from upper and lower secondary education (%) Enrolment in tertiary education (%) Graduates from tertiary education (%) Mean years of schooling (%)
	Digital skills	Possession of “basic” or “above basic” digital skills (general) (%) In addition to having used basic software features such as word processing, use of advanced spreadsheet functions, created a presentation or document integrating text, pictures and tables or charts, or written code in a programming language % of people with a degree in ICT % employed ICT specialists
Use	Use internet	Individuals using the Internet (%) or People who never used the internet (%)
	Basic activities	Streamed, played, or downloaded content online (%) AV communication via the internet (%) Created or managed a site or blog (%) Searched for advanced information (%)
	Use eCommerce	Searched for eCommerce information in last 12 months (%) Made a transaction in last 12 months (%)
	Use eBanking	Searched for online banking information in last 12 months (%) Made a payment or transaction (including mobile money) in last 12 months (%) Made or received digital payments in the past year (% ages 35-59) or Used the internet to pay bills or buy online in the past year (% age 15+)
	Use eGovernment	Searched for digital public service information in last 12 months (%) Made a digital public service transaction in last 12 months (%)
	eWork / entrepreneurship	Used the internet or a device for work in the last 12 months (%)
	Social media	Used social media in the last 12 months (%)
	eParticipation	Engaged in public discourse online in the last 12 months (%)
Supportive environment	Affordability	Cost of 100 MB of data Device price (cheapest mobile on the market)
	Legally valid identification	Ability to apply for a personal identity card Presence of an eID or national digital identification system to access government services Evidence on government websites that the national ID is digitalized Nationally recognised eSignature (%)
	Banking and financial inclusion	Individuals with access to financial services (%)
	Trust	Confidence in privacy of online activities (%) Presence of data protection law(s)
	Security	Existence of legislation that specifically addresses sexual harassment Percentage of individuals victims of a crime (%)

Table 2: Digital inclusion index by the Digital Future Society (2019)

Kim and Jang (2025)

Kim and Jang (2025) develop an individual-level digital inclusion index using expert surveys conducted in South Korea. Their framework conceptualises digital inclusion as a multidimensional process involving Access, Competency, and Use. The Access component addresses devices, affordability, social support, and frequency of internet use. The Competency component captures proficiency in using digital devices, evaluating online information, creating and sharing content, engaging in online communities, and protecting digital rights. The Use component covers daily activities, economic transactions, and work-related tasks (Table 3).

The authors argue that access and use are currently more critical than competency in the South Korean context, and recommend that policy prioritise securing access and usability before focusing on digital skills development. Although developed in a relatively high-income, high-connectivity context, the framework is proposed as adaptable for comparative and cross-national application. For this research, the access-first logic is particularly relevant: in many non-Western contexts, foundational access conditions remain the primary barrier to participation, making competency-level assessment premature without first establishing whether the infrastructure for participation exists at all.

Kim and Jang (2025)		
Component	**Sub-component**	**Indicators**
Access	Access to digital technology devices	A wired Internet subscription, Wi-Fi router setup, PC, laptop, smart TV, smartphone, home IoT devices, personal IoT devices, smart watch
	Opportunity cost of digital devices	A bundle subscription, a fixed-term contract, remote opportunities available
	Access to social support networks	Having someone to help you with the use of the internet near you, having any effect when you got help from near you, digital learning support from digital service centers, digital learning support by digital education assistance programs, online help from portal sites or SNS
	Access frequency and flexible access to the Internet	Frequency of daily Internet use, access to the internet anytime and anywhere, speed and connection difficulties
Competency	Proficiency in using digital devices	Manage PC files and programs, manage smartphone apps, transfer files phone-PC, create documents including Words and Excel files, change preferences in the settings of PC or smart phones, set up preferred online networks, use smartphone-connected smartwatches and smart electronic devices
	Ability of understanding and evaluating digital information	Use varied search platforms, assess information reliability and authenticity, verify cross-references and websites, detect fake websites
	Ability to create and share digital content	Upload content online, convert digital media to other forms, share content on social platforms
	Ability to engage in online political and community activities	Support politicians and political parties online, sign online petitions, join personal interest-based online communities, participate in policy-making processes on government websites
	Ability to stay digital privacy and security	Adjust posting privacy, install and use antivirus programs, manage cookies and browsing history, adjust security settings, change passwords on your PC/smartphone/tablet, block and unblock spam/calls/text messages
	Ability to protect digital rights	Report phishing independently, handle copyright infringement independently, report right violations on portals and social media independently, report illegal websites independently, take appropriate actions in response to offensive posts
Use	Usability for daily activities	Use messenger apps, use social networking sites or apps, use online communities, use digital services (digital care, weather info., music playback, map, etc.) with smart devices, use portal news/newspaper, broadcasting apps
	Usability for economic and financial activities	Use online banking and mobile payment apps, use online shopping, apply for public documents and pay tax and bills online, invest in stocks and cryptocurrencies online
	Usability for work related activities	Use email for school or work, use cloud server services, use teleconferencing apps, use digital content-based educational and training materials, use smart office, use generative AI

Table 3: ICT-inclusion index by Kim and Jang (2025)

4.1.5 SDI Inclusivity

Existing definitions of ICT inclusion share a common emphasis on access to technology, the usability of digital tools, and the development of digital skills. They also recognise that exclusion follows social characteristics: gender, age, income, education, and geography. These elements form a useful starting point for understanding what an inclusive SDI assessment framework should measure, but they are not sufficient on their own. SDIs are not general-purpose digital services: they encompass spatial data governance, institutional frameworks, financial resources, and standards that have no direct equivalent in general ICT systems.

An SDI assessment framework designed for inclusion of non-Western contexts should therefore measure indicators that align with inclusivity in the context of SDI. Creating this definition for SDI-inclusivity surfaces indicators that are especially worth measuring in non-Western contexts. And thus, has relevance for inclusive SDI assessment.

In the context of SDI research the definition for ICT-inclusion should be extended to carry the weight of all the SDI components. This results in the following definition for inclusivity in SDI:

Inclusivity in SDI refers to a situation where all stakeholders can participate and benefit both individually and collectively. It requires affordable access to ICT, capacity building in both basic digital skills and spatial literacy, accessible datasets with clear standards, and equal stakeholder representation in data governance and funding mechanisms.

This definition for SDI-inclusivity and its main requirements leads to the following four components of SDI-Inclusivity:

1. **SDI-enabling ICT infrastructure**
   Recognizing that use of SDI is enabled by ICT, indicators should measure the foundational infrastructure necessary for participation. This includes indicators related to: Access to electricity, stable internet connectivity, and possession of digital devices.

2. **Technical accessibility and interoperability**
   Beyond basic ICT access, SDI-inclusion requires that spatial data and related technologies are technically accessible and interoperable. Indicators should therefore assess whether spatial datasets, platforms, and standards are openly accessible, provided with understandable metadata and usable without technical, legal, or financial barriers.

3. **Enablement of digital and spatial literation**
   Inclusion in SDI depends on the capacity of individuals and institutions to understand, interpret, and use spatial information. Indicators should therefore capture the availability and accessibility of capacity-building opportunities.

4. **Societal representation and participation**
   True SDI-inclusion extends beyond technical and educational aspects to institutional and political dimensions. Indicators should assess societal participation in decision-making processes, the level of transparency in allocation of financial resources regarding spatial data. Additionally, fair representation of various parts of society in the making of spatial data-related policies and institutional arrangements that represent society and promote equal access to spatial data, digital services and opportunities for all user groups.

4.2 Global SDI Assessment Frameworks

Assessment frameworks for SDI are in some cases tailored to non-Western contexts, but do not emphasize end-user participation, unlike assessment frameworks for ICT-inclusion that are more client-focussed. This chapter examines two global, SDI-assessment frameworks; the IGIF (Scott, 2020) and GKI Readiness Index (2025) and evaluates how they could be in alignment with measuring SDI-performance for non-Western contexts using the criteria derived from section 4.1.5 SDI Inclusivity. These SDI Assessment Frameworks are not created for the purpose of inclusive assessment. They rather provide an overview of the current approaches to SDI assessment and can inspire components of the new, inclusive SDI assessment framework.

4.2.1 IGIF

The United Nations Integrated Geospatial Information Framework (IGIF) (UN 2018; 2023a; 2023b) is An internationally recognized model for national SDI development (UN 2024).

The goal of IGIF, is to provide a guide for maximizing geospatial information management and related resources in all countries. The IGIF consists of three parts: the overarching strategy, the implementation guide and the country-level action plan (CAP). The first part is the overarching strategy providing strategic guidance, focusing on policy, governance, and institutions (UN, 2018). The main emphasis is on the nine strategic pathways (Figure 6). The second part of IGIF (UN, 2023a) is an implementation guide. It describes what actions can be undertaken to improve the management of geospatial information. Again, following the nine strategic pathways' structure. The third part includes a country-level action plan (CAP), providing tools for identifying and engaging stakeholders (Table 5).

4.2.1.1 Strategic pathways and practical enablers

The IGIF main components are referred to as strategic pathways and are organized under three key areas: governance, technology and people (Figure 6: IGIF's nine strategic pathways). Represented as interconnected pieces of a puzzle, the pathways highlight how each component contributes to an effective framework. Each of the nine pathways includes four sub-elements that serve as practical enablers (Table 4). For instance, the capacity and education pathway is enabled by entrepreneurship, awareness, formal education and professional training. These practical enablers will be evaluated as indicators for their relevance to inclusivity.

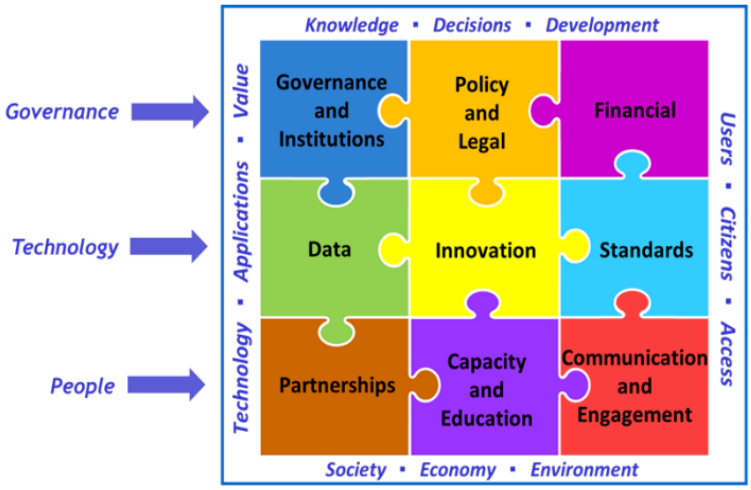

Figure 6: IGIF's nine strategic pathways

UN-IGIF

Component (Strategic pathway)	Sub-component (Practical enablers)	Indicators Ethiopia* *based on the ‘desired future state’ column in table 8.1 (Scott, 2020).*
Governance and Institutions	Governance model Leadership Value proposition Institutional arrangements	Effective geospatial information management; Increased capacity, capability and knowledge transfer; Integrated geospatial information systems and services; Economic return on investment; Enhanced national engagement and communication; Enriched societal value and benefits; GI governance & Policy; Institutional arrangements.
Policy and Legal	Legislation Policies, Norms and Guides Data protection, Licensing and sharing Responsibility and accountability	Effective geospatial management; Integrated geospatial information systems and services; Economic return on investment; Enhanced national engagement and communication; Geospatial policies and laws that stimulate data sharing, innovation and use of geospatial information; Developing complementary policy frameworks and creating awareness.
Financial	Business model Investment Opportunities Benefits realisation	Effective geospatial information management; Integrated geospatial information systems and services; Economic return on investment; Enhanced national engagement and communication; Enriched societal value and benefits; Use of geospatial information for decisions in utility, services, urban planning and management.
Data	Data themes Data supply chains Custodianship, acquisition and management Data curation and delivery	Effective geospatial information management; Integrated geospatial information systems and services; Economic return on investment; enhanced national engagement and communication; enriched societal value and benefits; governance arrangements; policy frameworks; metadata standards; Single central hub.
Standards	Quality Technology and data interoperability Community of practice Compliance	Effective Geospatial Information Management; Increased Capacity, Capability and Knowledge Transfer; Integrated Geospatial Information Systems and Services; Sustainable Education and Training Programs; Enhanced National Engagement and Communication.
Innovation	Technological advances Innovation and creativity Process improvement Bridging the Geospatial Digital Divide	Effective Geospatial Information Management; Increased Capacity, Capability and Knowledge Transfer; Integrated Geospatial Information Systems and Services; Economic Return on Investment; Sustainable Education and Training Programs; Status of geospatial technology centres of excellence and innovation networks; Status of the curriculum in universities and training institutions.
Partnerships	Cross-sector and interdisciplinary cooperation Community participation Industry partnerships and joint ventures International collaboration	Increased Capacity, Capability and Knowledge Transfer; Economic Return on Investment; International Cooperation and Partnerships; Enhanced National Engagement and Communication; Enriched Societal Value and Benefits.
Education and capacity	Formal education Awareness raising Professional workplace training Entrepeneurship	Increased Capacity, Capability and Knowledge Transfer; Sustainable Education and Training Programs; International Cooperation and Partnerships; Enhanced National Engagement and Communication; Enriched Societal Value and Benefits.
Communication and engagement	Stakeholder and user engagement Strategic messaging and engagement Communication strategy, plans and methods Monitoring and evaluation	Effective Geospatial Information Management; Increased Capacity, Capability and Knowledge Transfer; Integrated Geospatial Information Systems and Services; International Cooperation and Partnerships; Enhanced National Engagement and Communication; Enriched Societal Value and Benefits; Government officials at the highest levels advocate the value of geospatial information to the overall economic development of the nation.

Table 4: IGIF's 36 practical enablers and examples of indicators (Scott, 2020, p. 198)

******Indicators are not included in IGIF's framework, they are derived from a prior assessment (IGIF part 2) called an 'environmental scan' where a framework is created within IGIF to tailor to a country its specific needs (IGIF part 2, 2017). Examples of indicators are given based on the IGIF part 3: country-level action plan (CAP) for Ethiopia, as it is the exemplary Case Study in Gregg Scott's final thesis (Scott, 2020) and IGIF for South Africa is not yet in existence.*

One of the main components of the Country-level Action Plan (CAP, IGIF part 3) focuses on carrying out a needs assessment and preparing a gap analysis (Table 5: IGIF Part 3: Country-level Action Plan (CAP). (IGIF, 2017) 9). The needs assessment involves identifying current capabilities and describing a realistic future state based on national priorities. A baseline survey is used to collect detailed information about the country's existing geospatial information management situation. The work starts with the core team, but other stakeholders may need to take part in some parts of the survey. The survey follows IGIF's nine strategic pathways helping to identify gaps in data, technology, and capabilities. The most important gaps show parts of the SDI require attention and where investments should be made. The survey also provides a reference point for measuring progress when it is reviewed later.

In this second phase of the Country-level Action Plan (CAP), other activities also support the needs assessment and gap analysis. One of these is an environmental scan of internal and external factors that affect geospatial information management. In one method, a country reviews the technological, economic, social, and political factors that influence integrated geospatial information management. Another activity focuses on internal factors such as current skills, required policies, potential new applications, and the effects of outdated technology. These are IGIF's indicators, they can differ for every environmental scan made (IGIF, 2017).

Integrated Geospatial Information Framework *Country-level Action Plan (CAP)*				
Elements	Current Situation (Challenges)	Desired Future	Assessed Gap	Possible Strategies
The following elements are to be considered **Governance Model** **Leadership** **Value Proposition** **Institutional Arrangements**	To be derived from PEST and SWOT Analysis Report, Interviews and literature as well as the strategic alignment study. *Examples are:* *Lack of understanding about the value of geospatial information* *Geospatial information is not accessible* *There is no mandate for data sharing* *Weak link or communication gap between the political/policy level and geospatial information expertise* *Uncoordinated planning, design and implementation of developed projects* *Fragmented/siloed institutions*	Goals to be developed for each dimension or use the Strategic Pathway Objectives.	Refer to IGIF Part 2 Implementation Guide for assistance. *For example:* *There is a need to determine best approach of championing the importance of geospatial information – for example through an Executive Order or sponsored legislation.* *There is a requirement for governance mechanism for the coordination of geospatial information management that facilitates cross-agency coordination and cooperation.* *There is a need for a strategy to deliver the leadership, roles and responsibilities and guidance across all levels of government.*	List the strategies and activities to be included. *Examples are:* *Appoint steering committee* *Establish Coordination Unit and Specialist working groups* *Develop Geospatial Strategy* *Implement Governance Model* *Implement Reporting Framework*

Table 5: IGIF Part 3: Country-level Action Plan (CAP). (IGIF, 2017)

The main limitations of IGIF for inclusive assessment are its lack of concrete, comparable indicators. The environmental scan approach means no two applications are directly comparable. Additionally, Cooper et al. (2025) found that applying IGIF at local level may push municipalities to prioritise national government requirements over their own, potentially misallocating scarce resources.

4.2.2 GKI Readiness Index

Some frameworks focus more on economic development than on inclusivity. One example is the GKI Readiness Index (Geospatial Knowledge Infrastructure), introduced by geospatial world in 2017 (Narain, 2017). This index links spatial data infrastructures with innovation and national strategies for both Western and Global South countries. The GKI highlights five 'pillars' as main components that are organized in thirteen 'sub-pillars'. It provides a comparative framework that helps countries assess how prepared they are for developing a geospatial knowledge infrastructure, using the indicators shown in Table 6. It is important to note that the index is designed for a general but technically advanced audience, the sophisticated indicators of GKI assume that underlying technical necessities are already in place. For example, GKI emphasized the importance of AI, space technologies and high-level digital innovation. However, in many Global South countries it is of bigger effect to focus on basic infrastructure e.g. telecom coverage of rural areas or electrical reliability. The GKI Readiness Index does include Global South countries in its assessments while using technologically sophisticated indicators making it an interesting framework to put into comparison. The GKI is most useful to this research as a counterpoint: it illustrates what a technically sophisticated, innovation-oriented SDI assessment looks like, and thereby clarifies by contrast what is missing from existing frameworks.

GKI Readiness Index (Geospatial World, 2017)		
Component	Sub-Component	Indicator(s)
Infrastructure	Geospatial Infrastructure	Institutional capacity Staffing capacity Mandate clarity Technological readiness Geoplatform status Geodetic infrastructure Status geospatial databases Maintenance services
	Space infra	Data frequency Data resolution Data storage Data processing Presence of augmentation systems to enhance GNSS performance EO and GNSS data integration into national decision making processes.
	Hydrographic infra	Presence of hydrographic authority Availability of nautical charts Bathymetric datasets Use of advanced marine surveying technologies
Industry ecosystem	Industry capacity	Range and sophistication of offerings on GIS platforms Earth observation applications, GNSS services Sensor technologies Modelling tools Integration of AI, ML and data analytics for commercial solutions.
	Incubation and entrepreneurship	Investment incentives Firm creation Operational efficiency Regulatory clarity Private-sector growth Participation in global markets
	Innovation and government efficiency	Support for start-ups, incubators, accelerators and collaboration hubs. Funding availability
Institutional capacity	Geospatial institutional readiness	Institutional funding mechanisms, research mandates, staff expertise, laboratory infrastructure, alignment of research goals with national priorities.
	Knowledge ecosystem readiness	Collaboration between universities, research centres, industries, government agencies
User adoption	Geospatial application assessment	Number, variety and maturity of geospatial applications in use. and, their impact on operational efficiency. Their role in strategic decision-making. Degree of institutionalisation of geospatial use.
	Digital transformation and application	E-government development index, AI Readiness index, Network Readiness index
Policy landscape	Geospatial integration in cross sector policies	Integration of spatial tools in land management, agriculture, transport, logistics, energy, and urban development.
	Integrated digital innovation and data governance policies	Data governance, privacy, telecom infrastructure (5G), AI policies, and open data strategies.
	Geospatial and space policy governance	Clear policies, institutional mandates, licensing procedures, and compliance mechanisms.

Table 6: GKI indicators (p.185 GKI report, 2025)

4.3 Global South SDI Assessment Frameworks

The term Global South is used to describe countries and communities that have been affected by historical and present inequalities in the world. It often refers to nations in Africa, Asia, Latin America, the Caribbean, and Oceania that have lower or middle incomes. However, it is not only about geography. The Global South also represents the unequal relationships created by colonialism, imperialism, and globalization. These regions often face challenges such as slow economic development, dependence on stronger economies, and greater risks from climate change, health problems, and poverty. Even though the term is broad and sometimes unclear, it is useful for thinking about inequality and global connections (Ngcamu, 2023; Oduro-Marfo & Clarke, 2018). For this research, the Global South is referred to as 'non-Western contexts'.

Cooper et al. (2014) examined the application of Spatial Data Infrastructures (SDIs) in South Africa, Brazil, India, and China, emphasizing the institutional and legal complexities involved in SDI implementation and its importance for land-use planning. The study shows how SDIs support spatial and land development planning as stated in the Spatial Planning and Land Use Management Act (SPLUMA, 2011). The research first addresses spatial data challenges in South African planning, then explores the role, complexities, and value of SDIs both in other national contexts such as federal (India and Brazil) and centrally planned (China) systems. Ultimately, the study highlights the essential role of SDIs in enabling effective spatial planning, as well as their contribution to broader geospatial tools and technologies. Cooper et al. (2014) refer to various indicators for assessing SDIs in different national contexts.

The four SDI assessment studies reviewed in this section each address some of the specific conditions that make SDI development in these contexts different from the Western settings in which most assessment frameworks were developed.

4.3.1 Key variables for emerging countries: Eelderink (2006)

Eelderink (2006) conducted a thorough review of existing NSDI assessment frameworks and identified 94 potential variables (Table 7). Focussing on emerging countries, Eelderink (2006) based her research on six NSDI case studies: Colombia, Cuba, Nepal, Indonesia, Nigeria and Ethiopia. By conducting a literature review, the initial 94 potential variables were refined to 49 feasible variables that were specific, measurable, attainable, and traceable (SMART). And after analysing and comparing the six case studies on NSDIs, the list was reduced to 29 relevant variables. To validate these, a group of SDI experts was consulted, and their feedback was compared with the case study findings. From this comparison, 14 key variables were identified as most important for her global framework for assessment of NSDIs in emerging countries. These include digital data availability, capacity building, willingness to share, human capital, SDI awareness, access mechanisms, funding, leadership, vision, institutional arrangements, socio-political stability, interoperability, metadata availability, and related national initiatives.

Nevertheless, what works for the six national SDI contexts from Eelderink's research might not work at all in other national contexts in the Global South. The fact that Brazil and Colombia share a border, does not exclude that a different tailor-made approach might be required for both. In line with this reasoning South Africa cannot be compared with Nigeria or Ethiopia. An additional constraint is that technological advancements in the last 20 years will likely have impacted the status of NSDIs in the Global South.

Key variables for emerging countries (Eelderink, 2006)		
Component (Rajabifard et al., 2002)	Feasible variables	Key variables
Data	Availability of digital data	Availability of digital data
	Quality	
	Updating – adding of new data	
	Maintenance	
People	Willingness to share	Willingness to share
	Human capital	Human capital
	Capacity building	Capacity building
	Research to support NSDI	
	SDI education	
	User involvement	
	User satisfaction	
	SDI awareness	SDI awareness
Access network component	Access mechanism	Access mechanism
	Reliability	
	Performance	
Policy component	SDI directive	
	Funding	Funding
	Vision	Vision
	Institutional arrangements	Institutional arrangements
	Legal arrangements	
	Leadership	Leadership
	E-government existence	
	Socio-political stability	Socio-political stability
Standards component	Adoption of standards	
	Metadata availability	Metadata availability
	Interoperability	Interoperability
Other component	Communication channels	
	SDI maturity	
	Initiatives connected to SDI (country's activity)	Initiatives connected to SDI (country's activity)

Table 7: Selection of key variables by Eelderink (2006)

4.3.2 African NSDI Assessment: Makanga & Smit (2010)

Makanga and Smit (2010) assessed the status of NSDIs in 29 African countries using a modified version of the INSPIRE State of Play framework. Their research found that most NSDI initiatives on the continent remain at early stages, constrained by institutional and capacity challenges. The framework used for the assessment consists of 14 indicators across five classes: Organisational, Funding, Legal, Technical (Data), and Technical (Metadata) (Table 8).
Several of these indicators are directly relevant to the inclusive SDI assessment framework developed in this research. The requirement for maximum stakeholder participation (1B) corresponds to the societal representation dimension. The requirement for a reasonable budget (2A) relates to the financial resources component. The legal indicators (3A-3C) address data pricing and use, which connect to the accessibility dimension. The technical data indicators (4A1-4A3) address interagency coordination, standardisation, and geoportal access. And the metadata indicators (4B1-4B3) address metadata availability and quality, both of which are included in the inclusive framework.
The African focus of Makanga and Smit's work makes it particularly relevant to the South African case study, and their results for South Africa specifically are taken into account in Chapter 6. Their framework does not, however, address connectivity, electricity, or device access. This reflects the same implicit assumption of adequate infrastructure that characterises the global frameworks reviewed in Section 4.2.

SDI assessment viewpoints and indicators (Makanga & Smit, 2010)		
INDICATOR CLASS		INDICATOR
Organisational	**1A**	There is a National SDI Coordinating body (Government, Voluntary)
	1B	There is maximum stakeholder participation (Government, Private Sector)
	1C	There is an SDI Champion at the Highest Political Level
Funding	**2A**	There is a reasonable budget to fund SDI activities
	2B	The SDI initiative is self-sustaining
Legal	**3A**	There is a legal framework governing spatial data pricing
	3B	There is a legal framework governing spatial data use
	3C	There is a legal framework governing spatial data creation
Technical (Data)	**4A1**	There is a reasonable level of interagency coordination of spatial data creation efforts
	4A2	The data creation process is formally standardised for all data creators
	4A3	There is ready access to electronic spatial data through a Geo-portal, CDs and other forms
Technical (Metadata)	**4B1**	Metadata is captured for most of the spatial data that is created
	4B2	Data creators create metadata according to a prescribed standard
	4B3	There is a clearinghouse(s) that communicates most of the available data resources

Table 8: SDI assessment viewpoints and indicators (Makanga & Smit, 2010)

4.3.3 Cases from Thailand and Surinam

Supinarajoen (2022) and Bhola (2024) emphasized the need for basic infrastructure components (e.g., road infrastructure, telecom, electricity availability) in Global South contexts with their research in Thailand (Supinarajoen) and Surinam (Bhola).

Supinajaroen (2022) presents a case study on the use of National Continuously Operating Reference Stations (NCORS) data in Thailand, focusing on optimization and data accessibility within a broader technical modernization agenda. As part of this research, a concept for an NCORS data ecosystem was developed, including components and indicators that are incorporated into the inclusive SDI framework later proposed in this study. Bhola (2024) adopts a community-centred perspective through fieldwork conducted in Suriname. His case study within an Indigenous community illustrates how bottom-up SDI approaches can support inclusivity, strengthen local capacity, and improve data relevance in marginalized, lesser connected, regions. Together, these studies emphasize the need for SDI frameworks that are inclusive to Global South conditions.

4.4 Inclusive indicators from theory

The frameworks reviewed in Sections 4.2 and 4.3, together with the ICT inclusion frameworks discussed in Section 4.1.4, provide the source material for the first draft of the Inclusive SDI Assessment Framework. This section describes how indicators are identified to support inclusive SDI assessment for each SDI component and then assembles them into the draft framework (Table 9).

The framework is structured around the SDI components identified by van Loenen (2006): Datasets, Technology, Standards, Human Resources, Policies, Institutional Framework, and Financial Resources, supplemented by a dedicated Connectivity component. Connectivity is added because it represents the foundational ICT infrastructure without which participation in any other SDI component is impossible, and because it is systematically absent from existing SDI assessment frameworks. This addition is supported by the findings of Supinajaroen (2022), Bhola (2024), Kim and Jang (2025), and the Digital Future Society (2019).

4.4.1 Inclusive SDI components

To illustrate the concept of inclusive SDI assessment, a short definition as well as some examples will be provided in line with the SDI components by van Loenen (2006), as shown in figure 3.

4.4.1.1 Connectivity

People can only participate in SDI if they have access to digital infrastructure. Inclusive assessment of SDI therefore starts with measuring ICT-inclusion. For this reason, an additional component is included to represent basic digital infrastructure performance, as highlighted in previous studies (e.g., Kim & Jang, 2025; Digital Future Society, 2019). Relevant indicators cover internet access frequency (Kim & Jang, 2025), general household internet access (Digital Future Society, 2019), mobile data pricing (Eelderink, 2006), connection quality (Digital Future Society, 2019), and electricity access and reliability (Bhola, 2024; Digital Future Society, 2019). Together these capture the foundational conditions that allow for SDI participation among all user groups.

4.4.1.2 Technology

Inclusive assessment of technology refers to measuring broad accessibility in platforms and infrastructure. Technology allows for digital collection and low-cost sharing of information, increasing the accessibility to data for the digitally literate public that have the means to access. To measure technology, several indicators can be used. These include access to digital devices (Kim & Jang, 2025), access to telephony (Digital Future Society, 2019), and general access to digital devices (Digital Future Society, 2019), such as the percentage of households with a desktop or laptop computer and the percentage of households with a mobile phone. Access to spatial data (Bhola, 2024), availability of technical equipment (Bhola, 2024), and general data access (GKI, 2025) are also relevant. In addition, the number of languages available on an SDI portal (Eelderink, 2006) can indicate whether platforms are accessible to diverse user groups. Together, these indicators help assess the technology component in an inclusive manner.

4.4.1.3 Datasets

According to Digital Future Society (2019) inclusive data sets are those that reflect the diversity of society and capture information at local levels. When data contains demographic characteristics such as gender, age, income, and level of education, it becomes easier for decision-makers to understand the specific needs of different groups and respond more effectively.
At the same time, data must be accessible in order to enable participation. This includes the availability of digital spatial data (Eelderink, 2006; Supinarajoen, 2022) and ready access through platforms such as geo-portals, CDs, or other distribution formats (Makanga & Smit, 2010). The cost of accessing data is also an important factor, as high data pricing can create barriers for certain users (Eelderink, 2006). In this thesis, inclusive assessment of datasets will be conducted through the concept of accessibility of data.

4.4.1.4 Standards

Inclusive assessment of standards refers to measuring the use of clear and widely accepted rules that make spatial data easy to find, share, and use. An important part is assessing the availability of complete and understandable metadata, so users know what the data contains and how to use it. When data creators follow recognized standards such as ISO, different systems can work together more easily, which improves interoperability and improves access for different user groups (Digital Future Society, 2019).

The idea of inclusive assessment of standards is also reflected in the FAIR and CARE principles. FAIR stands for Findable, Accessible, Interoperable, and Reusable, and focuses on improving the technical usability of data. CARE stands for Collective benefit, Authority, Responsibility, and Ethics, and emphasizes the responsible and ethical use of data (Carroll et al., 2021). Together, these principles show that inclusivity in standards is not only about technical compatibility, but also about fairness and accountability in data governance.

Relevant indicators include whether data creators produce metadata according to prescribed standards (Makanga & Smit, 2010), whether metadata is captured for most spatial datasets (Makanga & Smit, 2010), and the general availability of metadata (Eelderink, 2006; Supinarajoen, 2022; Bhola, 2024). The type of metadata standard used (e.g., ISO, CEN, FGDC) (Eelderink, 2006) and the number of languages in which metadata is provided (Eelderink, 2006) are also important for assessing spatial data standards inclusively.

4.4.1.5 Human resources

Inclusive assessment of human resources refers to measuring access to education, training, and other capacity-building opportunities, with a strong focus on digital literacy for all members of society.

Relevant indicators include academic life expectancy (Digital Future Society, 2019) and access to education in terms of type and availability (Eelderink, 2006). Professional workplace training opportunities (IGIF, 2023) and general digital skills levels (Digital Future Society, 2019) are also important. This can be measured, for example, by the percentage of people with a degree in ICT and the percentage of employed ICT specialists. In addition, the availability of skilled personnel (data managers, GIS professionals, and policy experts) plays a key role in maintaining and developing SDI systems.

Additionally, awareness and engagement are important aspects of inclusive human resources assessment. Indicators such as SDI awareness (Eelderink, 2006), awareness-raising activities (IGIF, 2023), user involvement (Eelderink, 2006; Bhola, 2024), and broader community participation (IGIF, 2023; Bhola, 2024) help assess whether people are informed about and actively engaged in SDI processes. Measures such as the size of user involvement or the number of portal visitors (Eelderink, 2006) can also provide insight into the level of societal participation.

4.4.1.6 Policies

Inclusive assessment of policies refers to measuring the existence and effectiveness of laws, regulations, and strategic frameworks that aim to promote digital inclusion and reduce exclusion caused by technological change. They create the formal conditions that allow different social groups to participate in SDI processes. For example, in South Africa, the Recognition of Prior Learning (RPL) system enables existing GIS professionals to obtain formal certification based on their experience (SAGC, 2025). This helps prevent skilled practitioners from being excluded due to a lack of formal qualifications. Similarly, in Suriname, the government established special commissions to address indigenous land claims and support land titling processes (Bhola, 2024), demonstrating how institutional mechanisms can strengthen representation and participation in spatial governance.

Key indicators for inclusive assessment of SDI policies include the overall development approach (e.g., bottom-up or top-down) (Eelderink, 2006), and the degree of decentralisation or centralisation within governance structures (Eelderink, 2006). Policies that actively aim to bridge the digital divide (IGIF, 2023) are also important. Furthermore, the ability of communities and local actors to self-organize and influence SDI development (bottom-up) serves as an indicator of policy environments (Supinarajoen, 2022; Bhola, 2024). Together, measuring these elements contribute to inclusive policy assessment.

4.4.1.7 Institutional framework

An inclusive assessment of the institutional framework component refers to assessing governance structures and institutional arrangements that represent society and promote equal access to spatial data, digital services and opportunities for all user groups. An example of an institutional arrangement is the SDI act of South Africa that promotes data sharing between various levels of government, thereby reducing institutional silos (Department of Rural Development and Land Reform, 2014).

Indicators to inclusively assess the institutional framework include a reasonable level of interagency coordination in the creation and management of spatial data (Makanga & Smit, 2010), as well as the willingness of institutions to share data (Eelderink, 2006). Cross-sector and interdisciplinary cooperation between government, private sector, academia, and civil society (IGIF, 2023) is also important. Together, these factors show whether institutional arrangements support collaboration, transparency, and broad participation in SDI systems.

4.4.1.8 Financial resources

Inclusive assessment of financial resources refers to measuring transparent and accountable funding mechanisms for SDI-related projects. Funding should not only benefit urban economic centres, but also be allocated to rural areas and marginalized communities, especially to strengthen digital literacy and local capacity.

One important indicator for assessing financial resources inclusively is the degree of commercialisation of data (Eelderink, 2006). High levels of data commercialisation may create financial barriers for certain users, while more open and publicly funded models can support broader and more equitable access to spatial data.

In addition, when private companies become too dominant in financing or managing spatial data infrastructure, there is a risk of financial lock-in, where dependence on private companies limits public control and long-term sustainability (Cooper, 2025).

Van Loenen (2006) emphasizes the importance of building awareness and commitment among the people that control funding resources to promote development of SDI. Awareness will lead to commitment to sustainable funding. Indrajit (2018) confirmed this theory through his research on Indonesian Open Government Data (OGD). He found that an important change regarding financial resources occurred through moving the Geospatial Information Agency from the Ministry of Research and Higher Education to the Ministry of National Development and Planning. The latter is in charge of government budgets, so the move made it easier to receive more funding. This strengthened the spatial data coordination.

4.4.2 Inclusive SDI assessment

Table 9 presents the first version of the Inclusive SDI Assessment Framework, bringing together indicators from the Digital Future Society (2019), Kim and Jang (2025), Eelderink (2006), Makanga and Smit (2010), Supinajaroen (2022), Bhola (2024), IGIF (2023), and the GKI Readiness Index (2025). The indicators align with the SDI-inclusion components defined in Section 4.1.5, linked to the SDI components of van Loenen (2006), with connectivity added to address the foundational infrastructure barriers that are common in non-Western contexts but overlooked by most existing frameworks.
At this stage many indicators overlap or lack a clear unit of measurement. This is intentional: this version of the inclusive framework is designed to capture the full breadth of potentially relevant indicators drawn directly from theory. In chapter 5 they are refined through expert input.

Inclusive SDI framework derived from ICT-inclusion and SDI assessment frameworks		
SDI-inclusion components	Subcomponents	Indicator
SDI-enabling ICT-infrastructure	Connectivity	Access frequency and flexible access to the internet (Kim & Jang, 2025) Access to the internet (Digital Future Society, 2019) ▪ Mobile data coverage (Digital Future Society, 2019; Supinarajoen, 2022) ▪ Mobile data pricing (Eelderink, 2006) Access to electricity (Digital Future Society, 2019) ▪ Availability of electricity (Bhola, 2024) ▪ Availability of generator (Bhola, 2024) quality of connectivity (Digital Future Society, 2019) Point of access (Digital Future Society, 2019) ▪ % of households with internet access
Technical accessibility and interoperability	Technology	Access to digital technology devices (Kim & Jang, 2025) Access to telephony (Digital Future Society, 2019) Access to device (Digital Future Society, 2019) ▪ % of households with desktop/ laptop computer ▪ % of households with mobile phone Access to spatial data (Bhola, 2024) availability of technical equipment (Bhola, 2024). Data access (GKI, 2025) Number of languages used (SDI portal) (Eelderink, 2006).
	Datasets	There is ready access to electronic spatial data through a Geo-portal, CDs and other forms (Makanga & Smit, 2010). Availability of (digital) data (Eelderink 2006; Supinarajoen, 2022). Data pricing (Eelderink, 2006).
	Standards	Data creators create metadata according to a prescribed standard (Makanga & Smit, 2010) Metadata is captured for most of the spatial data that is created (Makanga & Smit, 2010) Availability of metadata (Eelderink, 2006; Supinarajoen, 2022; Bhola, 2024). Type and use of metadata standard (ISO, CEN, FGDC) (Eelderink, 2006). Number of languages used (metadata) (Eelderink, 2006).
Digital and spatial literation	Human resources	Academic life expectancy (Digital Future Society, 2019) ▪ Education (type, availability) (Eelderink, 2006). Professional workplace training (IGIF, 2023). Digital skills (Digital Future Society, 2019) ▪ % of people with a degree in ICT ▪ % employed ICT specialists. Skilled personnel: Data managers, GIS profs and policy experts SDI awareness (Eelderink, 2006) Awareness raising (IGIF, 2023) User involvement (Eelderink, 2006; Bhola, 2024) Community participation (IGIF, 2023) Community involvement (Bhola, 2024) Size of user involvement, number of visitors (Eelderink, 2006)
Societal representation and participation	Policies	Development approach (bottom-up, top-down) (Eelderink, 2006). Decentralisation/centralisation (Eelderink, 2006). Bridging the digital divide (IGIF, 2023) Self-organisation ability (Bottom-up) (Supinarajoen, 2022; Bhola, 2024).
	Institutional framework	There is a reasonable level of interagency coordination of spatial data creation efforts (Makanga & Smit, 2010). Willingness to share (Eelderink, 2006). Cross-sector and interdisciplinary cooperation (IGIF, 2023).
	Financial resources	Commercialisation of data (Eelderink, 2006)

Table 9: First version of the inclusive SDI assessment framework

5. Inclusive SDI assessment in perspective

For this chapter the SDI components will be used as described in the previous chapter, in alignment with the components of van Loenen (2006), and with the new component for connectivity (see chapter 4.4.1 Inclusive SDI componentsfor the description of these components). The indicators are inspired by existing frameworks (chapter 4) and have been evaluated by various experts on the non-Western SDI context. A total of eight experts participated through semi structured interviews as well as personal contact through email. The participants consist of professors and researchers on SDI (P2, P3, P6, P7) or related fields such as Geomatics (P8) and Land Administration (P1), as well as a Geospatial Industry Lead (P4) and lastly, a project officer and country coordinator for Indonesia with a background in SDI (P5).
Through these interviews and emails, the framework was improved and tailored to better assess inclusivity in SDI.

"There are some people who think that SDIs were only ever meant to be technical and nothing to people, which is complete rubbish." (P7, personal communication, January 2026).

5.1 Connectivity

Inclusivity in connectivity means that people have affordable and reliable internet access to use SDI services. Without connectivity for all user groups, SDI cannot function as an inclusive infrastructure. Connectivity is especially relevant in non-Western countries, as mentioned by P3: "*in a non-western context it is correct to emphasize basic physical infrastructure."* (P3, personal communication, January 2026)

The original indicators for connectivity came from different frameworks by Kim & Jang (2025), Digital Future Society (2019), Supinarajoen (2022), and Bhola (2024). They were presented as a general list of ideas, without standard units of measurement or clear differences between the indicators (Table 9). The transformation process organized and simplified them into five SMART indicators under two sub-components.

5.1.1 Access to Internet (1A–1C)

The percentage of households with internet access (1A), combines several overlapping ideas from the original sources. Concepts such as "access to the internet," "access frequency and flexible access," and "point of access" all describe whether and how people connect to the internet. Instead of measuring these separately, they are combined into one clear indicator. This is an internationally recognized measure collected by national statistics offices (e.g. StatSA, 2022 & OECD, 2023).
Participant 6, an SDI researcher, stated that: "data [telecom] bundle pricing is an important issue" when asked about the importance of connectivity assessment in SDI assessment (P6, personal communication, January 20, 2026). Hence, "Mobile data pricing" is kept as a separate indicator (1B). It is measured as the average cost of 100MB of mobile data.

Average download speed in Mbps (1C) comes from the original ideas of "quality of connectivity" and "mobile data coverage." The average download speed in Mbps is a standard indicator used by the Speedtest Global Index (Ookla). Mobile data coverage is included in the ICT-inclusion index and the Digital Inclusion index. However, Participant 8 explained that you can get at least LTE anywhere [in South Africa], the pricing of the data is what leads to exclusion. (P8, personal communication, January 30, 2026). Hence, mobile data coverage is excluded as an indicator and removed from the final framework.

5.1.2 Access to Electricity (1D–1E)

The access to electricity indicator is based on Bhola (2024) and Digital Future Society (2019). "Availability of electricity" is measured as the percentage of households with reliable electricity access (1D). The original idea of "availability of generator" by Bhola (2024) is expanded to "availability of backup power" (1E), which includes generators, solar energy, and battery capacity. This reflects the different energy solutions used, especially in lower-income countries. Both indicators are measured as percentages of households to allow for comparison.
Overall, the transformation removes overlap between concepts, gives each indicator one clear unit of measurement, and connects the framework to internationally recognized data sources. This makes the framework easier to apply in different national contexts.

5.2 Technology

Inclusivity in technology means that SDI systems are reliable, accessible, and usable for different types of users. Even if data and skills are available, technical constraints can still create exclusion. If the geoportal is unstable, slow, or difficult to access, only highly skilled or well-equipped users will benefit from it. Participant 3 stated that "*Access to equipment or devices can be an important obstacle [for SDI-inclusion]*" (P3, personal communication, January 6, 2026).

The original indicators for technology access came from different frameworks (Kim & Jang, 2025; Digital Future Society, 2019; Bhola, 2024; GKI, 2025; Eelderink, 2006). They were presented as a mixed list of broad ideas, such as "access to digital technology devices" and "access to technical equipment," together with some indicators that were already partly measurable, such as "% of households with a desktop/laptop computer" and "% of households with a mobile phone."
The transformation process organizes and improves these into three SMART indicators under the Technology sub-component.

5.2.1 Access to telephony (2A-2B)

Access to telephony is divided into two separate indicators instead of being treated as one general concept. The original sources use terms like "access to telephony" or "% of households with mobile phone" as broad categories. However, for SDI performance in non-Western contexts, it is important to distinguish between feature phones and smartphones. A feature phone only allows basic communication and gives little or no access to geoportals, spatial data, or online SDI services. In contrast, a smartphone or tablet allows full digital participation. For some participants, a feature phone could be enough to get what they need from the SDI. P6 stated that "Computers might not be necessary [for SDI-inclusion], People can use android or even feature phones." (P6, personal communication, January 20, 2026). Additionally, Participants 5 stated: "Depending on what people need [from SDI], an early warning system through SMS could be enough [for inclusion]." (P5, personal communication, January 14, 2026).

For this reason, indicator 2A measures access to feature phones as a percentage of the population. Indicator 2B measures access to smartphones and tablets as a percentage of households, since these devices are often shared within a household and used for accessing online data and services.

5.2.2 Access to computer (2C)

Access to a desktop or laptop computer (2C) directly builds on the original indicator "% of households with desktop/laptop computer," which appeared in several source frameworks. This type of device is still important for SDI use, because professional GIS software, downloading large datasets, and advanced geoportal use usually require a computer rather than a mobile device.

Spatial data access and language diversity are covered under the Datasets sub-component (3A–3D).
This clear separation ensures that the Technology sub-component focuses only on access to end-user devices, without mixing it with data availability or portal design.

5.3 Data

Inclusivity in data access means that spatial information is open, and easily accessible to all stakeholders of the SDI in a language they understand. Data is the core of SDI. As Participant 6 stated: “To include people [in SDI], you have to have the data open.” P6, personal communication, January 20, 2026). If access to data is restricted or incomplete, SDI-participation becomes exclusive.

The original indicators for data accessibility came from Makanga & Smit (2010), Eelderink (2006), and Supinarajoen (2022). They were described as broad and mostly qualitative ideas about data availability and pricing. However, they did not use clear measurement units and did not clearly separate different aspects such as access, openness, and quality. The transformation process organizes and converts these ideas into four SMART indicators under two sub-components: Access to Data (3A–3C) and Data Quality (3D).

5.3.1 Access to data (3A-3C)

Data available through a national geoportal (3A) directly translates the idea from Makanga & Smit (2010) of “ready access to electronic spatial data through a geoportal, CDs, and other forms.” While the original concept included different distribution methods, the geoportal is selected as the main indicator because it represents the modern standard for sharing spatial data in an SDI. It is also the most comparable system across countries. The unit of measurement is Yes/No, since the existence of a geoportal is a basic requirement before more detailed aspects of access can be evaluated. Older methods such as CDs are not included, as they are harder to measure.

National core datasets are openly available (3B) combines the original ideas of “availability of digital data” and “data pricing.” Instead of measuring pricing separately which can be difficult to compare between countries, the indicator focuses on openness. It is measured as the percentage of core datasets that are openly available. Open data means that the dataset is available without any cost. Datasets behind paywalls are therefore not counted. This method reduces overlap while still addressing both availability and affordability.

Number of languages used on the SDI portal (3C) was originally listed under the Technology sub-component (Eelderink, 2006). It is moved to the Datasets sub-component because it better reflects how accessible the data portal is to different user groups. It is measured as the number of languages available on the national geoportal interface, which allows comparison between countries.

5.3.2 Data quality (3D)

Spatial coverage of core datasets (3D) is included as a data quality indicator. Although it was not clearly listed in the original sources, it is closely related to the idea of data availability.
Participant 6 stated that: “spatial data coverage is very important [for SDI-inclusion]” (P6, personal communication, January 20, 2026). Additionally, Participant 7 emphasized that “collecting data on a national level is easier than collecting data on a finer level but data on a finer level is needed to compare provinces and cities.” (P7, personal communication, January 22, 2026).

Data may exist, but if it only covers part of the country, it cannot be considered fully inclusive. This indicator measures the percentage of national territory covered by core datasets. It shows whether spatial data is available equally across the country, including rural and remote areas that are often less represented.

Overall, this transformation clarifies the differences between access, openness, and quality, assigns clear measurement units, and improves comparability across national contexts.

Together, these indicators form an integrated assessment framework that enables inclusive evaluation of SDI development across non-Western contexts by incorporation of constraints (e.g., connectivity and power) that are particularly relevant for inclusivity.

5.4 Standards

Standards are relevant for both SDI-inclusion and basic functioning of SDI. As participant 8 stated: “for data to be usable [for capacity constrained institutes] it has to come in a particular standard or in a particular format.” (P8, personal communication, January 30, 2026).

5.4.1 Metadata for core datasets

The original indicators for standards came from several frameworks (Makanga & Smit, 2010; Eelderink, 2006; Supinarajoen, 2022; Bhola, 2024). They were written as general statements about whether metadata exists and whether standards are followed. The transformation turns these into three clear, measurable indicators under one sub-component: Metadata for core datasets (4A–4C).

Metadata availability (4A) combines two closely related ideas from Makanga & Smit (2010): that data creators follow a prescribed standard, and that metadata is captured for most spatial data. It also draws on the broader concept of metadata availability from Eelderink (2006), Supinarajoen (2022), and Bhola (2024). Instead of asking whether metadata "is available," the indicator measures this as a percentage of datasets that have metadata. This makes it easier to compare countries and to track progress over time.

Metadata quality (4B) comes from the original indicator on the type and use of metadata standards such as ISO, CEN, and FGDC (Eelderink, 2006). The original source lists several possible standards without specifying which one to use for comparison. In the transformed framework, ISO is chosen as the reference standard because it is the most widely used international standard for spatial metadata. The indicator is measured as the percentage of metadata records that comply with ISO standards. This gives a clear picture not just of whether metadata exists, but of how good it is.

Metadata language diversity (4C) directly follows the original indicator on the number of languages used in metadata (Eelderink, 2006). It is kept as a simple count of languages used in metadata records. This indicator is important for assessing SDI performance in non-Western contexts because metadata written only in one language limits access for users who speak other languages, especially in countries with multiple official or regional languages. Participant 1 states that “in Global South countries often many languages are spoken, and the systems tend to only run in the dominant legal language.” (P1, personal communication, December 2, 2025).

5.5 Human Resources

Inclusivity in human resources means that different groups of people have the skills, knowledge, and opportunities to participate in SDI. If only a small group of experts understand how to use the SDI, it becomes exclusive.

The original indicators for digital and spatial literacy came from several frameworks by the Digital Future Society (2019), Eelderink (2006), IGIF (2023), and Bhola (2024). They covered a wide range of ideas, from general education levels to community involvement, but many were broad or overlapping. The transformation organizes these into five clear, measurable indicators across two sub-components: Human capital & Capacity building (5A–5C) and SDI user participation (5D–5E).

5.5.1 Human capital & Capacity building (5A-5C)

Availability of academic GIS or Geomatics programs (5A) draws from the original concepts of "academic life expectancy" (Digital Future Society, 2019) and "education type and availability" (Eelderink, 2006). These original indicators were broad and difficult to measure in a way that is specific to SDI. The transformation narrows the focus to the availability of university-level GIS and Geomatics programs, measured as a simple count of programs. This is more directly relevant to building the skilled workforce that an SDI needs, and it is easier to verify through national education records or university databases. Participant 1 stated that “the local offer of university courses might lose significance since people go abroad to study.” (P1, personal communication, December 2, 2025).
And participant 2 stated that “people can attend online university, when there is sufficient connectivity.” (P2, personal communication, December 5, 2025).

Professional workplace training (5B) comes directly from IGIF (2023) and relates to the broader concept of capacity building beyond formal education. Because the type and quality of workplace training varies greatly between countries and organizations, this indicator is assessed qualitatively rather than as a number. A qualitative assessment can capture whether training programs exist, how they are organized, and who has access to them.

Skilled SDI personnel (5C) combines several overlapping original indicators: "% of people with a degree in ICT," "% of employed ICT specialists," and "skilled personnel including data managers, GIS professionals and policy experts" (Digital Future Society, 2019; Eelderink, 2006). Rather than measuring general ICT skills the indicator focuses specifically on the number of people with GIS skills. This keeps the focus on the professionals who directly contribute to building and maintaining an SDI.

5.5.2 SDI user participation (5D-5E)

SDI awareness among users (5D) transforms the concepts of "SDI awareness" (Eelderink, 2006), "awareness raising" (IGIF, 2023), and "community involvement" (Bhola, 2024; IGIF, 2023) into a single measurable indicator. These original concepts all point to the same underlying question: do people know about the SDI and understand what it offers? Because awareness is difficult to measure from existing data sources, this indicator is assessed through a survey with a Likert scale score from 1 to 5, requiring fieldwork. This approach is standard in social science research and allows for meaningful comparison across user groups and countries.

User involvement (5E) directly operationalizes "size of user involvement" and "number of visitors" (Eelderink, 2006) as the number of unique users of the national geoportal. This is the most straightforward and objective way to measure actual engagement with the SDI, as geoportal visitor data is typically available through web analytics tools. Broader concepts such as "community participation" (IGIF, 2023) are considered covered by the combination of 5D and 5E together, since awareness and actual usage jointly reflect the level of community engagement with the SDI.

5.6 Policy

Inclusivity in policies means that SDI development is guided by clear political commitment to eliminate the digital divide. Policies set the direction and priorities of SDI. Without inclusive policies, strong institutions and technology may reinforce existing inequalities.

The original indicators for policies came from Eelderink (2006), IGIF (2023), Supinarajoen (2022), and Bhola (2024). They described general governance concepts related to how SDIs are developed and managed. The transformation organizes these into five indicators across two sub-components: Governance (6A–6B) and Political will (6C–6E).

5.6.1 Governance (6A-6B)

Development approach (6A) comes directly from Eelderink (2006) and is closely related to the concept of "self-organisation ability" from Supinarajoen (2022) and Bhola (2024). All of these original concepts ask fundamentally the same question: Does the government drive SDI development from the top, or do communities and organizations drive SDI development from the bottom? Because this cannot be captured in a single number, it is assessed qualitatively through a review of policy documents and governance structures. This allows the evaluator to understand not just what is written in policy, but how decisions are actually made in practice. According to Participant 6, bottom up data generation is one of the best ways to give people a sense of ownership. He also warned to not underestimate what they know, referring to the value of indigenous knowledge (P6, personal communication, January 20, 2026).

Decentralisation/centralisation (6B) also comes from Eelderink (2006) and is closely connected to 6A. While 6A looks at the direction of SDI development, 6B looks at how authority and responsibility are distributed across government levels. A highly centralised SDI is managed by one national body, while a decentralised one shares responsibilities across regional or local institutions. Like 6A, this is assessed qualitatively through reviewing local municipal and institutional engagement via interviews.

5.6.2 Political will

Bridging the digital divide (6C) comes from IGIF (2023) and reflects whether there is political commitment to making spatial data and digital infrastructure accessible to all parts of society, including rural areas, low-income groups, and marginalized communities. It is assessed by looking at whether a national digital inclusion policy exists and how far it has been implemented.

Corruption index (6D) is added as a new indicator not explicitly present in the original source list. However, it is highly relevant to SDI performance because corruption affects how public resources are allocated, whether data is shared openly, and whether SDI benefits reach all parts of society equally. It is measured using an established international index, such as the Corruption Perceptions Index (Transparency International), which allows for consistent comparison across countries.
Participant 2 stated that “Adding a corruption index would be good because [in South Africa] there was a lot of redress and transformation coming from apartheid, where only white people were allowed to be surveyors.” (P2, personal communication, December 5, 2025).

Professional registration initiatives (6E) is also an addition to the original source indicators. It measures the number of national programs that formally register or license GIS and geospatial professionals. This indicator reflects political will to recognize and support the geospatial profession, which is an important condition for building a SDI. It is measured as a simple count of active programs, which can be verified through national professional bodies or government records.

5.7 Institutional Framework

The original indicators for the institutional framework came from Makanga & Smit (2010), Eelderink (2006), and IGIF (2023). They described broad concepts about coordination, cooperation, and willingness to share data between institutions. The transformation organizes these into four indicators across three sub-components: SDI coordination (7A), data sharing (7B–7C), and institutional SDI participation (7D).

5.7.1 SDI coordination

Existence of a national SDI coordinating body (7A) comes directly from Makanga & Smit (2010), who describe a "reasonable level of interagency coordination" as an important condition for a functioning SDI. The original statement is qualitative and vague, making it difficult to measure consistently. The transformation operationalizes this as whether a national SDI coordinating body exists. This is a concrete and verifiable fact that can be confirmed through official government sources. The existence of such a body indicates that coordination is formally organized, rather than happening informally or not at all.

5.7.2 Data sharing

Legislation on data sharing and data sharing arrangements (7B) draws from the concept of "cross-sector and interdisciplinary cooperation" (IGIF, 2023) and the broader principle of willingness to share (Eelderink, 2006). Rather than measuring cooperation in abstract terms, the transformation focuses on whether formal legal and institutional arrangements for data sharing exist. This is measured by looking at whether national legislation on data sharing is in place and whether formal data sharing agreements between institutions have been established. Participant 1 stated that "the Global South often has a more bureaucratic culture. When there is no law saying that something should be done it might not happen." (P1, personal communication, December 2, 2025).

"Data siloes are a problem [in the Global South]. Each government agency creates its own silo and is behaving like a data Tzar." (P1, personal communication, December 2, 2025).

Institutional willingness to share (7C) also originates from Eelderink (2006) and is closely related to 7B. While 7B assesses whether the legal and institutional structures for sharing exist, 7C assesses whether sharing actually happens. Participant 2 stated that "Sometimes nothing happens after legislation, except for a photo opportunity." (P2, personal communication, December 5, 2025). There is often a gap between what policies say and what institutions do. This indicator is assessed qualitatively, looking at the difference between what is required by law or policy and what is actually published or shared. A large gap between policy and practice signals that willingness to share remains limited despite formal commitments.

5.7.3 Institutional SDI participation

SDI awareness among data providers (7D) is a new indicator that is not explicitly present in the original source list but follows logically from the participation focus of the framework. While indicator 5D measures awareness among end users of the SDI, 7D focuses on the institutions and professionals who create and provide spatial data. Their awareness of the SDI, what it is, how it works, and what their role in it is, is a key condition for active institutional participation. A low awareness amongst institutions could lead to data duplication & funding constraints. Because awareness cannot be measured from existing records, it is assessed through a survey using a Likert scale score from 1 to 5, requiring fieldwork among institutional data providers.

5.8 Financial Resources

Inclusivity in financial resources means that SDI development and access are not limited by economic barriers. Even a technically strong SDI can become exclusive when paywalls are too high.
Here is a description of the transformation: The original source indicators for financial resources contained only one explicit concept: "commercialisation of data" (Eelderink, 2006). This single idea was broad and lacked a clear unit of measurement. The transformation expands this into two indicators that together give a more complete picture of how SDI activities are funded and sustained.

5.8.1 SDI funding

Commercialisation of core datasets (8A) directly operationalizes the original concept from Eelderink (2006). This indicator is measured as the percentage of core datasets that are available under a commercial licensing model. In the context of SDI assessment in non-Western contexts, a high percentage of commercially licensed core datasets is generally a negative signal, as it creates financial barriers that limit access for smaller organizations, researchers, and citizens.

Public funding allocation for SDI (8B) is derived from the indicator by Eelderink (2006) “internal funding”. It is added because funding is a fundamental condition for SDI development and sustainability, and because the source of funding matters as much as the amount. The indicator measures the annual SDI budget.

SDI awareness in funding agency (8C) is derived from the work of van Loenen (2006) and Indrajit (2018). It highlights that greater awareness among funding authorities leads to stronger commitment to sustainable funding. This indicator measures the extent to which funding bodies understand the value of SDI and actively support it through consistent financial support.

5.9 indicators for assessing SDI performance in non-Western contexts

Table 10 presents a set of indicators designed to assess the development and performance of SDIs, with a specific focus on applicability in non-Western contexts. The framework is organised into eight main components, following the distribution of SDI components by van Loenen (2006): human resources, technology, financial resources, institutional framework, policies, standards, datasets and the additional component for connectivity. For each component, one or more indicators are listed that are considered relevant to SDI performance in non-Western contexts.

Connectivity indicators 1A through 1E are included because reliable internet access and electricity supply cannot be assumed in many non-Western contexts, whereas Western SDI assessment frameworks typically treat these as given conditions rather than variables worth measuring.
The feature phone indicator 2A is included because in many non-Western contexts, basic mobile phones remain more common than smartphones, meaning that SDI access through web-based platforms is not available to a significant share of the population.
Finally, the language indicator 3C addresses the fact that many non-Western countries are linguistically diverse, with large parts of the population not proficient in the official or administrative language in which SDI portals are typically offered.

Other indicators in the framework are relevant to both Western and non-Western SDIs, but are included here with a specific focus on the position of underrepresented stakeholders. Indicators related to data sharing, institutional coordination, funding transparency, and professional registration apply broadly across different national contexts. However, in non-Western settings these indicators often reveal deeper structural problems, such as the concentration of SDI governance among a small number of actors, the commercialisation of core datasets, and the absence of meaningful municipal participation. The framework therefore treats these indicators not as universal benchmarks but as tools for identifying where structural exclusion occurs and for whom.

Inclusive SDI framework indicators					
Component	**Sub-component**	**Indicator**	**Sub-indicator**		**Tentative unit of measure**
ICT-infrastructure	Connectivity	Access to Internet	1A	Households with internet access	% of households
			1B	Mobile data pricing	Average cost of 100MB
			1C	Quality of connectivity	Average Mbps (download speed)
		Access to electricity	1D	Availability of electricity	% of households with reliable access
			1E	Availability of backup power (generator, solar, battery)	% of households with backup power
Technical accessibility and interoperability	Technology	Access to technical equipment	2A	Access to telephony (feature phone)	% of population with access
			2B	Access to telephony (smartphone, tablet)	% of households with access
			2C	Access to desktop- or laptop computer	% of households with access
	Datasets	Access to data	3A	Data available through national geoportal	Yes / No
			3B	National core data sets are openly available	% of core datasets open access
			3C	Number of languages used (SDI portal)	Number of languages
		Data quality	3D	Spatial coverage of core datasets	% of the national territory mapped
	Standards	Metadata for core datasets	4A	Metadata availability	% of datasets with metadata
			4B	Metadata quality (ISO)	% compliancy
			4C	Metadata language diversity	Number of languages
Digital and spatial literation	Human resources	Human capital & Capacity building	5A	Availability of academic GIS or Geomatics programs	Number of programs
			5B	Professional workplace training	Qualitative
			5C	Skilled SDI personnel (Geomatics, GIS)	Nr of people with GIS skills
		SDI (user) participation	5D	SDI awareness (user)	Survey-based score (fieldwork required)
			5E	User involvement (size)	Nr of unique users geoportal
Societal representation and participation	Policies	Governance	6A	Development approach (bottom-up, top-down)	Qualitative assessment / policy document review
			6B	Decentralisation/centralisation	Qualitative assessment / institutional mapping
		Political will	6C	Bridging the digital divide	Qualitative assessment / Existence of national digital inclusion policy
			6D	Corruption index	Transparency international, 2021
			6E	Professional registration initiatives	Number of national registration or licensing programs for GIS professionals
	Institutional framework	SDI coordination	7A	Existence of a national SDI coordinating body	Yes / No
		Data sharing	7B	Data sharing arrangements	Existence of institutional data sharing legislation
			7C	Willingness to share	Qualitative assessment / policy-practice gap score
		(institutional) SDI participation	7D	SDI awareness (data provider)	Survey-based score (fieldwork required), count of duplicate data.
	Financial resources	SDI funding	8A	Commercialisation of (core) data sets	% of core datasets with commercial licensing
			8B	Public funding allocation for SDI	Amount of public funding to SDI in local currency
			8C	SDI awareness in funding agency	Qualitative assessment, institutional mapping

Table 10: Inclusive SDI framework indicators

6. Inclusive SDI assessment in practice

To perform an inclusive assessment of the SDI of South Africa and the City of Cape Town, the framework developed in chapter 5 (Table 10) is applied across all eight components. Each indicator is evaluated using the sources described in the methodology, supplemented where necessary by insights from the expert interviews. Where data was unavailable, this is noted as a finding in itself, since the absence of measurable data is relevant information for performing a SMART-analysis on the framework.

The National SDI of South Africa has a strong legislation and a relatively centralised political system in which national institutions play a leading role in coordinating spatial data (Republic of South Africa, 2004; Department of Rural Development and Land Reform, 2014). At the local level, the City of Cape Town provides insight into a municipal SDI context. They were the first local authority to launch their geoportal in early 2015 (ESRI, 2020). The platform has grown from 29 to 220 open datasets over the past decade. In practice, however, access remains uneven: 79% of households have internet access, and many of those lack the devices needed to use the geoportal effectively (City of Cape Town Corporate GIS, 2024). This gap between technical availability and actual access illustrates why a more inclusive assessment is necessary to get a more complete picture of SDI development.

6.1 Connectivity

Indicator		Unit of measure	Source
1A	Households with internet access	% of households: 79%	StatSA, 2023; City of Cape Town Corporate GIS, 2024
1B	Mobile data pricing	Average cost of 100MB: R30 per month	Telkom, 2026
1C	Quality of connectivity	Average Mbps (download speed): 65 Mbps	Ookla Global Speedtest Index 2026
1D	Availability of electricity	% of households with reliable access: 88%	Geoportal South Africa, 2025; Geoportal Cape Town, 2025
1E	Availability of backup power (generator, solar, battery)	% of households with backup power: unknown	NA

Table 11: Connectivity component indicators

According to Statistics South Africa (2023), 78.6% of South African households have internet access (1A) through at least one member. However, this figure includes access from workplaces, public hotspots, and internet cafés. Only 14.5% of households have a fixed internet connection at home. In Cape Town, a 2024 household survey found that 640 households have no internet access at all, while the majority of those who do connect rely on mobile data rather than a stable home connection (City of Cape Town Corporate GIS, 2024). Since using SDI platforms typically requires a reliable personal connection, occasional or shared access offers limited practical benefit for meaningful SDI participation.

Mobile data pricing (1B) presents a similar picture. Telkom (2026) offers a 500MB bundle for R30 per month, roughly equivalent to one hour at the national minimum wage of R30.23 per hour (Department of Employment and Labour, 2026). For formally employed workers, this appears relatively affordable. However, approximately 30% of South Africa's total employment is in the informal sector (Ebrahim and Van den Berg, 2024). Here, around 60% of workers earn less than R3,500 per month, well below the minimum wage equivalent of approximately R4,800 per month (Jobs Guru, 2025). For these workers, even a basic data bundle can be a financial burden. It is also worth noting that 500MB is likely insufficient for regular, productive SDI use, which involves accessing geoportals and downloading spatial datasets.

In terms of connection quality (1C), South Africa performs reasonably well at the national level. One participant noted that LTE coverage is available in almost every part of the country (P8, personal communication, January 30, 2026). According to the Ookla Global Speedtest Index for February 2026, the national average mobile download speed is 65.41 Mbps, while Cape Town's average reaches 88.55 Mbps. These speeds are sufficient for most SDI applications. However, rural areas are likely to experience lower speeds.

Concerning electricity access (1D), the World Bank (2023) reports that 87.7% of South Africans have access to electricity. In Cape Town 95.8% of people are connected to the electricity grid (City of Cape Town Corporate GIS, 2024). However, connection does not equal reliability. Around 17% of Cape Town households experience regular power cuts, and nationally 12.3% of the population has no electricity access at all. Reliable electricity is essential for charging devices and maintaining internet access, both of which are necessary conditions for SDI participation. A household that is technically connected to the grid but regularly without power cannot consistently engage with digital SDI services.

No data is currently available for indicator 1E on backup power availability at either the national or Cape Town level.

From a connectivity perspective, the SDI of South Africa and the City of Cape Town has performance issues regarding power reliability and internet access, mostly affecting a group of potential end-users (Table 19). Taken together, these indicators point to a situation in digital infrastructure that is sufficient for the majority of stakeholders, but the group of potential end-users left with insufficient infrastructure makes for an insufficient performance verdict. Limited connectivity and unreliable power are a cause of SDI-exclusion for those affected by it.

6.2 Technology

Indicator		Unit of measure	Source
2A	Access to telephony (feature phone)	% of households with access: 96.1%	City of Cape Town Corporate GIS, 2024; StatSA, 2024
2B	Access to telephony (smartphone, tablet)		City of Cape Town Corporate GIS, 2024; StatSA, 2024
2C	Access to desktop- or laptop computer	% of households with access: 25%	City of Cape Town Corporate GIS, 2024; StatSA, 2024

Table 12: Technology component indicators

According to Statistics South Africa (2024), 3.9% of South African households have no access to a landline or mobile phone (2A, 2B), meaning the large majority have at least some form of telephone access. In Cape Town, the 2024 household survey shows that 7,688 households have access to a mobile phone, while around 7.5% do not (City of Cape Town Corporate GIS, 2024). Neither Statistics South Africa (2024) nor the City of Cape Town Corporate GIS (2024) distinguishes between feature phones and smartphones, which is an important limitation for assessing indicators 2A and 2B. Feature phones can only make calls and send or receive text messages, while smartphones and tablets can access websites and applications. Without knowing how many users have a smartphone rather than a basic phone, it is not possible to determine how many people can only be an end-user through text-based SDI services, or more sophisticated SDI-services through apps and websites.

Statistics South Africa (2024) reports that only 25.3% of South African households have access to a computer (2C). In Cape Town this figure is considerably higher at 49.2%, though still below half of all households (City of Cape Town Corporate GIS, 2024). A computer is essential for more advanced SDI tasks such as working with GIS software, downloading and processing spatial datasets, or participating in data governance platforms, activities that are difficult or impossible on a mobile phone.

From a technology perspective, the SDI of South Africa and the City of Cape Town have performance issues in several parts. Overall telephone access is high, which means most people have at least a basic entry point into digital communication. However, the absence of data distinguishing device types (feature phone, smartphone) is a serious gap. A feature phone cannot be used to access web-based spatial data platforms, though it could allow people to receive text-based SDI services. The 7.5% of Cape Town households with no phone at all face complete exclusion from this dimension of the SDI. Computer access is more critical at the national level, where only one in four households owns a device capable of supporting sophisticated SDI use.

6.3 Datasets

Indicator		Unit of measure	Source
3A	Data available through national geoportal	Yes / No: Yes	Geoportal South Africa, 2025; Geoportal Cape Town, 2025
3B	National core data sets are openly available	% of core datasets open access: Almost all core datasets. However, some are hard to find.	Geoportal South Africa, 2025; Geoportal Cape Town, 2025 Websites of the custodians. Appendix B.
3C	Number of languages used (SDI portal)	Number of languages: 1, English	Geoportal South Africa, 2025; Geoportal Cape Town, 2025
3D	Spatial coverage of core datasets	% of the national territory mapped: Unknown	NA

Table 13: Data component indicators

Both a national and a city-level geoportal exist in South Africa (3A). The national geoportal functions as a data discovery platform but remains underdeveloped, with only four custodians actively contributing metadata. The City of Cape Town launched its geoportal in early 2015, becoming the first local authority in South Africa to do so (ESRI, 2020). Starting with 29 datasets, it has grown to 220 openly accessible datasets over the past decade.

Most national core datasets identified by the Committee for Spatial Information (

Appendix B: List of proposed Base Dataset Custodians; CSI, 2013) are available at no cost (3B). Administrative boundaries are accessible through an ArcGIS Online platform (MDB, 2026a), aerial imagery through OpenStreetMap South Africa (2024), and road data through the Humanitarian OpenStreetMap Team (HOT, 2026). Social statistics are available through Statistics South Africa (2026), cadastre data through ArcGIS Online (MDB, 2026b), and environmental datasets through the Department of Forestry, Fisheries and the Environment (2026). Hydrology data is available from the Department of Water and Sanitation at no cost, though the platform is not user-friendly (DWS, 2026). Satellite imagery from the South African National Space Agency is not openly available, and both land use and land cover datasets are currently inaccessible to the public.

South Africa has 12 official languages, and Cape Town is primarily associated with three: English, Afrikaans, and isiXhosa. Despite this, both the national SASDI portal and the Cape Town SDI portal are available in English only (3C). As one participant noted, it is very easy to expect people to interact with the SDI in English, but it is not fair (P7, personal communication, January 22, 2026). Another interviewee acknowledged the assumption commonly made in the sector that most people who would want this data would have at least a basic understanding of English (P4, personal communication, January 6, 2026). This stands in contrast to other areas of government, where legal documents are routinely translated into English, Afrikaans, and isiXhosa for Cape Town, and into additional languages elsewhere depending on the region (P8, personal communication, January 30, 2026).

Spatial coverage of core datasets (3D) remains incomplete and uneven. Land-cover mapping is progressing at around 86,000 square kilometres per year, though limited government funding has created a dependency on public-private partnerships to maintain momentum. The National Spatial Reference System supports positional accuracy across mapping and surveying activities. And at the local level, Cape Town conducts its own aerial flights for higher-resolution imagery rather than relying on national data. Despite these efforts, some townships still lack cadastral boundaries entirely, and informal settlements present particular challenges as fires and other changes can alter parcel boundaries over time. Formalisation through surveying occurs in some cases (P8, personal communication, January 30, 2026; P7, personal communication, January 22, 2026).

From a datasets perspective, the SDI of South Africa and the City of Cape Town has performance issues regarding stakeholder participation. The existence of geoportals at both levels is a meaningful foundation, but the national platform remains only partially backed by core dataset custodians. Free availability of core datasets aligns with the definition for SDI inclusivity in Section 4.1.5 SDI Inclusivity, but fragmentation across multiple platforms places a burden on users with limited technical capacity. The English-only interface of both portals is a clear gap that excludes non-English speaking users. The most serious concern is spatial coverage: gaps are most pronounced in informal settlements and townships. Where cadastral boundaries are absent, these communities are effectively invisible in official spatial datasets, limiting their ability to advocate for services or access land rights.

6.4 Standards

Indicator		Unit of measure	Source
4A	Metadata availability	% of datasets with metadata: SPLUMA not followed by all custodians	SPLUMA; CSI, 2013
4B	Metadata quality (ISO)	% compliancy: Unknown	SPLUMA; CSI, 2013; DALRRD, 2023
4C	Metadata language diversity	Number of languages: 1 (English)	SPLUMA; CSI, 2013

Table 14: Standards component indicators

The Spatial Planning and Land Use Management Act (SPLUMA) requires all 258 municipalities to capture data according to the same standard, meaning that data collected at the local level can theoretically be aggregated upward to the national level (P4, personal communication, January 6, 2026). SASDI further supports this through a set of South African National Standards and aligned ISO standards covering metadata, data models, addressing, data quality, product specifications, and web services (CSI, 2013). These provide the technical foundation for indicator 4A on metadata availability. However, only four custodians actively contribute metadata to the national geoportal, which suggests that compliance with these requirements is far from universal. A legal obligation to capture metadata does not guarantee that metadata is actually available, complete, or findable by end users.

South Africa has a comprehensive and internationally aligned framework for metadata quality (4B). SANS 1878-1:2011 defines a spatial metadata profile with a clear structure and common terminology. SANS 19115 and ISO 19115:2003 provide international standards for describing geographic data, extended by SANS 19115-2 to cover imagery and gridded data. Data quality is addressed through SANS 19157:2014, SANS 19158:2012, and SANS 19131:2012, while web service standards include SANS 19128 for Web Map Services and SANS 19142 for Web Feature Services (DALRRD, 2023). Despite the breadth of this framework, no quantitative compliance data is currently available to show what percentage of datasets actually meet these standards in practice.

Both the national SASDI portal and the Cape Town SDI portal provide metadata in English only (4C). As established under indicator 3C, many government documents in South Africa are routinely translated into multiple local languages, typically English, Afrikaans, and isiXhosa for Cape Town, with additional languages in other regions (P8, personal communication, January 30, 2026). SDI metadata has not followed this practice, and the assumption that users will understand English is openly acknowledged within the sector (P4, personal communication, January 6, 2026).

From a standards perspective, the SDI of South Africa and the City of Cape Town seems to be performing well. The legislative and technical frameworks for metadata availability and quality are well established and internationally aligned, representing a serious institutional commitment to interoperability. However, the existence of standards does not confirm that they are being applied. Given the low level of custodian participation in the national geoportal, uneven compliance is a reasonable expectation. Metadata available only in English further limits access for the large share of South Africa's population that is not confident in English. Metadata is a means to understand what a dataset contains or what its limitations are, allowing users to make meaningful use of it. The absence of multilingual metadata is a clear and addressable gap, particularly given that multilingual communication is already standard practice in other parts of government.

6.5 Human Resources

Indicator		Unit of measure	Source
5A	Availability of academic GIS or Geomatics programs	Number of programs: 4 BSc in geomatics	University websites
5B	Professional workplace training	Qualitative: Unknown	NA
5C	Skilled SDI personnel (Geomatics, GIS)	Nr of people with GIS skills: Unknown	NA
5D	SDI awareness (user)	Survey-based score (fieldwork required): Unknown	NA
5E	User involvement (size)	Nr of unique users geoportal: Unknown	NA

Table 15: Human Resources component indicators

Excluding private institutions, four South African universities offer a BSc in Geomatics: the University of Cape Town, the University of Pretoria, the University of KwaZulu-Natal, and Stellenbosch University (5A). Beyond university programs, ESRI offers a free online learning platform that provides accessible GIS training to a broader audience. However, participating in this platform requires reliable internet connectivity, a stable power supply, and access to a desktop or laptop computer, conditions that are not universally available in South Africa, as established under indicators 1D, 1E, and 2C. All four universities are located in major urban centres, creating access barriers for students from rural areas, and university education carries financial costs that exclude lower-income groups.

Graduate programs provide pathways for professionals from non-GIS backgrounds to develop spatial skills (5B), broadening the pool of SDI-capable personnel beyond those with formal geomatics qualifications (P8, personal communication, January 30, 2026). This form of workplace and graduate-level training is an important complement to academic programs, particularly given the limited number of university geomatics programs nationally. However, such training depends on institutional capacity. Smaller municipalities may lack capacity to offer or support this kind of training.

South Africa has historically faced a shortage of skilled staff in the mapping and land sector (RSA RCMRD, 2015), but the situation has improved considerably in recent years (5C). As one participant noted, the skills gap is actively being addressed through curriculum changes, and SDI-related competencies are now embedded in most relevant academic programs (P8, personal communication, January 30, 2026). The same participant confirmed that a substantial professional community now exists, particularly in GIS and geomatics, and that Cape Town has GIS professionals embedded within its institutions and government structures.

To determine whether end users are aware of the SDI (and how to benefit from it), citizen science initiatives offer a useful starting point (5D). For example, miniSASS is a mobile application for river and water quality monitoring, shows that public engagement with spatial data tools is possible and already occurring. However, these types of initiatives are not yet very common. Since awareness of this kind is difficult to measure from existing data sources alone, it is best assessed through a survey with end-users using a Likert scale score from 1 to 5, which requires fieldwork.

Data on user involvement was not successfully collected during this research (5E). Unique user IDs from portal visits would be the most appropriate measure for this indicator, but this data was not made available.

From a human resources perspective, the SDI of South Africa and the City of Cape Town is showing signs of improvement. Pathways into GIS education exist at both the university and online level, and the professional skills gap that was documented a decade ago is being actively addressed. The picture for user awareness and involvement is incomplete, as the data needed to assess indicators 5D and 5E was not available through existing sources.

6.6 Policies

Indicator		Unit of measure	Source
6A	Development approach (bottom-up, top-down)	Qualitative assessment / policy document review: Top-down	Interviews
6B	Decentralisation/centralisation	Qualitative assessment / institutional mapping: Centralised	Interviews
6C	Bridging the digital divide	Qualitative assessment / Existence of national digital inclusion policy: Yes	SABC News, 2026
6D	Corruption index	Score out of 100: 44	Transparency International, 2021
6E	Professional registration initiatives	Number of national registration or licensing programs for GIS professionals: Unknown	Interviews; SAGC, 2025

Table 16: Policy component indicators

SASDI operates as a top-down system (6A). Data collection across levels of government functions independently rather than in an integrated, upward-flowing manner. As one participant noted, feeding data up from the bottom to the top does not happen, and all levels of government collect data independently of one another (P4, personal communication, January 6, 2026). This is confirmed by another participant who stated directly that SASDI is top-down (P7, personal communication, January 22, 2026).

South Africa has 257 municipalities, yet very few are actively involved in SASDI (6B). The national SDI framework has not received meaningful participation from the majority of local governments, leaving SDI governance concentrated among a small number of central actors (P7, personal communication, January 22, 2026).

According to the SABC News (2026), digital illiteracy is recognised as a structural problem in South Africa, and there are political commitments to address it (6C). Government communications have acknowledged the digital divide and signalled intent to implement digital inclusion policies, though the translation of political commitment into measurable action remains limited.

South Africa scores 44 out of 100 on the Corruption Perceptions Index (6D), where 0 represents extreme corruption and 100 represents full transparency, placing the country in the lower-middle range globally (Transparency International, 2021). As Cooper (2025) notes, many municipalities are in poor financial health due to carelessness with spending, uncompetitive procurement, limited value for money, poor project management, unfunded budgets, and substantial unauthorised expenditure.

South Africa has several mechanisms to formalise and broaden recognition of GIS and geomatics professionals (6E). The grandfather clause allows experienced practitioners to gain formal recognition based on prior practice. Recognition of Prior Learning provides a pathway for individuals without formal qualifications to have their skills officially acknowledged. The South African Geomatics Council law examination, supported by a Self-Assessment Tool, helps candidates evaluate their readiness for professional registration (SAGC, 2025).

From a policy perspective, the SDI of South Africa and the City of Cape Town are performing inadequately when compared to the posed definition for SDI-inclusivity in Section 4.1.5 SDI Inclusivity. The purely top-down development approach limits the ability of local communities and municipalities to shape the SDI. This means that local, and indigenous knowledge are largely absent from national SDI governance.
Corruption and financial mismanagement at the municipal level add to this problem by undermining the reliable allocation of resources to SDI-related services, disproportionately affecting the communities those municipalities serve (Cooper, 2025; Transparency International, 2021). The political acknowledgement of the digital divide is a positive signal but falls short of the concrete implementation needed to constitute meaningful progress.
The one area of relative strength is professional registration, where mechanisms such as Recognition of Prior Learning and the grandfather clause demonstrate a genuine effort to widen access to formal recognition for practitioners who did not follow a conventional academic pathway (SAGC, 2025).

6.7 Institutional Framework

Indicator		Unit of measure	Source
7A	Existence of a national SDI coordinating body	Yes / No: Yes	Stuart.zip? - CSIR
7B	Data sharing arrangements	Existence of institutional data sharing legislation: Yes	Stuart.zip?; Department of Rural Development and Land Reform, 2014
7C	Willingness to share	Qualitative assessment / policy-practice gap score: Unknown	Interviewees
7D	SDI awareness (data provider)	Survey-based score (fieldwork required): Unknown	NA

Table 17: Institutional Framework component indicators

Oversight of the South African Spatial Data Infrastructure is provided by the Committee for Spatial Information, a statutory body established under the SDI Act (7A). The Committee is supported by six subcommittees covering policy and legislation, data, systems, standards, marketing, and education, a structure that closely mirrors the core components of SDI as defined by Rajabifard et al. (2002) and Van Loenen (2006). The Committee is responsible for guiding the development and coordination of SDI activities at the national level.

Several legislative instruments underpin data sharing within South Africa's SDI (7B). The primary framework is the Spatial Data Infrastructure Act of 2003, whose central purpose is to ensure the open sharing of spatial information among organs of state. The Deeds Registries Amendment Act of 2013 addresses the rectification of errors in property descriptions and related documents. The RSA RCMRD country report of 2015 identifies these and other acts as forming part of the legislative foundation for data sharing obligations.

Despite this legislative framework having been in place since 2003, actual data sharing practice falls significantly short of its potential (7C). As one participant acknowledged, the tools are in place from a legislative point of view, but the SDI Act has not worked as well as it should have (P4, personal communication, January 6, 2026). A telling illustration of this gap is that the legal obligation to share data does not require it to be provided in a digital or usable format, as providing paper maps is sufficient to satisfy the requirement and counts as sharing the dataset (P4, personal communication, January 6, 2026). In practice, data exchange often relies on personal relationships between individuals rather than structured institutional mechanisms, with personal connections frequently proving more effective than connecting to a portal (P4, personal communication, January 6, 2026).

No data was collected for indicator 7D during the research period. A survey-based assessment of SDI awareness among data-providing organisations would be required to populate this indicator meaningfully.

From an institutional framework perspective, the SDI of South Africa and the City of Cape Town has some performance issues. The existence of a statutory coordinating body with a structured subcommittee system is a meaningful foundation, but the effectiveness of the Committee ultimately depends on who participates in it and whether underrepresented stakeholders such as smaller municipalities have genuine input, something that requires further empirical assessment. The legislative basis for data sharing is well established, but its scope is limited to organs of state and does not automatically extend to civil society. More critically, the gap between what the legislation requires and what institutions actually do is significant. When data sharing obligations can be satisfied by providing paper maps, and when access to data depends more on personal relationships than on open institutional channels, many stakeholders are left out.

6.8 Financial Resources

Indicator		Unit of measure	Source
8A	Commercialisation of (core) data sets	% of core datasets with commercial licensing: Is taking place for data managed by the Water Boards and Eskom	Cooper, 2025
8B	Public funding allocation for SDI	Annual SDI budget breakdown: R792.3 Million	Nyhontso, 2025
8C	SDI awareness at funding agency	Qualitative assessment: Unknown	NA

Table 18: Financial Resources component indicators

A recurring challenge in South Africa's SDI landscape is the extent to which core spatial datasets are controlled by private companies rather than government (8A). Due to limited institutional capacity, many municipalities and government departments have outsourced data collection and management to private entities, meaning the government does not own the resulting data (P7, personal communication, January 22, 2026). This creates a structural dependency, as the South African government is often reliant on private companies such as Water Boards and Eskom to collect and manage spatial data (Cooper, 2025). The practical consequence is that publicly funded data cannot always be publicly shared since data providers are sometimes only allowing users to use it for themselves. As one participant explained, if a private party owns the data, the government has to buy it. This could lead to issues regarding data dissemination, since the government might not have the rights to share it (P4, personal communication, January 6, 2026).

Public funding for SDI-related activities in South Africa is present but fragmented across departments and programmes (8B). The Land Administration Branch has been allocated R792.3 million for the 2025/2026 financial year, with priorities including the National Spatial Development Framework, regional plan implementation, and modernisation of the cadastral information system. A National Spatial Data Observatory, developed in partnership with the CSIR, is also being funded to support spatial planning with real-time data. Despite these allocations, concerns have been raised by the interviewees about whether funding reaches the institutions and personnel responsible for day-to-day SDI implementation. As one participant put it, the people responsible for SDI work need to be empowered through the necessary budgets to be able to carry it out (P4, personal communication, January 6, 2026).

A critical barrier to effective SDI financing is the limited awareness of SDI roles and responsibilities among the bodies that control budget allocations (8C). As one participant described, the ideal scenario would be one in which a recognised data custodian can approach a treasury department with a clear mandate and a specific funding request, stating their official custodianship of a dataset and the precise amount needed to maintain it (P4, personal communication, January 6, 2026). The implication is that this level of clarity and recognition does not currently exist, and that data custodians lack the funding channels to make such requests effectively.

From a financial resources perspective, the SDI of South Africa and the City of Cape Town are performing insufficiently when put next to the definition for SDI-inclusivity in Section 4.1.5 SDI Inclusivity. When core spatial datasets are owned by private companies rather than government, citizens and organisations cannot access that data for free, which goes against the basic requirement of an inclusive SDI.

6.9 Conclusion/overview of case study

The table below brings together the results of the inclusive SDI assessment across all eight components. For each indicator, the unit of measurement and the score or finding from the South African and Cape Town context are recorded. Where data was unavailable, this is noted explicitly, since the absence of measurable data is itself a relevant finding for evaluating the framework. Together, these results form the basis for the SMART analysis carried out in Section 6.10 and the final framework revisions presented in Chapter 7.

Indicator		Unit of measure	Score
1A	Households with internet access	% of households	79% of households
1B	Mobile data pricing	Average cost of 100MB	R30 per month
1C	Quality of connectivity	Average Mbps (download speed)	65 Mbps
1D	Availability of electricity	% of households with reliable access	88%
1E	Availability of backup power (generator, solar, battery)	% of households with backup power	Unknown
2A	Access to telephony (feature phone)	% of population with access	96.1%
2B	Access to telephony (smartphone, tablet)	% of households with access	
2C	Access to desktop- or laptop computer	% of households with access	25%
3A	Data available through national geoportal	Yes / No	Yes
3B	National core data sets are openly available	% of core datasets open access	Almost all core datasets. However, some are hard to find.
3C	Number of languages used (SDI portal)	Number of languages	1 (English)
3D	Spatial coverage of core datasets	% of the national territory mapped	Unknown
4A	Metadata availability	% of datasets with metadata	SPLUMA not followed by all custodians
4B	Metadata quality (ISO)	% compliancy	Unknown
4C	Metadata language diversity	Number of languages	1 (English)
5A	Availability of academic GIS or Geomatics programs	Number of programs	4 BSc in geomatics
5B	Professional workplace training	Qualitative	Unknown
5C	Skilled SDI personnel (Geomatics, GIS)	Nr of people with GIS skills	Unknown
5D	SDI awareness (user)	Survey-based score (fieldwork required)	Unknown
5E	User involvement (size)	Nr of unique users geoportal	Unknown
6A	Development approach (bottom-up, top-down)	Qualitative assessment / policy document review	Top-down
6B	Decentralisation/centralisation	Qualitative assessment / institutional mapping	Centralised
6C	Bridging the digital divide	Qualitative assessment / Existence of national digital inclusion policy	Yes
6D	Corruption index	Out of 100	44 out of 100
6E	Professional registration initiatives	Number of national registration or licensing programs for GIS professionals	Unknown
7A	Existence of a national SDI coordinating body	Yes / No	Yes, CSIR
7B	Data sharing arrangements	Existence of institutional data sharing legislation	SDI Act
7C	Willingness to share	Qualitative assessment / policy-practice gap score?	Unknown
7D	SDI awareness (data provider)	Survey-based score (fieldwork required)	Unknown
8A	Commercialisation of (core) data sets	% of core datasets with commercial licensing	Is taking place for data managed by Eskom and the Water Boards
8B	Public funding allocation for SDI	Annual SDI budget breakdown.	R792.3 million
8C	SDI awareness at funding agency	Qualitative assessment	Unknown

Table 19: Overview of the Inclusive SDI assessment

6.10 A review of the framework itself

Applying the inclusive SDI framework to South Africa and the City of Cape Town has revealed important insights about the practical measurability of its indicators. The SMART criteria, which require indicators to be Specific, Measurable, Achievable, Relevant, and Time-bound (UNDP, 2006), provide a useful lens for evaluating which indicators performed well in practice and which require revision in future applications of the framework.

The majority of indicators proved workable. Connectivity indicators 1A through 1D are all specific in what they measure, available through nationally recognised data sources such as Statistics South Africa and the Ookla Global Speedtest Index, and directly relevant to SDI participation. The exception is 1E on backup power availability, for which no data could be found at either the national or city level. Until this data is systematically collected, the indicator cannot be meaningfully applied and should be treated as aspirational in the current iteration of the framework.

Technology indicators 2A, 2B, and 2C are well defined and measurable through national household surveys. The main limitation encountered was the absence of a distinction between feature phones and smartphones in existing data sources, which reduced the precision of indicators 2A and 2B. This is a data collection issue rather than a flaw in the indicator design itself, and the indicators remain relevant and worth retaining.

Dataset indicators 3A through 3D performed well overall. The existence of a geoportal is a binary and easily verifiable fact, the openness of core datasets is assessable through custodian websites, and the number of portal languages is straightforward to count. Spatial coverage is the most complex of the four, as complete national figures are difficult to obtain and coverage varies significantly by dataset type and region. Nevertheless, the indicator captures a genuinely important dimension of SDI performance and should be retained with the understanding that it may require qualitative supplementation.

Assessing the standards component in the South African context is constrained by the limited availability of compliance data. What can be established is the existence and scope of the relevant legislation regarding metadata. The two metadata quality indicators 4A and 4B are relevant and well defined but proved difficult to measure in practice. Calculating the percentage of core datasets with metadata and the percentage complying with ISO standards requires not only access to all of them, but also extensive labour. Both indicators are worth retaining for future applications where compliance monitoring is more advanced, potentially through automation or artificial intelligence. Indicator 4C on metadata language diversity is straightforward to assess and performed well.

Human resources indicators 5A and 5B on academic programs and workplace training are interesting in principle but raised questions on what would be a sufficient threshold. Counting the number of university programs says little without also knowing how many students graduate annually or what the sector's actual demand for GIS professionals is. These indicators may be better consolidated with 5C, which focuses on the number of skilled SDI personnel, into a single indicator that captures the pipeline from education to professional practice more holistically. Indicator 5C itself is specific and relevant, though precise national figures are difficult to obtain. Indicator 5E on geoportal user numbers is straightforward in design but the data was not available during this research, pointing to a transparency gap rather than a flaw in the indicator.

Indicator 5D on SDI awareness among end users is the most problematic in the framework. As currently defined, it is not sufficiently specific to measure reliably. The concept of awareness covers a wide range of possible states, from knowing that a geoportal exists to understanding one's role within a broader SDI system, and the survey approach requires fieldwork that was beyond the scope of this research.

Policy indicators 6A and 6B on development approach and decentralisation are qualitative by design and could be assessed through a combination of expert interviews and policy document review. Both are specific, relevant, and realistic to measure within a normal research timeframe. Indicator 6C on bridging the digital divide is harder to work with. As currently defined, the unit of measure is whether a national digital inclusion policy exists, but this alone says little about whether that policy is actually being implemented or having any effect. In its current form the indicator is not meaningfully measurable, and future versions of the framework should consider combining it with connectivity and capacity indicators to create a broader measure of digital inclusion progress. Indicators 6D on the corruption index and 6E on professional registration initiatives are both clear and measurable through existing sources, and both worked well in practice.

Institutional framework indicators 7A through 7C are among the strongest in the framework. Whether a coordinating body exists is a simple yes or no question, data sharing legislation can be checked through legal documents, and willingness to share can be assessed qualitatively through interviews and a review of the gap between policy and practice. Indicator 7D on SDI awareness among data providers has the same problems as 5D. It is still unclear whether awareness is best measured through a survey or through measuring the number of duplicate datasets.

Financial resources indicators 8A, 8B, and 8C all worked well in theory. The commercialisation of core datasets can be checked through licensing information, public funding can be found in national budget documents, and SDI awareness among funding bodies can be explored through interviews. The main problem with 8C is that there is no agreed unit of measure. The work of Indrajit (2018) on how the institutional position of SDI bodies relative to finance ministries affects funding outcomes offers a useful starting point for making this indicator more precise in future versions of the framework.

Overall, the framework performed well in the South African context. The large majority of indicators are applicable and produced meaningful findings. The indicators that proved most difficult, namely 1E, 5D, and 6C, share a common characteristic: they depend either on data that is not yet systematically collected, or on a level of fieldwork that exceeds what is achievable within a single research project. This is not a reason to remove them from the framework, but rather a signal that their application requires either dedicated data collection efforts or further refinement of their operational definitions. The case study has thus served its intended purpose, not only as an assessment of SDI performance in South Africa, but as a test of the inclusive framework itself.

SMART evaluation matrix

Indicator	1A	1B	1C	1D	1E	2A	2B	2C	3A	3B	3C	3D	4A	4B	4C	5A
Specific																
Measurable																
Achievable																
Relevant																
Time-bound																

Indicator	5B	5C	5D	5E	6A	6B	6C	6D	6E	7A	7B	7C	7D	8A	8B	8C
Specific																
Measurable																
Achievable																
Relevant																
Time-bound																

Table 20: SMART evaluation of inclusive SDI assessment framework

**Green - Yes; Yellow - Partial; Red – No*

Indicators 1A through 1D, most dataset indicators, and the majority of policy and institutional indicators score well across all five criteria because they rely on established (inter)national data sources, have clear units of measure, and can be assessed within a reasonable research timeframe.

Indicator 1E fails on measurability, achievability, and time-boundedness because no data on backup power availability exists at either the national or city level. Indicators 2A and 2B score partially on specificity and measurability because existing data sources do not distinguish between feature phones and smartphones, which is the distinction the indicators require. Indicators 4A and 4B score partially throughout because quantitative data on standard compliancy for core datasets is hard to acquire, making them time-consuming and difficult to measure in practice. Indicators 5A and 5B score partially on specificity and relevance because counting programs says little without knowing graduate numbers or sector demand. Indicator 5D scores 'no' on specificity, measurability, achievability, and time-boundedness because the concept of awareness is too broadly defined and requires fieldwork that was beyond the scope of this research. Indicator 6C scores 'no' on measurability and 'partially' elsewhere because the existence of a policy alone does not capture implementation or impact. Indicator 7D shares the same problems as 5D and scores 'no' on measurability, achievability, and time-boundedness for the same reasons. Indicator 8C scores 'partially' throughout because no definite unit of measure was found for SDI awareness among funding bodies.

7. Final framework

The final version of the framework (V3) incorporates the revisions identified during the case study application. Compared to the intermediate version (V2), the main changes are the removal of indicator 1E on backup power due to data unavailability, the consolidation of the three human resources capacity indicators (5A, 5B, 5C) into a single indicator capturing the full pipeline from education to professional practice, and the revision of awareness indicators (5B, 7D, 8C) to acknowledge measurement challenges and introduce proxy measures where direct assessment is not feasible. The framework retains its eight-component structure and is presented in full below.

Inclusive SDI framework					
Component	**Sub-component**	**Indicator**	**Sub-indicator**		**Unit of measure**
ICT-infrastructure	Connectivity	Access to Internet	1A	Households with internet access	% of households
			1B	Mobile data pricing	Average cost of 100MB
			1C	Quality of connectivity	Average Mbps (download speed)
		Access to electricity	1D	Availability of electricity	% of households with reliable access
Technical accessibility and interoperability	Technology	Access to technical equipment	2B	Access to telephony (smartphone, tablet, feature phone)	% of households with access
			2C	Access to desktop- or laptop computer	% of households with access
	Datasets	Access to data	3A	Data available through national geoportal	Yes / No
			3B	National core datasets are openly available	% of core datasets open access
			3C	Number of languages used (SDI portal)	Number of languages
		Data quality	3D	Spatial coverage of core datasets	% of national territory mapped
	Standards	Metadata for core datasets	4A	Metadata availability	% of datasets with metadata
			4B	Metadata quality (ISO)	% compliancy for core datasets
			4C	Metadata language diversity	Number of languages
Digital and spatial literation	Human resources	Human capital & Capacity building	5A	Skilled SDI personnel (Geomatics, GIS), including graduates and workplace-trained professionals	Number of people with GIS skills, including annual graduates and participants in workplace training programmes
		SDI (user) participation	5B	SDI awareness (end-users)	Survey-based score; proxy measures such as citizen science participation rates
			5C	User involvement (size)	Number of unique users of national geoportal
Societal representation and participation	Policies	Governance	6A	Development approach (bottom-up, top-down)	Qualitative assessment through policy document review and stakeholder interviews
			6B	Decentralisation and centralisation	Qualitative assessment through stakeholder interviews
		Political will	6C	Bridging the digital divide	Existence of national digital inclusion policy as proxy
			6D	Corruption index	Corruption Perceptions Index score (Transparency International)
			6E	Professional registration initiatives	Number of national registration or licensing programmes for GIS professionals
	Institutional framework	SDI coordination	7A	Existence of a national SDI coordinating body	Yes / No
		Data sharing	7B	Data sharing arrangements	Existence of institutional data sharing legislation
			7C	Willingness to share	Qualitative assessment of policy-practice gap through interviews
		(institutional) SDI participation	7D	SDI awareness (data provider)	Survey-based score; or proxy measures such as duplicate datasets
	Financial resources	SDI funding	8A	Commercialisation of core datasets	% of core datasets with commercial licensing
			8B	Public funding allocation for SDI	Amount of public funding allocated to SDI in local currency
			8C	SDI awareness at funding agency	Qualitative assessment through stakeholder interviews; proximity of SDI coordinating body to ministry of finance as proxy indicator

Table 21: Final inclusive SDI assessment framework

The main changes applied are the removal of 1E (Availability of backup power (generator, solar, battery) due to data unavailability, the consolidation of 5A (Availability of academic GIS or Geomatics programs) , 5B (professional workplace training) and 5C (Skilled SDI personnel (Geomatics, GIS)) into the new 5A to capture the full pipeline from education to professional practice. The indicators for SDI Awareness' (5B; 7D; 8C) descriptions have been revised acknowledging the measurement challenges, adding substitute 'proxy' indicators in case of 8C, drawing on the Indrajit (2018) framework. For 6C, political will to bridge the digital divide is hard to measure effectively, but, if there is a national policy addressing the issue it's a good start.

8. Discussion

This chapter reflects on the findings of the research in relation to the main research question: How to measure SDI performance in non-Western contexts? The discussion addresses five themes that cut across the results of the literature review, the expert interviews, and the case study application: the added value of an inclusivity-focused assessment approach, the gap between formal frameworks and lived realities, the importance of ground truth and local knowledge, the heterogeneity of SDI user needs, and the potential role of SDI within broader e-government agendas.

8.1 The added value of an inclusive assessment approach

This research extends conventional SDI assessment by adding a component that most existing frameworks overlook: whether basic participation in an SDI is technically possible for a given population in the first place. Frameworks such as the UN-IGIF and the GKI Readiness Index treat internet connectivity, electricity supply, and device access as background assumptions rather than variables worth measuring. The framework developed here makes these conditions explicit, covering internet access, mobile data pricing, download speed, and electricity availability, so that they can be assessed and compared across different national contexts.

The South Africa and Cape Town embedded case study shows why this matters. Judged on technical and institutional criteria alone, the country's SDI looks reasonably well developed: a statutory coordinating body exists, a metadata standards framework is in place, and geoportals operate at both national and city level. A fuller picture looks different. Fewer than one in four South African households owns a computer capable of supporting sophisticated SDI use. Both geoportals operate exclusively in English, despite the country having twelve official languages. Core spatial datasets are absent or incomplete across many informal settlements and townships. Framework modifications that were deducted from the case study mostly encompass data constraints, leading to removal of indicators which would have been a relevant input if data were available (1E, Availability of backup power) and consolidation for other indicators (5A, 5B, 5C) into one.

A standard GKI-style assessment would not surface many of the issues mentioned above, which is precisely the added value of incorporating the availability of foundational infrastructure (connectivity) and inclusive perspectives on the SDI components (van Loenen, 2006) into the assessment framework, allowing for a more complete and inclusive assessment.

8.2 The gap between formal frameworks and lived realities

What keeps coming up across the case study is the distance between what legislation and policy prescribe and what takes place in practice. South Africa has had an SDI Act since 2003, a comprehensive suite of ISO-aligned metadata standards, and a statutory coordinating body with structured subcommittees. Despite this, only four custodians actively contribute metadata to the national geoportal, data sharing obligations can formally be satisfied by providing paper maps, and access to data often depends more on personal relationships between officials than on open institutional channels. This pattern, of strong formal structures coexisting with weak implementation, is consistent with findings from South African municipalities (Cooper et al., 2025), and across the African continent (Makanga & Smit, 2010).

Qualitative indicators in the framework are there for exactly this reason. Indicators such as 6A (development approach), 7C (willingness to share), and 8C (SDI awareness among funding bodies) cannot be captured by a simple yes/no or percentage score. They require interview-based assessment that investigates the gap between policy and practice. As Participant 2 observed, "sometimes nothing happens after legislation, except for a photo opportunity" (P2, personal communication, December 5, 2025). A framework that does not include this kind of qualitative assessment will consistently overestimate SDI performance in non-Western contexts.

8.3 The importance of ground truth and local knowledge

One of the clearest lessons from the case study is that national-level statistics can mask local inequalities. South Africa's national average mobile download speed of 65 Mbps suggests a well-connected country, yet this figure conceals the very different conditions experienced by rural communities. Similarly, an electricity access rate of 87.7% at the national level obscures the fact that 12.3% of the population has no electricity access at all, and that roughly 17% of Cape Town households experience regular power cuts even where grid connections exist.

Spatial data coverage (indicator 3D) ran into the same problem. This indicator proved among the more difficult to assess precisely, because coverage varies enormously by dataset type and by geographic area. Some townships lack cadastral boundaries entirely, meaning those communities are effectively invisible in official spatial records. As Participant 7 noted, "collecting data on a national level is easier than collecting data on a finer level, but data on a finer level is needed to compare provinces and cities" (P7, personal communication, January 22, 2026). An inclusive SDI assessment framework must therefore be sensitive to the fact that the communities most in need of spatial data services are often the least represented in existing datasets.

The near-total absence of indigenous and community-generated spatial knowledge from South Africa's formal SDI is a related concern. The framework partially captures this through the development approach indicator (6A), which assesses whether SDI development is bottom-up or top-down. However, the degree to which informal, indigenous, and local knowledge is formally recognised and integrated within the SDI is not yet adequately measured.

8.4 Different users have different needs

The framework assesses SDI performance as a multi-dimensional phenomenon, but the case study reinforced how substantially the needs and capabilities of different user groups vary. A national government data custodian, a municipal GIS officer, a smallholder farmer, and a community activist interact with spatial data through entirely different channels and with different levels of technical capacity. For some, full geoportal access and the ability to download and process datasets is essential. For others, as Participant 5 observed, "depending on what people need from the SDI, an early warning system through SMS could be enough for inclusion" (P5, personal communication, January 14, 2026). This has real consequences for how inclusive SDI assessment is set up. A framework that evaluates only at the level of sophisticated geoportal use will systematically underestimate the extent to which simpler forms of spatial information access can constitute meaningful participation.

8.5 SDI as part of a broader e-government agenda

Several participants suggested that the conditions for SDI performance are partly determined by factors that lie outside the SDI itself. Where SDI development is framed as an internal government coordination tool rather than as a public-facing digital service, it is structurally less likely to reach diverse user groups. Participant 2 suggested making SDI part of a wider e-government to gain more political support and institutional resources available (P2, personal communication, December 5, 2025). As Indrajit (2018) showed in the Indonesian context, an SDI coordinating body that sits close to or within the ministry of finance has more direct access to budget allocation processes, making it easier to secure the funding needed for inclusive SDI development. This relationship is captured in indicator 8C of the final framework.

8.6 Limitations of the framework

The SMART analysis in Chapter 6 identified several indicators that could not be fully operationalised within the scope of this research. Indicator 1E on backup power availability was retained in the intermediate framework but removed from the final version because no systematic data source exists at either the national or city level. Indicators 5B and 7D on SDI awareness among users and data providers respectively proved too broadly defined and too dependent on primary fieldwork to be assessed reliably. Indicator 6C on bridging the digital divide was reduced to a binary proxy (whether a national digital inclusion policy exists) which captures intent but not implementation.

The indicators address genuinely important parts of inclusive SDI assessment, but they require dedicated data collection efforts. In particular, the measurement of awareness among users, data providers, and funding bodies, remains a challenge that needs further attention.

A further limitation concerns generalisability. The framework was developed and tested in a single country setting. South Africa is a useful case precisely because it combines a relatively advanced formal SDI structure with deep structural inequalities in access, but this combination is not universal. Applying the framework in countries at earlier stages of SDI development, or in contexts with different linguistic, political, or infrastructural conditions, may require capturing additional dimensions of SDI in order to achieve a more inclusive assessment.

9. Conclusion

This research set out to answer the question: how to measure SDI performance in non-Western contexts? The answer developed through three iterative phases: a literature-based framework construction, an expert validation round, and an empirical case study on the national SDI of South Africa and the local SDI of the City of Cape Town.

The first phase established what an inclusive SDI assessment framework should measure. Drawing on ICT inclusion frameworks by the Digital Future Society (2019) and Kim and Jang (2025), and on SDI assessment literature including Eelderink (2006), Makanga and Smit (2010), Supinajaroen (2022), and Bhola (2024) it was concluded that an inclusive SDI assessment framework for non-Western contexts should centre its indicators around the concept of SDI-inclusivity. This is defined as a situation where all stakeholders can participate in and benefit from an SDI, both individually and collectively, through affordable access to ICT, capacity building in digital and spatial skills, accessible datasets with clear standards, and equal stakeholder representation in data governance and funding mechanisms. This definition led to a first draft framework (V1) structured around eight components: connectivity, technology, datasets, standards, human resources, policies, institutional framework, and financial resources. The connectivity component is the key addition to conventional SDI assessment frameworks, as it captures the foundational infrastructure conditions that are frequently absent in non-Western contexts yet overlooked by existing assessment tools.

The second phase refined the framework through semi-structured interviews with eight international experts in SDI, geomatics, and related fields. Their feedback led to the consolidation of overlapping indicators, the introduction of a corruption index (6D) and professional registration initiatives (6E) as new policy indicators, the removal of mobile data coverage as a standalone indicator on the grounds that pricing rather than coverage is the primary barrier to connectivity in the South African context, and the clarification of measurement units across the framework. This produced the intermediate version (V2).

The third phase applied V2 to the embedded case study. The picture that emerges is of an SDI that is institutionally and legally well-established, but that falls short when it comes to inclusive performance. Regarding access, barely one in four households owns a computer, electricity is unreliable for a large part of the population, and both geoportals are English-only. Then there is a wide gap between what the formal framework prescribes and what actually happens. Data sharing arrangements exist but are not respected by all stakeholders. Lastly, private ownership of core datasets limits what can be publicly shared, and budget allocations do not reliably reach the people and institutions maintaining the SDI.

The SMART analysis showed that the large majority of indicators are specific, measurable, achievable, relevant, and time-bound and produced meaningful findings when applied. A small number of indicators, such as those dependent on survey-based fieldwork or on data not yet systematically collected, required revision in the final version (V3) of the framework, either through consolidation, the addition of proxy measures, or removal where no decent substitute was available. The final framework is presented in Chapter 7 (page 51) and consists of thirty indicators across eight components, offering a structured method for SDI assessment in non-Western contexts.

The research contributes a tested framework for inclusive SDI assessment in non-Western contexts, filling a gap in a literature that has been dominated by Western-centric tools. In a more practical sense, it provides policymakers and SDI practitioners with an instrument for identifying where challenges in SDI performance occur. The case study of South Africa and the City of Cape Town illustrates both the utility of the framework and the depth of the challenges that remain: challenges which require not only technical improvements to the SDI, but sustained political commitment to digital inclusion, genuine multilingual accessibility, and forms of community engagement that South Africa's top-down SDI has yet to institutionalise.

10. Recommendations

The following recommendations are addressed to three audiences: researchers working on SDI assessment in non-Western contexts, policymakers and SDI practitioners more generally, and specifically the institutions responsible for the South African national SDI and the City of Cape Town local SDI.

10.1 For researchers

Test the framework in additional non-Western contexts.
The framework was developed and validated through a single embedded case study. Applying it in countries at earlier stages of SDI development, or in contexts with very different linguistic and infrastructural conditions would allow for further evaluation and improvements.

Develop measurement approaches for awareness indicators.
Indicators 5B (SDI awareness among end users), 7D (SDI awareness among data providers), and 8C (SDI awareness among funding bodies) all require further methodological development. Future research should explore whether proxy measures such as geoportal traffic data, counts of duplicate datasets as an inverse measure of institutional SDI awareness, or the proximity of the SDI coordinating body to the ministry of finance as developed by Indrajit (2018), can substitute for direct survey-based measurement where fieldwork is not feasible.

10.2 For policymakers and SDI practitioners in non-Western contexts

Embed SDI development within national digital inclusion strategies.
Political commitment to bridging the digital divide, as measured by indicator 6C, is a necessary but not sufficient condition for SDI participation. Where national digital inclusion policies exist, SDI development should be explicitly named as a component of those strategies, ensuring that connectivity investments, device access programmes, and digital skills initiatives also support SDI participation.

Prioritise multilingual accessibility.
English-only SDI portals and metadata are a straightforward barrier to end-user participation in linguistically diverse contexts. Given that multilingual communication is already standard practice in other areas of government in many non-Western contexts, SDI platforms should be treated the same.

Strengthen the legal definition of data sharing obligations.
Where data sharing arrangements can be satisfied by providing paper records or data in non-digital formats, the arrangement is effectively meaningless. Legislation should be revised to require that data is shared in digital, open, and machine-readable formats.

Protect the public ownership of core spatial datasets.
The dependency of government bodies on privately owned spatial data creates structural barriers for sharing data. Contracts with private data providers should emphasize that data collected for the government remains open to the public.

Invest in subnational SDI participation.
In South Africa and likely across many non-Western contexts, the majority of municipalities have no meaningful participation in the national SDI. National SDI governance should support municipal participation.

10.3 Specifically for the South African national SDI and the City of Cape Town

Use Cape Town's geoportal experience to support other municipalities.
A structured programme to share the technical and institutional lessons of Cape Town’s recent experience with building their SDI could benefit other South African municipalities, particularly those in smaller municipalities.

Translate SDI portals and metadata into additional official languages.
South Africa's twelve official languages and Cape Town's three dominant languages (English, Afrikaans, and isiXhosa) make multilingual portal design straightforward. This is the most direct action available to the institutions responsible for both portals, and its absence a decade after their launch is an unnecessary barrier to SDI participation.

11. Reference list

Ahmad, M., Ali, A., Nawaz, M., Sattar, F., & Hussain, H. (2024). A review of Pakistan's National Spatial Data Infrastructure using multiple assessment frameworks. *ISPRS International Journal of Geo-Information, 13*(9), 328. https://doi.org/10.3390/ijgi13090328.

Ali, A., Imran, M., Jabeen, M., Ali, Z., & Mahmood, S. A. (2021). Factors influencing integrated information management: Spatial data infrastructure in Pakistan. *Information Development*, *39*(2), 213-234. https://doi.org/10.1177/02666669211048483

Ali, M., Papageorgiou, G., Aziz, A., Loukis, E., Charalabidis, Y., López Pellicer, F. J., & Alexopoulos, C. (2024). A framework for the multi-dimensional assessment of interoperability for open data ecosystems development. *Information Polity, 29*(4). https://doi.org/10.1177/15701255241297172

Bhola, R. (2024). *Assessment for the development of a local Spatial Data Infrastructure to improve geospatial data management for the Indigenous community in Kwamalasamutu, Suriname* (Master's thesis). https://studenttheses.uu.nl/handle/20.500.12932/47268

Calzati, S., & van Loenen, B. (2023). An ethics assessment list for geoinformation ecosystems: Revisiting the integrated geospatial information framework of the United Nations. *International Journal of Digital Earth*, *16*(1), 1418-1438. https://doi.org/10.1080/17538947.2023.2200041

Carroll, S. R., Herczog, E., Hudson, M., Russell, K., & Stall, S. (2021). Operationalizing the CARE and FAIR Principles for Indigenous data futures. *Scientific data*, *8*(1), 108. https://doi.org/10.1038/s41597-021-00892-0

City of Cape Town Corporate GIS. (2024). *2024 Household Survey. https://odp-cctegis.opendata.arcgis.com/datasets/d5095485fa2a4312abbf3b80706d3275/explore*

City of Cape Town. (2026). *Register for a municipal account*. City of Cape Town. Retrieved January 20, 2026, from https://www.capetown.gov.za/City-Connect/Register/eservices-and-municipal-accounts/Register-for-a-municipal-account

Coetzee, S., & Wolff-Piggott, B. (2015). A review of SDI literature: Searching for signs of inverse infrastructures. In C. R. Sluter, C. B. M. Madureira Cruz, & P. M. L. de Menezes (Eds.), *Cartography — Maps connecting the world* (Lecture Notes in Geoinformation and Cartography, pp. 113–127). Springer. https://doi.org/10.1007/978-3-319-17738-0_9

Cooper, A. K., Makgale, F., & Hattingh, M. (2025). Is local level implementation of the Integrated Geospatial Information Framework (IGIF) in South Africa feasible?. *Advances in Cartography and GIScience of the ICA*, *5*, 9. https://doi.org/10.5194/ica-adv-5-9-2025

Cooper, A., van Huyssteen, E., Das, S., Coetzee, M., & Mans, G. (2014). Assessment of spatial data infrastructures. *Town and Regional Planning, 64*, 65–75. journals.ufs.ac.za

Crompvoets, J., (2006). National spatial data clearinghouses worldwide development and impact. Dissertation. Wageningen University and Research Centre, Wageningen. https://doi.org/10.18174/121754

Crompvoets, J. W. H. C., Rajabifard, A., van Loenen, B., & Delgado Fernández, T. (Eds.). (2008). *A multi-view framework to assess spatial data infrastructures* (Lecture/monograph). The Melbourne University Press. Wageningen University & Research

Department of Agriculture, Land Reform and Rural Development. (2023, March 10). *Spatial information standards* (Government Notice No. 3128). Government Gazette, 48187. https://gazettes.africa/archive/za/2023/za-government-gazette-dated-2023-03-10-no-48187-part-1.pdf

Department of Cooperative Governance and Traditional Affairs. (2020). *Profile: City of Cape Town.* https://www.cogta.gov.za/ddm/wp-content/uploads/2020/11/City-of-CT-September-2020.pdf

Department of Employment and Labour. (2026). *National minimum wage flyer 2026*. https://www.labour.gov.za/DocumentCenter/Publications/Basic%20Conditions%20of%20Employment/National%20Minimum%20Wage%20flyer%202026.pdf

Department of Forestry, Fisheries and the Environment. (2026). *OCIMS data resources*. https://ocims.environment.gov.za/DataResources.html

Department of Rural Development and Land Reform. (2014, November 10–11). *Country report for the Republic of South Africa: 48th Technical Committee and Governing Council meeting of the Regional Centre for Mapping of Resources for Development (RCMRD).* Republic of South Africa. Retrieved from: https://ggim.un.org/country-reports/documents/SouthAfrica-2015-country-report.pdf

Department of Water and Sanitation. (2026). *GIS data*. https://www.dws.gov.za/iwqs/gis_data/

Digital Future Society (2019). Measuring the margins: A global framework for digital inclusion. https://collections.unu.edu/eserv/UNU:7584/n201219_Report-7_A_global_framework_for_digital_inclusion-2.pdf

Dijk, J. A. G. M. van. (2006). Digital divide research, achievements and shortcomings. *Poetics*, *34*(4-5), 221-235. https://doi.org/10.1016/j.poetic.2006.05.004

Ebrahim, A. Q., & Van den Berg, C. L. (2024). The barriers to technology adoption among businesses in the informal economy in Cape Town. *South African Journal of Information Management, 26*(1), 1872. https://doi.org/10.4102/sajim.v26i1.1872

Eelderink, Lyande (2006). Towards key variables to assess National Spatial Data Infrastructures (NSDIs) in developing countries [Master's thesis, GIMA — Geographical Information Management and Applications, Utrecht University / Delft University of Technology / Wageningen University / University of Twente]. University of Twente Repository. https://purl.utwente.nl/essays/101980

ESRI. (2020). Providing Easy Access to Powerful Location Data. Retrieved from: https://www.esri.com/en-us/landing-page/industry/government/2020/city-cape-town-case-study

Eurostat (2023a). Glossary: E-inclusion. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:E-inclusion

Eurostat (2023b). Glossary: Digital divide. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Digital_divide

Fortes, L. P. S., & de Araújo, V. O. H. (2013). *Permanent Committee for Geospatial Data Infrastructure of the Americas (PC-IDEA)*. Retrieved from: https://unstats.un.org/unsd/geoinfo/rcc/docs/rcca10/E%20Conf_103_12_PCIDEA%20Final%20Report%202009_2013.pdf

Geospatial World. (2025). *Geospatial knowledge infrastructure readiness index*. Retrieved from: https://geospatialworld.net/consulting/reports/gki-readiness-index/2025/pdf/gki-readiness-report-2025.pdf

Grus, J. Crompvoets & A. K. Bregt (2010) Spatial data infrastructures as complex adaptive systems, International Journal of Geographical Information Science, 24:3, 439-463, https://doi.org/10.1080/13658810802687319

Grus, L, 2010, Assessing Spatial Data Infrastructures, Wageningen University, dissertation, https://edepot.wur.nl/134275

Grus, L., Crompvoets, J., Bregt, A. K., van Loenen, B., Fernandez, T. D., & Vandenbroucke, D. (2011). Evaluating the application of the multi-view spatial data infrastructure assessment framework. Journal of Spatial Science, 56(1), 121–141. https://doi.org/10.1080/14498596.2011.567438

Herrera-Murillo, D. J., Ochoa-Ortiz, H., Ahmed, U., López-Pellicer, F. J., Re, B., Polini, A., & Nogueras-Iso, J. (2025). Collective intelligence in humanitarian voluntary geographic information: The case of the HOT Tasking Manager. *ACM Transactions on Computer-Human Interaction*. https://doi.org/10.1145/3733600. https://www.economicsandpeace.org/wp-content/uploads/2024/06/GPI-2024-web.pdf

Humanitarian OpenStreetMap Team. (2026). *South Africa roads (OpenStreetMap Export)* [Data set]. The Humanitarian Data Exchange. https://data.humdata.org/dataset/hotosm_zaf_roads

Indrajit, A. (2018). One Data Indonesia to support the implementation of open data in Indonesia. In B. van Loenen, G. Vancauwenberghe, & J. Crompvoets (Eds.), *Open data exposed* (Information Technology and Law Series, Vol. 30, pp. 247–267). T.M.C. Asser Press. https://doi.org/10.1007/978-94-6265-261-3_13

Institute for Economics & Peace. Global Peace Index 2024: Measuring Peace in a Complex World, Sydney, June 2024. Available from: http://visionofhumanity.org/resources

Instituto Brasileiro de Geografia e Estatística (IBGE). (2022, August 3–5). *Country Report of Brazil* [Report]. Twelfth Session of the United Nations Committee of Experts on Global Geospatial Information Management, New York, NY, United States. Retrieved from: https://ggim.un.org/country-reports/documents/Brazil_Report_GGIM_2022.pdf

Ivánová, I., N. Brown, R. Fraser, N. Tengku, and E. Rubinov. 2019. “Fair and Standard Access to Spatial Data as the Means for Achieving Sustainable Development Goals.” International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences XLII-4-W20: 33–39. https://doi.org/10.5194/isprs-archives-XLII-4-W20-33-2019

Jobs Guru. (2025, March 23). *South Africa's informal sector: Navigating the labyrinth of economic policies*. South African Worker and Student Portal. https://joub.co.za/south-africas-informal-sector-navigating-the-labyrinth-of-economic-policies/

Kim, Y., & Jang, C. Y. (2025). Evaluating Digital Inclusion: A Framework for Indexing Inclusive Progress. Public Organization Review, 1-18. DOI:10.1007/s11115-025-00857-6

Loenen, B. van. (2006). *Developing geographic information infrastructures; the role of information policies*. [Dissertation (TU Delft), Delft University of Technology]. DUP Science. DOI:10.1080/13658810701851412

Loenen, B. van, Crompvoets, J. and A. Poplin. 2010. Assessing geoportals from a user perspective, in the proceedings of the GeoValue Workshop, Sept. 30 Oct. 2, 2010, Hamburg, Germany https://pure.tudelft.nl/ws/portalfiles/portal/132718500/2010_BVL_JC_AP_Geovalue.pdf

Makanga, P., & Smit, J. (2010). A review of the status of spatial data infrastructure implementation in Africa. *South African Computer Journal, 45*. https://doi.org/10.18489/sacj.v45i0.36

Mulder, A. E., Wiersma, M. G., & van Loenen, B. (2020). Status of national open spatial data infrastructures: A comparison across continents. *International Journal of Spatial Data Infrastructures Research, 15*, 56–87. https://doi.org/10.2902/1725-0463.2020.15.art3

Municipal Demarcation Board. (2026a). *MDB open data portal*. https://dataportal-mdb-sa.opendata.arcgis.com/search

Municipal Demarcation Board. (2026b). *Cadastre* [Data set]. ArcGIS Online. https://www.arcgis.com/home/item.html?id=7acce354daaa4a3ea9d83dcaf64cd70d

Narain, A. (2017, March 15). *The Global Geospatial Industry Outlook tells the Geospatial Readiness Index of the Countries.* Geospatial World. Retrieved from: https://geospatialworld.net/article/global-geospatial-industry-outlook/

Nebert, D. (2004). Developing Spatial Data Infrastructures: The SDI Cookbook. Technical report, Global Spatial Data Infrastructure. Retrieved from: https://www.geos.ed.ac.uk/~gisteac/proceedingsonline/Source%20Book%202004/SDI/Global/Global%20Spatial%20Data%20Infrastructure/SDI%20Cookbook/SDI%20Cookbook%20v1-1_May%2001.pdf

Ngcamu, B. S. (2023). Climate change effects on vulnerable populations in the Global South: a systematic review. *Natural Hazards*, *118*(2), 977-991. https://doi.org/10.1007/s11069-023-06070-2

Nyhontso, M. (2025, July 8). *Budget Vote 42 speech: Department of Land Reform and Rural Development 2025/26* [Speech]. South African Government. https://www.gov.za/news/speeches/minister-mzwanele-nyhontso-land-reform-and-rural-development-dept-budget-vote-202526

Oduro-Marfo, S., & Clarke, M. (2018). Global South: what does it mean and why use the term?. *University of Victoria*, *8*. Retrieved from: https://onlineacademiccommunity.uvic.ca/globalsouthpolitics/2018/08/08/global-south-what-does-it-mean-and-why-use-the-term/

OECD (2023). Africa's Development Dynamics (AfDD). Table 11 – Communications and infrastructure https://data-viewer.oecd.org/?chartId=ff54cae2-d0c1-4681-8d61-15f9069a6b58

Ogunbiyi, J. (2021). *Reviewing the status of national spatial data infrastructure: A case study in Southern African Countries* (Doctoral dissertation, Vienna). Retrieved from: https://repositum.tuwien.at/bitstream/20.500.12708/17901/1/Ogunbiyi%20John%20-%202021%20-%20Reviewing%20the%20status%20of%20national%20spatial%20data...pdf

Ookla. (2026, February). *Speedtest global index: South Africa*. https://www.speedtest.net/global-index/south-africa

OpenStreetMap South Africa. (2024). *Aerial imagery*. https://aerial.openstreetmap.org.za/

Rajabifard, A., & Williamson, I. P. (2001, April). Spatial data infrastructures: concept, SDI hierarchy and future directions. In *Proceedings of GEOMATICS'80 Conference* (Vol. 10). Retrieved from: https://minerva-access.unimelb.edu.au/bitstream/handle/11343/33897/66253_00001151_01_4_01Raj_Iran.pdf?sequence=1

Rajabifard, A., Feeney, M.E.F., and Williamson, I.P., 2002. Future directions for SDI development. International Journal of Applied Earth Observation and Geoinformation, 4 (1): 11–22. https://doi.org/10.1016/S0303-2434(02)00002-8

REPUBLIC OF SOUTH AFRICA (RSA). 2004. Spatial Data Infrastructure Act, Act No 54 of 2003. Pretoria: Government Printer.

Rhind D. (2000). Funding an NGDI. In: Geospatial Data Infrastructure Concepts, Cases and Good Practices. Groot. R. and J. McLaughlin (eds.). Oxford University Press, pp. 39-55.

SABC News. (2026, February 2). *Govt moves to close digital divide in SA schools* [Video]. YouTube. https://www.youtube.com/watch?v=0BC46NrCTI8

Scott, G. (2020). A national strategic geospatial information framework to support the implementation of the sustainable development goals (SDGs). *Doctoral diss.,* *https://minerva-access.unimelb.edu.au/items/fa93bcfd-3331-5012-99e6-4d73580fe850/full* .

Sofianopoulos, S., Faka, A., & Chalkias, C. (2025). SDI-enabled smart governance: A review (2015–2025) of IoT, AI and geospatial technologies — applications and challenges. *Land, 14*(7), 1399. https://doi.org/10.3390/land14071399

South African Geomatics Council. (2025). *Draft Recognition of Prior Learning Policy and the Draft Core Knowledge Areas for the Geomatics Profession. Retrieved from: https://sagc.org.za/sagc-news/*

Stakeholder Identification and Analysis. *Retrieved from:* https://ggim.un.org/UN-IGIF/documents/UN-IGIF%20CAP%20-%20Task%202%20-%20Stakeholder%20Identification%20and%20Analysis.pdf

Statistics South Africa. (2022). *Census 2022 Statistical Release. Retrieved from: https://census.statssa.gov.za/assets/documents/2022/P03014_Census_2022_Statistical_Release.pdf*

Statistics South Africa. (2023). *Sustainable Development Goals: Country Report 2023*. *Retrieved from:* https://strapi7453567.s3.eu-central-.amazonaws.com/SDG_Country_report_1_4309124d91.pdf

Statistics South Africa. (2024). *General household survey 2024* (Report No. P0318). https://www.statssa.gov.za/publications/P0318/P03182024.pdf

Statistics South Africa. (2026). *Stats SA: Improving lives through data ecosystems*. https://www.statssa.gov.za/

Supinajaroen, W. (2022). Optimising the use of National CORS data in the context of Thailand: policy outlooks from a data ecosystem perspective. [Dissertation (TU Delft), Delft University of Technology]. https://doi.org/10.7480/abe.2022.18

Telkom. (2026). *Prepaid social bundle*. https://www.telkom.co.za/prepaid-services/social-bundle

Transparency International. (2021). *Corruption Perceptions Index*. UNESCO World Trends in Freedom of Expression and Media Development. https://www.unesco.org/en/world-media-trends/corruption-perceptions-index

United Nations Development Programme (2006). RBM in UNDP: Selecting Indicators, at www.undp.org/eo/documents/methodology/rbm/Indicators PaperI.doc, [accessed March 2006].

United Nations, Committee of Experts on Global Geospatial Information Management. (2018, July 24). *Integrated Geospatial Information Framework: Part 1: Overarching strategic framework*. *Retrieved from:* https://ggim.un.org/meetings/ggim-committee/8th-session/documents/part%201-igif-overarching-strategic-framework-24july2018.pdf

United Nations, Committee of Experts on Global Geospatial Information Management. (2023a, March. *Integrated Geospatial Information Framework: Part 2: Implementation guide*. *Retrieved from:* https://ggim.un.org/UN-IGIF/documents/Solving_the_Puzzle_FINAL_17Mar2023.pdf

United Nations, Committee of Experts on Global Geospatial Information Management. (2023b, March). *Integrated Geospatial Information Framework: Part 3: Country-level action plans*.

United Nations, Committee of Experts on Global Geospatial Information Management. (2024). *Global Survey on the Use and Implementation of the UN-IGIF. Retrieved from: https://ggim.un.org/UN-IGIF/documents/Report_Global_Survey.pdf*

United Nations. (2015). *Transforming our world: The 2030 Agenda for Sustainable Development* (A/RES/70/1). Retrieved from: https://sdgs.un.org/2030agenda

Vandenbroucke, D., Janssen, K., & Van Orshoven, J. (2008). INSPIRE State of Play: *A multi-view framework to assess SDIs*, p. 145. Retrieved from: https://research.wur.nl/en/publications/a-multi-view-framework-to-assess-spatial-data-infrastructures/

World Bank. (2023). *Access to electricity (% of population) — South Africa* [Data set]. https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS?locations=ZA

World Bank. (2025). *Worldwide Governance Indicators (WGI): Political Stability and Absence of Violence/Terrorism: Percentile Rank*. World Bank DataBank. Retrieved November 25, 2025, from https://databank.worldbank.org/source/worldwide-governance-indicators/Series/PV.PER.RNK#

Yin, R. K. (2018). *Case study research and applications: Design and methods* (6th ed.). SAGE Publications. Retrieved from: https://us.sagepub.com/en-us/nam/case-study-research-and-applications/book250150

Appendix A: Digital inclusion index by Digital Future Society (2019)

(Complete with level two indicators)

Digital Future Society (2019)		
Component	**Sub-component**	**Indicators**
Access	Access to electricity	Access to electricity as % of general/rural/ urban population (GSMA-MIC: World Bank); Access to electricity (GSMA-MIC: International Energy Agency)
	Access to telephony	Fixed-telephone subscriptions per 100 inhabitants (GSMA-MIC: ITU) Mobile phone subscriptions per 100 inhabitants (GSMA-MIC: ITU) • 2G Coverage - Population covered by a cellular network (%) (GSMA-MIC: ITU) • 3G Coverage - Population covered by at least a 3G mobile network (%) (GSMA-MIC: ITU) • 4G Coverage - Population covered by at least an LTE/WiMAX mobile network (%) (GSMA-MIC: ITU) Internet-enabled (GSMA-MIC: ITU)
	Access to device	Percentage of households with desktop/ laptop computer (GSMA-MIC: ITU) Presence of personal computer or tablet computer in household (AUS-DII: Roy Morgan Single Source) Mobile/tablet - Percentage of households with mobile phone (GSMA-MIC: ITU)
	Access to the internet	Access to the internet (%) (ITU-IDI) • Fixed Internet subscriptions per 100 inhabitants (GSMA-MIC:ITU) • Active mobile-broadband subscriptions per 100 inhabitants (GSMA-MIC:ITU)
	Quality of connectivity	Average quality of connectivity (GSMA MIC: GSMA Intelligence) 2. Average mobile download speeds (GSMAMIC: Ookla Speedtest Intelligence Data) 3. Average mobile upload speeds (GSMAMIC: Ookla Speedtest Intelligence Data) 4. Average mobile latency (GSMA-MIC: Cisco, OpenSignal) 5. Secure internet servers per 1 million inhabitants (GSMA-MIC: World Bank) 6. International internet bandwidth (bit/s) per user (GSMA-MIC: ITU) 7. Internet exchange points (IXPs) per 10 million people (GSMA-MIC: Packet Clearing House) 8. Digital dividend spectrum in MHz per operator (GSMA-MIC: GSMA Intelligence) 9. Other spectrum below 1GHz per operator (GSMA-MIC: GSMA Intelligence) 10. Above 1GHz spectrum per operator (MHz per operator) (GSMA-MIC: GSMA Intelligence)
	Point of access	% of households with internet access (AUS-DII: Roy Morgan Single Source); Home (%); Work (%); Hotspot (%); 11. Public hotspot (free) - Does the government provide public Wi-Fi access in the largest city in the country and is it free to connect to? (EIU-III) 12. Third party hotspot (free) - Does the largest privately owned ISP provide public Wi-Fi access to its customers in the largest city in the country and is it free to connect to? (EIU-III) Other (%)
Skills	Adult literacy	Adult literacy (%) (WEF:UNESCO)
	Academic life expectancy	Enrolment in primary education (%) (WEF: UNESCO) 13. Critical thinking in teaching (%) (WEF-GCI) 14. STEM (%) (WEF-GCI) 15. Coding (%) (WEF-GCI) Gross graduation ratio from primary education (%) (EIU-III: UNESCO); Enrolment in secondary education (%) (EIU-III: UNESCO) 16. Critical thinking in teaching (%) (WEF-GCI) 17. STEM - Share of all students in secondary education enrolled in vocational programmes (UNESCO) 18. Coding - Share of all students in secondary education enrolled in vocational programmes (UNESCO) Gross graduation ratio from upper and lower secondary education (%)

		(WEF:UNESCO) 19. Gross graduation ratio from lower education (%) (WIPO-GII: UNESCO) 20. Gross graduation ratio from upper education (%) (WIPO-GII: UNESCO) Enrolment in tertiary education (%) (WIPO-GII: UNESCO); Graduates from tertiary education (%) (WIPO-GII: UNESCO); 21. Graduates from tertiary education in Natural Sciences, Math and Statistics Programmes (%) (WIPO-GII: UNESCO) 22. Graduates from tertiary education in Engineering, Manufacturing and Construction (%) (WIPO-GII: UNESCO) Mean years of schooling (%) (EIU-III: UNDP)
	Digital skills	Possession of “basic” or “above basic” digital skills (general) (%) (EC-DESI: Eurostat); 23. Possession of “basic” or “above basic” digital skills: information (%) (EC-DESI: Eurostat) 24. Possession of "basic" or "above basic" digital skills: communication (%) (EC-DESI: Eurostat) 25. Possession of “basic” or “above basic” digital skills: problem solving (%) (ECDESI: Eurostat) 26. Possession of “basic” or “above basic” digital skills: software for content creation (%) (EC-DESI: Eurostat) In addition to having used basic software features such as word processing, use of advanced spreadsheet functions, created a presentation or document integrating text, pictures and tables or charts, or written code in a programming language (EC-DESI: Eurostat); 27. In the private sector (%) 28. In the public sector (%) % of people with a degree in ICT (EC-DESI: Eurostat) 29. In the private sector (%) 30. In the public sector (%) % employed ICT specialists (EC-DESI: Eurostat) 31. In the private sector (%) 32. In the public sector (%)
	Use internet	Individuals using the Internet (%) (ITU-IDI) or People who never used the internet (%) (EC-DESI: Eurostat) 33. Individuals using the Internet once in the last 3 months (%) (ITU-IDI) 34. People who use the Internet at least once a week (%) (EC-DESI: Eurostat)
	Basic activities	Streamed, played, or downloaded content online (%) (EC-DESI: Eurostat); AV communication via the internet (%) (EC-DESI: Eurostat); Created or managed a site or blog (%) (EC-DESI: Eurostat); Searched for advanced information (%) (EC-DESI: Eurostat);
	Use eCommerce	Searched for eCommerce information in last 12 months (%) (EIU-III: UNCTAD) 35. Compared products and services online (%) (EIU-III) Made a transaction in last 12 months (%) (EC-DESI: Eurostat) 36. Purchased a project or service (EIU-III) 37. Frequency of purchase of goods via the internet (EIU-III) 38. People who ordered goods or services online (EC-DESI: Eurostat) 39. Used the internet to pay bills or buy online in the past year (% age 15+) (World Bank) 40. Sold a product or service (active) 41. People who sold goods or services online (%) (EC-DESI: Eurostat) 42. Developed a commercial site/portal (%) (EC-DESI: Eurostat) 43. Developed a digital commerce product or service for 3rd parties (%) (EC-DESI: Eurostat)
Use	Use eBanking	Searched for online banking information in last 12 months (%) (EIU-III) Made a payment or transaction (including mobile money) in last 12 months (%) (World Bank) 44. Made a transfer from website or app (%) 45. Made a transfer via SMS or other nonwebsite or app solutions (%) Made or received digital payments in the past year (% ages 35-59) (World Bank) or Used the internet to pay bills or buy online in the past year (% age 15+) (World Bank) 46. Made a transfer from website or app (%) 47. Made a transfer via SMS or other nonwebsite or app solutions (%)
	Use eGovernment	Searched for digital public service information in last 12 months (%) (EC-DESI: Eurostat) 48. Number of administrative steps related to major life events (birth of a child, new residence, etc) that can be done online (UNDESA-EGDI) 49. Number of administrative steps related to business administration (register/close a company, declare corporate taxes, pay VAT, apply for a licence/permit) that can be done online (UNDESA-EGDI) Made a digital public service transaction in last 12 months (%) (EC-DESI: Eurostat) 50. Number of administrative steps related to business administration (register/close a company, declare corporate taxes, pay VAT, apply for a licence/permit) that can be done online (UNDESA-EGDI)

		51. Number of administrative steps related to business administration (register/close a company, declare corporate taxes, pay VAT, apply for a licence/permit) that can be done online (UNDESA-EGDI)
	eWork / entrepreneurship	Used the internet or a device for work in the last 12 months (%) (EC-DESI: Eurostat) 52. PC, internet or system based (%) 53. Coding (%) 54. Designed an application/solution (%) 55. Apps developed per person (%) 56. Companies per 100 persons (%) 57. Startups per 100 persons (%)
	Social media	Used social media in the last 12 months (%) (EC-DESI: Eurostat) 58. Found information and communicated with people (passive) (%) 59. Consumed social media content (passive) (%) 60. Commented and shared social media nonsocial content (e.g. news) (active) (%) 61. Produced content for social media content (active) (%)
	eParticipation	Engaged in public discourse online in the last 12 months (%) (UNDESA-EGDI) 62. Found information (passive) (%) 63. Voted for / rated a suggestion (passive) (%) 64. Commented on… (active) (%) 65. Made a proposal (petition, budget…) (active) (%)
Supportive environment	Affordability	Cost of 100 MB of data (GSMA-MIC) 66. Cost of 100MB of data (% of monthly GDP per capita) (GSMA-MIC: Tarifica) 67. Cost of 500MB of data (% of monthly GDP per capita) (GSMA-MIC: Tarifica) Mobile broadband handset + 500MB, postpaid and prepaid, cap, in MB (GSMAMIC: ITU) 68. Cost of 1GB of data (% of monthly GDP per capita) (GSMA-MIC: Tarifica) Mobile broadband USB_1GB, postpaid and prepaid, cap, in GB (GSMA-MIC: ITU) Device price (cheapest mobile on the market) (GSMA-MIC) 69. Cost of cheapest internet-enabled mobile device (GSMA-MIC: Tarifica) 70. Cost of cheapest internet-enabled PC (GSMA-MIC)
	Legally valid identification	Ability to apply for a personal identity card (UNDESA-EGDI) Presence of an eID or national digital identification system to access government services (UNDESA-EGDI: World Bank) 71. Simple login and password (%) 72. Is there any kind of authentication (a digital ID) required to access online services? Evidence on government websites that the national ID is digitalized (UNDESA-EGDI) Nationally recognised eSignature (%) 73. Nationally recognised 2-factor authentication (%) 74. Nationally recognised 3-factor authentication (%)
	Banking and financial inclusion	Individuals with access to financial services (%) 75. Individuals with access to a bank account (%) 76. Individuals with access to alternative financial services (e.g. mPesa, mobile money) (%)
	Trust	Confidence in privacy of online activities (%) (EIU-III: ITU Cyber Security Index) 77. Extent of trust in information received from government websites / apps (%) (EIU-III: ITU Cyber Security Index) 78. Extent of trust in information received from non-government websites / apps that are based in my country (%) (EIU-III: ITU Cyber Security Index) 79. Extent of trust in information received from "other people using social media" (%) (EIU-III: ITU Cyber Security Index) 80. Extent of agreement with the statement: "making purchases online is safe and secure" (%) (EIU-III: ITU Cyber Security Index) Presence of data protection law(s) (EIU-III: ITU Cyber Security Index) 81. Presence of legal penalties in place for firms that do not follow the law? (EIU-III: ITU Cyber Security Index) 82. Privacy Regulations - Are there financial penalties in place for firms that do not follow the law? (EIU-III: ITU Cyber Security Index)
	Security	Existence of legislation that specifically addresses sexual harassment (World Bank) 83. Is there legislation that specifically addresses sexual harassment? (World Bank) 84. Is there sexual harassment legislation in public places? (World Bank) 85. Are there civil remedies for sexual harassment in employment? (World Bank) Percentage of individuals victims of a crime (%) (UN Women) 86. Percentage of individuals victims of cyber crime (e.g. ITU Cyber Security Index) 87. Percentage of individuals victims of violent crime (%) 88. Percentage of individuals victims of domestic violence (%) (UN Women)

Appendix B: List of proposed Base Dataset Custodians

(As per the study conducted by the CSI Data Sub-Committee)

Theme	Dataset	Custodian	Recommended Base data coordinator
Administrative Boundaries	National Boundaries	Municipal Demarcation Board	Municipal Demarcation Board info@demarcation.org.za Tel: +27 12 342 2481/2 www.demarcation.org.za
	Provincial Boundaries	Municipal Demarcation Board	
	District Municipality	Municipal Demarcation Board	
	Local Municipality	Municipal Demarcation Board	
	Metro	Municipal Demarcation Board	
	Magisterial districts	Department of Justice	
	Voting districts	Independent Electoral Commission (IEC)	
	Wards	Municipal Demarcation Board	
	Tradition Boundaries	Provincial Department of Traditional Affairs	
	Tribal Authorities	Department of Traditional Affairs	
Imagery	Aerial photography (0.35m – 0.5m)	National Geo-spatial information NGI	National Geo-spatial Information (NGI), Department of Rural Development and Land Reform (DRDLR) www.ngi.gov.za Tel: +27 21 658 4302
	Satellite Imagery	South African National Space Agency (SANSA)	
Roads	National roads	National Geo-spatial Information (NGI) South African National Roads Agency Limited (SANRAL) National Roads Agency (NRA)	Department of Transport (DoT) Tel: +27 12 309 3657 www.transport.gov.za
	Main, secondary, other	National Geo-spatial Information (NGI) Provincial Government Local Authorities	
	Streets	Provincial Government Local Authorities	
Social Statistics	Place name	Statistics South Africa STATSSA National Geo-spatial Information (NGI) Provincial Government Local Authorities SA Geographic Names Council	Statistics South Africa (STATSSA) info@statssa.gov.za Tel: +27 12 310 8600 http://beta2.statssa.gov.za
	Enumerator Areas	STATSSA	
	Small areas	STATSSA	
	Dwelling frame	STATSSA Eskom Department of Water and Sanitation (DWS) Local Authorities	
Land use	Land use	National Geo-spatial Information (NGI) National department Provincial Government Local Authorities	National Geo-spatial Information ((NGI)), Department of Rural Development and Land Reform (DRDLR) Tel: +27 21 658 4302 www.ngi.gov.za
Land Cover	Land Cover	National Geo-spatial Information (NGI) National department Provincial Government Local Authorities	
Cadastre	Land parcel boundaries	Chief Surveyor General (CSG) Provincial Surveyors General Department of Agriculture Forestry and Fisheries (DAFF) Local Authorities	Chief Surveyor General (CSG) Tel: +27 12 326 8050 www.csg.dla.gov.za
	Deeds register attributes	Deeds Office	
Hydrology	Water courses, streams and rivers	Department of Water and Sanitation (DWS) National Geo-spatial Information (NGI) Local Authorities Catchment Management Agencies (CMA)	Department of Water Affairs (DWA) Tel: +27 12 336 8387 www.dwa.gov.za/default.aspx
	Drainage networks catchments	Department of Water and Sanitation (DWS)	
	Water bodies (e.g. dams, lakes)	Department of Water and Sanitation (DWS) National Geo-spatial Information (NGI)	

		Local Authorities Catchment Management Agencies (CMA)	
	Water resources: boreholes, groundwater	Department of Water and Sanitation (DWS) Catchment Management Agencies (CMA)	
Geodesy	Trigonometrical Beacons	National Geo-spatial Information (NGI)	National Geo-spatial Information ((NGI)), Department of Rural Development and Land Reform (DRDLR) Tel: +27 21 658 4302 www.ngi.gov.za
	Town Survey Mark Schemes	National Geo-spatial Information (NGI) Local Authorities	
	Benchmarks	National Geo-spatial Information (NGI) Local Authorities	
	TrigNet GNSS Base station network	National Geo-spatial Information (NGI)	
	Geoid Model	National Geo-spatial Information (NGI)	
Conservation Areas	Conservation and Protected areas	Department of Environmental Affairs (DEA) Provincial Government Local Authorities	Department of Environmental Affairs DEA callcentre@environment.gov.za Tel: +27 86 111 2468 Tel: +27 12 310 3911 www.environment.gov.za

Appendix C: Interview Guide

Template used for conducting the semi-structured interviews with SDI experts (P1–P8)

Interview details

Format: Semi-structured interview, approximately 30 minutes Participants: SDI experts P1–P8
Background information to be recorded before the interview:
- Interview number:
- Nationality of participant:
- Occupation / affiliation:

Opening

Before we begin, I would like to ask your permission to record this conversation and keep the recording until the end of my thesis research, after which it will be destroyed.
Start recording.
Do you give permission for this interview to be recorded, transcribed, and saved for the duration of my thesis research?

Part 1: Professional background

1. Could you briefly introduce yourself and describe your role and experience in the field of spatial data infrastructures?
2. How are you involved in SDI development, and specifically in the South African context if applicable?

Part 2: SDI assessment in non-Western contexts

3. How would you design a framework with the goal of assessing SDI performance is non-Western contexts?
4. Are there any indicators you would consider particularly relevant for the South African national SDI?
5. And for the City of Cape Town local SDI specifically?

Part 3: Evaluation per SDI component for measuring SDI performance in non-Western contexts

The following components are drawn from van Loenen (2006) and serve as the structural basis for the framework being developed. For each component, a set of prompts is provided to guide the discussion.

Datasets

- Should datasets include information captured at local levels to reflect more local perspectives?
- Should datasets include information segmented by demographic characteristics (gender, age, income, education level)

Institutional framework

- What institutional arrangements would best ensure equal access to spatial data for all user groups?
- How effective is the SDI Act in enabling data sharing across different levels of government?

Financial resources

- How should accountability in SDI funding be measured?
- Should there be dedicated funding for increasing user participation?
- To what extent are data custodians empowered by treasury departments to fulfil their roles?

Human resources

- How important is capacity building and digital literacy for SDI performance in non-Western contexts?
- Is citizen science a viable mechanism for bottom-up SDI participation, for example through land parcel registration programmes?

Policies

- What role do laws and regulations play in promoting SDI-performance in non-Western contexts?
- Is Recognition of Prior Learning (RPL), which allows GIS professionals to gain certification without a formal academic degree, a relevant indicator?

Technology

- How should equal accessibility to platforms (software) and technical equipment (hardware) be assessed?
- How relevant is the availability of connectivity and power infrastructure as an indicator?

Standards

- How relevant are the FAIR principles (Findable, Accessible, Interoperable, Reusable) for non-Western SDI performance?
- And the CARE principles (Collective benefit, Authority, Responsibility, Ethics)?

Part 4: Status of SDI in South Africa and Cape Town

How would you describe the current state of SDI performance in South Africa and the City of Cape Town?
Possible discussion topics:

- The role of private companies versus municipalities in data ownership and management
- Willingness to share data versus data siloing behaviour
- Top-down versus bottom-up data flows across levels of government
- User participation and the limitations posed by mobile-only access

End of interview guide